

NFPA® 660

Standard for Combustible Dusts and Particulate Solids

2025 Edition



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NFPA® 660

Standard for

Combustible Dusts and Particulate Solids

2025 Edition

This edition of NFPA 660, *Standard for Combustible Dusts and Particulate Solids*, was prepared by the Technical Committees on Fundamentals of Combustible Dusts, Agricultural Dusts, Combustible Metals and Metal Dusts, Handling and Conveying of Dusts, Vapors, and Gases, and Wood and Cellulosic Materials Processing, released by the Correlating Committee on Combustible Dusts. It was issued by the Standards Council on November 16, 2024, with an effective date of December 6, 2024.

This edition of NFPA 660 was approved as an American National Standard on December 6, 2024.

Origin and Development of NFPA 660

NFPA 660 was written by consolidating the requirements of NFPA 652, *Standard on the Fundamentals of Combustible Dust*; NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities*; NFPA 484, *Standard for Combustible Metals*; NFPA 655, *Standard for Prevention of Sulfur Fires and Explosions*; NFPA 664, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities*; and NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*, and making them into individual chapters in NFPA 660, so that this standard provides safety requirements for all combustible dusts and particulate solids.

One effect of this consolidation is that the definitions and terminology from each document have been standardized and are all found in Chapter 3, and fundamental requirements that apply to all of the industries or commodities covered by NFPA 660 are located in the first 10 chapters. Annex material in A.1.3 explains the organization of this combined document and how to determine the requirements for a piece of equipment, building, or facility.

The 2025 edition of NFPA 660 also includes some changes from the last editions of the source documents, including but not limited to the following:

- Requirements from the industry- or commodity-specific standards that were deemed to be fundamental have been moved to the first 10 chapters.
- Requirements that are covered in the fundamental chapters have been removed from the industry- and commodity-specific chapters.
- Terminology for “deflagration vent/venting” was made consistent throughout.
- Terminology for types of sulfur size reduction machinery was updated.
- Terms such as *transient releases*, *management of change*, *operational readiness review*, and *explosive- and propellant-actuated devices* have been defined.
- Requirements for operational readiness reviews have been added.
- New requirements have been added to evaluate self heating, thermal instability, water reactivity, and chemical reactivity hazards.
- Information has been added to document who is qualified to perform a DHA.
- Text has been added throughout Chapter 8 and the annexes to address the level of protection provided by flame-resistant garments.
- Elements of general safety training and job-specific training and frequency of refresher training have been specified.
- Requirements for bonding and grounding of housekeeping equipment have been clarified.
- Resistance limits for flexible connectors have been updated.
- References to risk assessments and DHAs have been edited for consistency throughout.
- Industrial hygiene exposure limits have been referenced for recycling of AMS exhaust to buildings.



- Changes in Chapter 21 clarify what kind of flexible connectors can be used in agricultural and food processing facilities.
- DHA requirements for existing processes and facility compartments in agricultural and food processing facilities have been revised.
- Guidance on responding to silo fires has been added.
- Test standards for portable vacuum cleaners used with combustible metals have been provided.
- Additive manufacturing requirements in Chapter 22 were updated.
- Changes in Chapters 23 and 25 clarify when manifolding of dust collection ducts is permitted.
- Guidance for spark detection systems has been updated.
- An annex has been added to assist in calculating the thermal dose to personnel from flash fires and building compartment deflagrations.

The technical committees would like to recognize two long-standing technical committee members, Erdem Ural and Robert Zalosh, who were instrumental in the development of several NFPA standards and passed away during the final stages of development of NFPA 660. Each having served more than 25 years on NFPA committees, they both had an incredible impact on the explosion protection and combustible dust industry, and their presence is deeply missed.

Finally, this edition of NFPA 660 is dedicated to workers who have suffered injuries or lost their lives from the hazards of combustible dusts, in the hope that it will help prevent such tragedies in the future.

Correlating Committee on Combustible Dusts

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

Chris Aiken, Cargill, Inc., MN [U]
Matthew J. Bujewski, Aon- Commercial Risk Consultants, MO [I]
John M. Cholin, J. M. Cholin Consultants, Inc., NJ [SE]
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Brian Edwards, Fike Corporation, GA [M]
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Jason Krbec, CV Technology, Inc., FL [M]
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Rep. FM

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Niels H. Pedersen, Nederman LLC, NC [SE]
Jeffrey R. Roberts, AXA XL/Global Asset Protection Services, LLC, MS [I]
Jeramy Slaunwhite, Rembe Inc., Canada [M]

Alternates

Will Baeder, Ardent Mills, CO [U]
(Alt. to Kevin Kimbell)
Craig Froehling, Cargill, Inc., MN [U]
(Alt. to Chris Aiken)
Samuel A. Rodgers, Retired, VA [SE]
(Alt. to Walter L. Frank)

Andrew Ryerson, FM, RI [I]
(Alt. to John A. LeBlanc)
Jeffery W. Sutton, TUV SUD America Inc./Global Risk Consultants Corporation, MN [SE]
(Alt. to Arthur P. Mattos, Jr.)

Nonvoting

Brad D. Burrige, Novelis, Inc., KY [U]
Rep. TC on Fundamentals of Combustible Dusts
Ashok Ghose Dastidar, Fauske & Associates, IL [SE]
Rep. TC on Handling and Conveying of Dusts, Vapors, and Gases
Mark W. Drake, Self-employed, KS [SE]
Rep. TC on Combustible Metals and Metal Dusts
William R. Hamilton, US Department of Labor, DC [E]

Adam Philip Herschel Henson, US Chemical Safety Board, DC [U]
Timothy J. Myers, Exponent, Inc., MA [SE]
Rep. TC on Agricultural Dusts
Jason P. Reason, Airdusco, Inc., IN [M]
Rep. TC on Wood and Cellulosic Materials Processing
Liliana Silvera, Occupational Safety & Health Administration (OSHA), MD [E]

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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.

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Kevin Baumhover, Todd & Sargent Inc., IA [SE]
Matthew J. Bujewski, Aon- Commercial Risk Consultants, MO [I]
Michael F. Dacey, Marsh Risk Consulting, NC [I]
Ashok Ghose Dastidar, Fauske & Associates, IL [SE]
David Depuydt, Brown & Brown/Hays Companies, MN [I]
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Matthew S. Gibbons, Archer Daniels Midland Company, IL [U]
 Rep. National Oilseed Processors Association
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Bruce James, Ag Growth International (AGI), Canada [M]
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Kevin Kimbell, Ardent Mills, LLC, OK [U]
James E. Maness, JEM Safety Consulting, DE [U]
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Jess P. McCluer, National Grain and Feed Association, VA [U]
Bruce McLelland, Fike Corporation, MO [M]
William Mosier, Syngenta, NC [U]

Jack E. Osborn, Airdusco, Inc., TN [M]
Philip J. Parsons, Baker Engineering & Risk Consultants, Inc., TX [SE]
Michelle Peatross, Jensen Hughes, MD [SE]
Eric Norman Peterson, VAA Engineering, Planning, and Design Services, LLC, MN [SE]
Jeffrey R. Roberts, AXA XL/Global Asset Protection Services, LLC, MS [I]
Andrew Ryerson, FM, RI [I]
 Rep. FM
Nicholas P. Schlentz, Boss Products LLC, TX [M]
Robert D. Shafto, Zurich Insurance, MI [I]
Jeremy Slaunwhite, Rembe Inc., Canada [M]
Matthew G. Spencer, US Poultry and Egg Association, GA [U]
Jeffery W. Sutton, TUV SUD America Inc./Global Risk Consultants Corporation, MN [SE]
Kristoffer Tannerfeldt, Firefly AB, Sweden [M]
Ryan Z. VanVeen, Walinga, Canada [M]
Dana L. Watts, General Mills, GA [U]
Colin Peter Winnie, Ingredion, IN [U]
Alan Zola, American Crystal Sugar Company, MN [U]
 Rep. US Beet Sugar Association

Alternates

Darren Adams, Fred D. Pfening Company, OH [M]
 (Alt. to William F. Kearns)
Will Baeder, Ardent Mills, CO [U]
 (Alt. to Kevin Kimbell)
Payton Ball, Rembe Inc., SC [M]
 (Alt. to Jeremy Slaunwhite)
Ken Eckard Botes, Marsh Risk Consulting, GA [I]
 (Alt. to Michael F. Dacey)
Manuel Chavez, Kellanova, CA [U]
 (Alt. to Nancy J. Marks)
Eric Douglas Colvin, Consolidated Grain & Barge Company, MN [U]
 (Alt. to Matthew S. Gibbons)
Alan Cummings, Ingredion, IL [U]
 (Alt. to Colin Peter Winnie)
Peter Diakow, BakerRisk, TX [SE]
 (Alt. to Philip J. Parsons)
Jason Eardley, Archer Daniels Midland Company, IL [U]
 (Alt. to Jess P. McCluer)

Per E. Forsberg, Firefly AB, Sweden [M]
 (Alt. to Kristoffer Tannerfeldt)
Chris Frendahl, Conversion Technology Inc., GA [SE]
 (Alt. to Adam Haroz)
Andrew Janeczek, Jensen Hughes, GA [SE]
 (Alt. to Michelle Peatross)
James Karnesky, Exponent, Inc., CA [SE]
 (Alt. to Timothy J. Myers)
John A. LeBlanc, FM, MA [I]
 (Alt. to Andrew Ryerson)
Bob Petrochko, Dustcon Solutions, FL [SE]
 (Alt. to Timothy Michael Heneks)
Ronald A. Stein, Aon Global Risk Consultants, MO [I]
 (Alt. to Matthew J. Bujewski)
Julia C. Wigger, Cargill, Inc., IA [U]
 (Alt. to Craig Froehling)

Nonvoting

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

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Philip Basile, Clayton Associates, NJ [M]
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Brad D. Burrige, Novelis, Inc., KY [U]
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Ashok Ghose Dastidar, Fauske & Associates, IL [U]
Jeffrey J. Davis, Fike Corporation, GA [M]
Scott G. Davis, GexCon US, MD [SE]
Burke Desautels, IEP Technologies/Hoerbiger, MA [M]
Scott E. Dillon, Engineering Systems, Inc. (ESI), MN [SE]
Keenan Thomas Dotson, Los Alamos National Laboratories (LANL), NM [U]
Peter F. Downing, Environment & Safety Solutions, Inc., NJ [SE]
Warren Greenfield, WG Associates LLC, NJ [SE]
Timothy Michael Heneks, Dustcon Solutions, Inc., FL [SE]
Eli Horden, The Boeing Company, WA [U]
Daniel J. Hubert, Amerex/Janus Fire Systems, IN [M]

Dehong Kong, Princeton Safety Solutions, Inc., MD [SE]
Jason Krbec, CV Technology, Inc., FL [M]
Kevin Kreitman, Albany Fire Department, OR [E]
Michelle R. Murphy, Mica, LLC, NH [SE]
Timothy J. Myers, Exponent, Inc., MA [SE]
Jack E. Osborn, Airdusco, Inc., TN [M]
Brion Russell Pearson, Idaho National Laboratory, ID [RT]
Daniel B. Prather, Dualdraw, CO [M]
Jerry Ruch, Honeywell International, LA [U]
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Rep. FM
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Patrick A. Thornton, Oak Ridge National Laboratory, TN [U]

Alternates

Jason L. Angell, Liberty Mutual, KY [I]
(Voting Alt.)
Andreas Brandl, IEP Technologies, MA [M]
(Alt. to Burke Desautels)
Scott D. Cowan, Albany Fire Department, OR [E]
(Alt. to Kevin Kreitman)
Jason Hudson, Novelis, Inc., GA [U]
(Alt. to Brad D. Burrige)
Laura Jacobsen, The Boeing Company, CA [U]
(Alt. to Eli Horden)
David R. Johnson, North American Hoganas, PA [M]
(Alt. to Doug Thomas)
Jared Murray, Westinghouse, UT [U]
(Alt. to Ashok Ghose Dastidar)

Jason P. Reason, Airdusco, Inc., IN [M]
(Alt. to Jack E. Osborn)
Nicholas S. Reding, Exponent, Inc., TX [SE]
(Alt. to Timothy J. Myers)
Scott R. Rockwell, Consolidated Nuclear Security, LLC. (CNS), TN [SE]
(Alt. to Tom Christman)
Scott Ryan, Allegheny Technologies Inc. (ATI), NC [M]
(Alt. to Ryan Condon)
Lon L. Scholl, Fike/Suppression Systems Inc., PA [M]
(Alt. to Jeffrey J. Davis)

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

Albert Muller, Lebanon, NJ [O]
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Laura E. Moreno, NFPA Staff Liaison

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Technical Committee on Fundamentals of Combustible Dusts

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Novelis, Inc., KY [U]

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David Kirk Arens, PHM Brands, NE [U]
Todd E. Baker, Horizon Systems, Inc., KS [M]
Elizabeth C. Buc, Fire & Materials Research Laboratory, LLC, MI [RT]
John M. Cholin, J. M. Cholin Consultants, Inc., NJ [SE]
Randal R. Davis, IEP Technologies/HOERBIGER, MA [M]
Peter F. Downing, Environment & Safety Solutions, Inc., NJ [SE]
Mark W. Drake, Self-employed, KS [SE]
Vahid Ebadat, Stonehouse Process Safety, Inc., NJ [SE]
Walter L. Frank, Frank Risk Solutions, Inc., PA [SE]
Warren Greenfield, WG Associates LLC, NJ [SE]
Dale C. Hansen, Harrington Group, Inc., GA [SE]
Shawn M. Hanson, Greater Naples Fire Rescue District, FL [E]
Dehong Kong, Princeton Safety Solutions, Inc., MD [SE]
Jason Krbec, CV Technology, Inc., FL [M]
Richard F. Masta, Georgia-Pacific LLC, GA [U]
Arthur P. Mattos, Jr., TUV SUD America Inc./Global Risk Consultants, NC [SE]
Michael A. Maxwell, Sly Incorporated, OH [M]
Eric P. Maynard, Jenike Johanson Inc., NH [SE]
Jess P. McCluer, National Grain and Feed Association, VA [U]
Bruce McLelland, Fike Corporation, MO [M]
Farai Oliver Mvere, Nordson Corporation, OH [M]

Timothy J. Myers, Exponent, Inc., MA [SE]
Caroline Nosbisch, American International Group, Inc. (AIG), MD [I]
Jack E. Osborn, Airdusco, Inc., TN [M]
Niels H. Pedersen, Nederman LLC, NC [M]
Geoffrey A. Raifsnider, Global Finishing Solutions, WI [M]
Ali S. Rangwala, Worcester Polytechnic Institute, MA [SE]
Jeffrey R. Roberts, AXA XL/Global Asset Protection Services, LLC, MS [I]
Jerry Ruch, Honeywell International, LA [U]
Andrew Ryerson, FM, RI [I]
Rep. FM
Steve Sallman, United Steelworkers, PA [L]
Thomas C. Scherpa, DuPont, NH [U]
Nicholas P. Schlentz, Boss Products LLC, TX [M]
Jeremy Searfoss, City of Reading Department of Fire & Rescue Services, PA [E]
Samantha Shriver, Dow Chemical, MI [U]
Rep. American Chemistry Council
Jeremy Slaunwhite, Rembe Inc., Canada [M]
Jef Snoeys, INBUREX Consulting, FL [SE]
Robert D. Taylor, PRB Coal Users Group, IN [U]
TJ Tuetken, Ardent Mills, LLC, NE [U]
Christopher Unangst, Jensen Hughes, GA [SE]

Alternates

Payton Ball, Rembe Inc., SC [M]
(Alt. to Jeremy Slaunwhite)
David E. Bell, Novelis, Inc., KY [U]
(Alt. to Brad D. BurrIDGE)
Nick Deery, Global Finishing Solutions, WI [M]
(Alt. to Geoffrey A. Raifsnider)
Angela M. Fuqua, Harrington Group, Inc., TX [SE]
(Alt. to Dale C. Hansen)
David Grandaw, HOERBIGER Safety Solutions/IEP Technologies, IL [M]
(Alt. to Randal R. Davis)
Marc T. Hodapp, Fire & Risk Alliance, LLC, MD [SE]
(Alt. to John M. Cholin)
Brian Arthur Jackson, 3M Canada Company, Canada [M]
(Alt. to Denise Albrecht)
Robert Jackson, Fike Corporation, MO [M]
(Alt. to Bruce McLelland)
Edward L. Jones, Nordson Corporation, OH [M]
(Alt. to Farai Oliver Mvere)
John A. LeBlanc, FM, MA [I]
(Alt. to Andrew Ryerson)

Jeronimo Lopez, Luminant (Vistra Corporation), TX [U]
(Alt. to Robert D. Taylor)
Philip J. Parsons, Baker Engineering & Risk Consultants, Inc., TX [U]
(Voting Alt.)
Jason P. Reason, Airdusco, Inc., IN [M]
(Alt. to Jack E. Osborn)
Nicholas S. Reding, Exponent, Inc., TX [SE]
(Alt. to Timothy J. Myers)
Samuel A. Rodgers, Retired, VA [SE]
(Alt. to Walter L. Frank)
Jeffrey D. Sprouse, Bunge North America, MO [U]
(Voting Alt.)
Jeffery W. Sutton, TUV SUD America Inc./Global Risk Consultants Corporation, MN [SE]
(Alt. to Arthur P. Mattos, Jr.)
Jessie Michael Warren, Jensen Hughes, TX [SE]
(Alt. to Christopher Unangst)
Robert Williamson, Nederman, NC [M]
(Alt. to Niels H. Pedersen)

Nonvoting

William R. Hamilton, US Department of Labor, DC [E]
Laura E. Moreno, NFPA Staff Liaison

Adam Philip Herschel Henson, US Chemical Safety Board, DC [U]

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Committee Scope: This Committee shall have primary responsibility for information and documents on the management of fire and explosion hazards from combustible dusts and particulate solids.

Technical Committee on Handling and Conveying of Dusts, Vapors, and Gases

Ashok Ghose Dastidar, *Chair*
Fauske & Associates, IL [SE]

John M. Cholin, J. M. Cholin Consultants, Inc., NJ [SE]
Daniel W. Deaver, Georgia Gulf Sulfur Corporation, GA [U]
Burke Desautels, IEP Technologies/Hoerbiger, MA [M]
Tony DiLucido, Zurich Risk Engineering Services, PA [I]
Dennis W. Eaves, Beecher Carlson, GA [I]
Vahid Ebadat, Stonehouse Process Safety, Inc., NJ [SE]
Walter L. Frank, Frank Risk Solutions, Inc., PA [SE]
Stephen T. Greeson, HSB Professional Loss Control, TX [I]
Adam Haroz, Conversion Technology Inc., GA [SE]
Robert T. Hash, Airsystem Sales, Inc., TN [M]
Fatima Gamal Ibrahim, Jensen Hughes, CA [SE]
Eric Jandrain, Georgia-Pacific LLC, WI [U]
Jason Krbec, CV Technology, Inc., FL [M]
Eric P. Maynard, Jenike Johanson Inc., NH [SE]
Bruce McLelland, Fike Corporation, MO [M]
Jack E. Osborn, Airdusco, Inc., TN [M]
Philip J. Parsons, Baker Engineering & Risk Consultants, Inc., TX [SE]
Niels H. Pedersen, Nederman LLC, NC [M]

Geoffrey A. Raifsnider, Global Finishing Solutions, WI [M]
Ali Reza, Exponent, Inc., CA [SE]
Jeffrey R. Roberts, AXA XL/Global Asset Protection Services, LLC, MS [I]
Rep. Global Asset Protection Services, LLC
Jerry Ruch, Honeywell International, LA [U]
Mark L. Runyon, Marsh Risk Consulting, OR [I]
Andrew Ryerson, FM, RI [I]
Rep. FM
Thomas C. Scherpa, DuPont, NH [U]
Nicholas P. Schlentz, Boss Products LLC, TX [M]
Samantha Shriver, Dow Chemical, MI [U]
Rep. American Chemistry Council
Jeremy Slaunwhite, Rembe Inc., Canada [M]
Jeffery W. Sutton, TUV SUD America Inc./Global Risk Consultants Corporation, MN [SE]
Kristoffer Tannerfeldt, Firefly AB, Sweden [M]
Robert D. Taylor, PRB Coal Users Group, IN [U]
Tony L. Thomas, Flamex, Inc., NC [M]

Alternates

Alexandre Silva Cardoso, Baker Engineering & Risk Consultants, Inc., Canada [SE]
(Alt. to Philip J. Parsons)
Randal R. Davis, IEP Technologies/HOERBIGER, MA [M]
(Alt. to Burke Desautels)
Nick Deery, Global Finishing Solutions, WI [M]
(Alt. to Geoffrey A. Raifsnider)
Colin Delaney, DuPont, DE [M]
(Alt. to Thomas C. Scherpa)
John A. Donner, TUV SUD America Inc./Global Risk Consultants Corporation, VA [SE]
(Alt. to Jeffery W. Sutton)
Per E. Forsberg, Firefly AB, Sweden [M]
(Alt. to Kristoffer Tannerfeldt)
Chris Frendahl, Conversion Technology Inc., GA [SE]
(Alt. to Adam Haroz)

Robert Jackson, Fike Corporation, MO [M]
(Alt. to Bruce McLelland)
Jerry J. Jennett, Georgia Gulf Sulfur Corporation, GA [U]
(Alt. to Daniel W. Deaver)
John A. LeBlanc, FM, MA [I]
(Alt. to Andrew Ryerson)
Ed W. Pridgen, Flamex, Inc., NC [M]
(Alt. to Tony L. Thomas)
Jason P. Reason, Airdusco, Inc., IN [M]
(Alt. to Jack E. Osborn)
Samuel A. Rodgers, Retired, VA [SE]
(Alt. to Walter L. Frank)
Dan Rousseau, Nederman, LLC, NC [M]
(Alt. to Niels H. Pedersen)
Robert D. Shafto, Zurich Insurance, MI [I]
(Alt. to Tony DiLucido)

Nonvoting

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

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 fires and explosions in the design, construction, installation, operation, and maintenance of facilities and systems processing or conveying flammable or combustible dusts, gases, vapors, and mists.

Technical Committee on Wood and Cellulosic Materials Processing

Jason P. Reason, *Chair*
Airdusco, Inc., IN [M]

Robert C. Berry, AIG, NC [I]

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

Benjamin Craig, Insight Risk/D.B.A. REM Risk Consultants, TX [SE]

Stephen E. Dale, Cincinnati Insurance Company, OH [I]

Ashok Ghose Dastidar, Fauske & Associates, IL [SE]

Randal R. Davis, IEP Technologies/HOERBIGER, MA [M]

Scott E. Dillon, Engineering Systems, Inc. (ESI), MN [SE]

Dennis W. Eaves, Beecher Carlson, GA [I]

Dan A. Guaricci, ATEX Explosion Protection, L.P., FL [M]

Adam Haroz, Conversion Technology Inc., GA [SE]

Todd Hensley, Entecco Filter, NC [M]

Jason Krbec, CV Technology, Inc., FL [M]

Peter Levitt, Sternvent Division of Durex, Inc., NJ [M]

Richard F. Masta, Georgia-Pacific LLC, GA [U]

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

Ken J. Mayeaux, International Paper Company, TN [U]

Bruce McLelland, Fike Corporation, MO [M]

Jeremy Miller, Liberty Mutual, GA [I]

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

Jeffrey C. Nichols, Industrial Fire Prevention LLC, GA [M]

Matthew Paine, FM, RI [I]

Jeffrey S. Patton, II, The Hanover Insurance Group, MD [I]

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

Jeramy Slaunwhite, Rembe Inc., Canada [M]

Francois Tanguay, Louisiana Pacific Canada Ltd., Canada [U]

Allen Wagoner, FLAMEX, Inc., NC [M]

Alternates

Chris Frendahl, Conversion Technology Inc., GA [SE]
(Alt. to Adam Haroz)

Peter Karalis, IEP Technologies, MA [M]
(Alt. to Randal R. Davis)

Jack E. Osborn, Airdusco, Inc., TN [M]
(Alt. to Jason P. Reason)

Gilles David Plourde, Fike Corporation Canada, Canada [M]
(Alt. to Bruce McLelland)

Ed W. Pridgen, Flamex, Inc., NC [M]
(Alt. to Allen Wagoner)

Andrew Ryerson, FM, RI [I]
(Alt. to Matthew Paine)

Jason Schurtz, Cincinnati Insurance, OH [I]
(Alt. to Stephen E. Dale)

Keith Sullivan, Liberty Mutual Insurance, IL [I]
(Alt. to Jeremy Miller)

Till Westerbarkey, REMBE, Inc., SC [M]
(Alt. to Jeramy Slaunwhite)

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 fires and explosions in wood processing, woodworking facilities, and facilities that use other cellulosic materials as a substitute or additive for wood.

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Standard for

Combustible Dusts and Particulate Solids

2025 Edition

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

A reference in brackets [] following a section or paragraph indicates material that has been extracted from another NFPA document. 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 Z.

Chapter 1 Administration

1.1* Scope. This standard addresses the fire, flash fire, and explosion hazards of combustible dusts and particulate solids.

1.1.1 This standard also addresses agricultural and food processing facilities in accordance with the scope of Chapter 21.

1.1.2 This standard also addresses all metals and alloys that are in a form that is capable of combustion or explosion, as well as other hazards, in accordance with the scope of Chapter 22.

1.1.3 This standard also addresses the processing of sulfur and the handling of sulfur in any form, as well as other hazards entailed in processing sulfur, in accordance with the scope of Chapter 23.

1.1.4 This standard also addresses industrial, commercial, or institutional facilities that process wood or manufacture wood products using wood or other cellulosic fiber as a substitute for or an additive to wood fiber, and facilities that process wood, creating wood chips, particles, or dust, as well as other hazards

entailed in forest products facilities, in accordance with the scope of Chapter 24.

1.1.5 This standard also addresses processes and facilities handling combustible dusts and particulate solids not otherwise covered by Chapters 21, 22, 23, or 24, in accordance with the scope of Chapter 25.

1.2 Purpose. The purpose of this standard is to prescribe the minimum requirements necessary to prevent or mitigate the fire, flash fire, and explosion hazards posed by combustible dusts and particulate solids.

1.3* Application.

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

1.3.2* The user shall be permitted to use Figure 1.3.2 for guidance when using this standard.

1.3.3 This standard shall apply to all facilities and operations that manufacture, process, blend, convey, repackage, generate, or handle combustible dusts or particulate solids.

1.3.4* This standard shall apply to the storage or use of ignitable fibers/flyings, specifically with regard to fire hazards.

1.3.5 This standard shall apply to the production, processing, handling, and storage of agricultural and food products as well as other hazards in accordance with the scope in Chapter 21.

1.3.6 This standard shall apply to the production, processing, finishing, handling, recycling, storage, and use of all metals and alloys that are in a form that is capable of combustion or explosion, as well as other hazards in accordance with the scope of Chapter 22.

1.3.7 This standard shall apply to the size reduction of sulfur and the handling of sulfur in any form, as well as other hazards entailed in processing sulfur, in accordance with the scope of Chapter 23.

1.3.8 This standard shall apply to industrial, commercial, or institutional facilities that process wood or manufacture wood products using wood or other cellulosic fiber as a substitute for or an additive to wood fiber, and facilities that process wood, creating wood chips, particles, or dust, as well as other hazards entailed in forest products facilities, in accordance with the scope of Chapter 24.

1.3.9 This standard shall not apply to the following:

- (1) Storage or use of consumer quantities of such materials on the premises of residential or office occupancies
- (2) Storage or use of commercially packaged materials at retail facilities
- (3) Such materials displayed in original packaging in mercantile occupancies and intended for personal or household use or as building materials
- (4)* Warehousing of sealed containers of such materials when not associated with an operation that handles or generates combustible dust, except where covered in Chapter 22
- (5) Such materials stored or used in farm buildings or similar occupancies for on-premises agricultural purposes

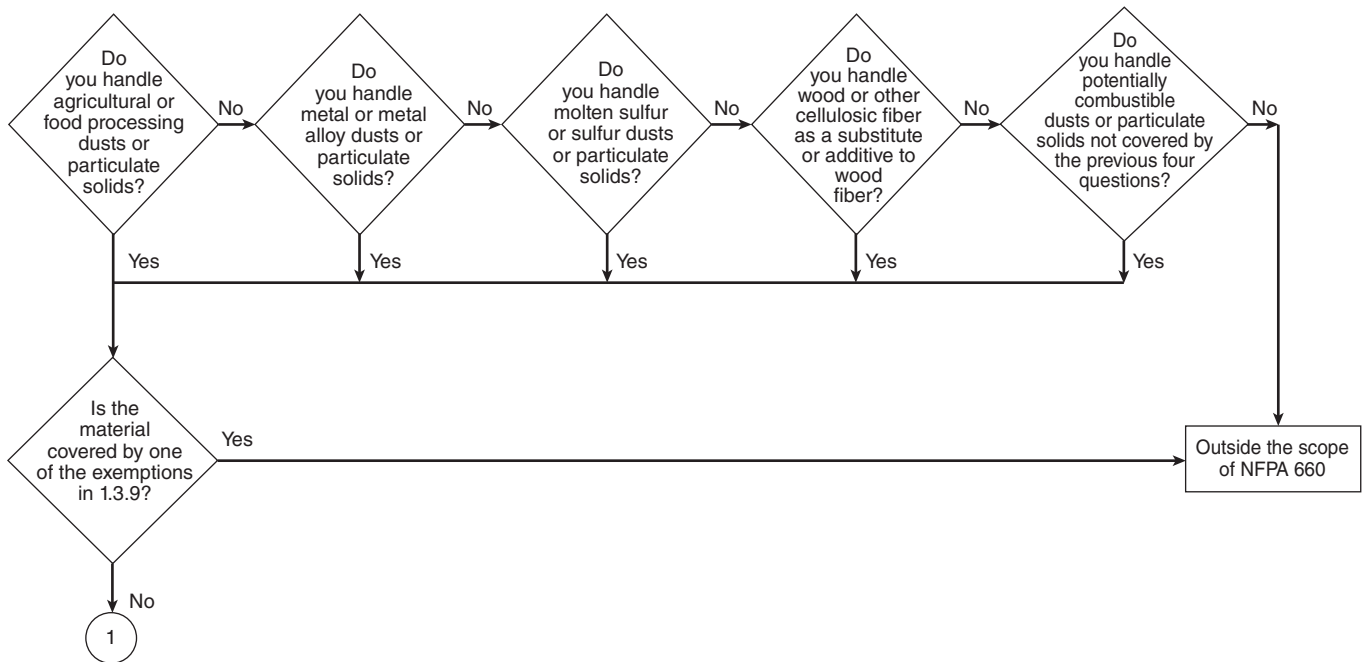


FIGURE 1.3.2 Document Flow Diagram for Combustible Dust Hazards Evaluation.

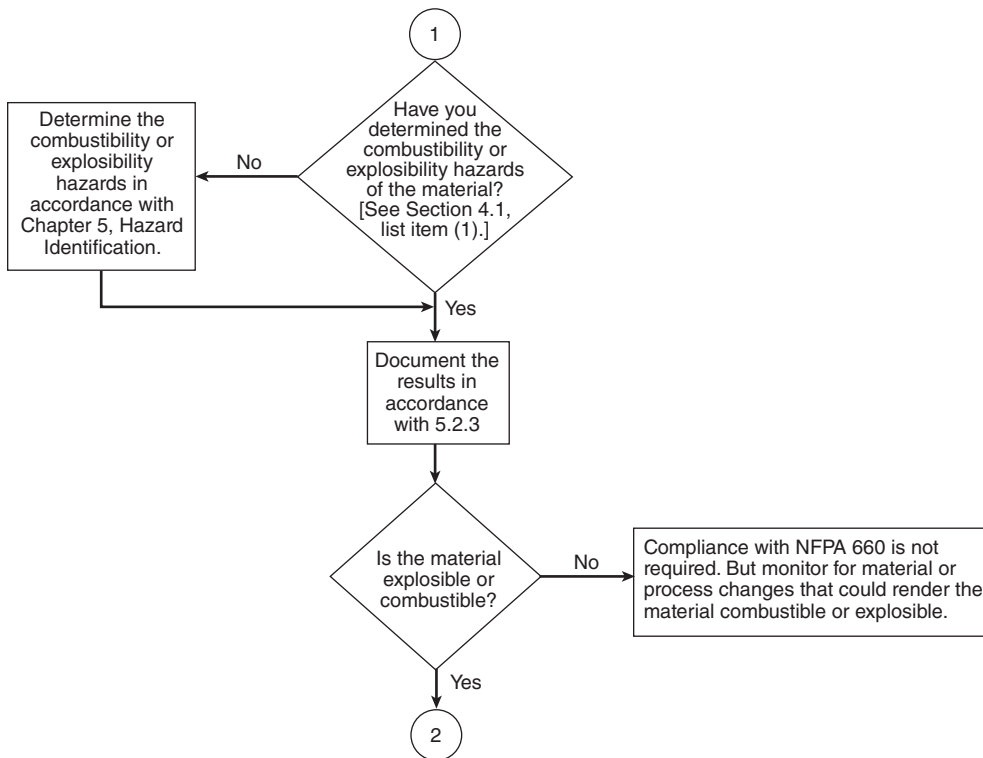


FIGURE 1.3.2 Continued

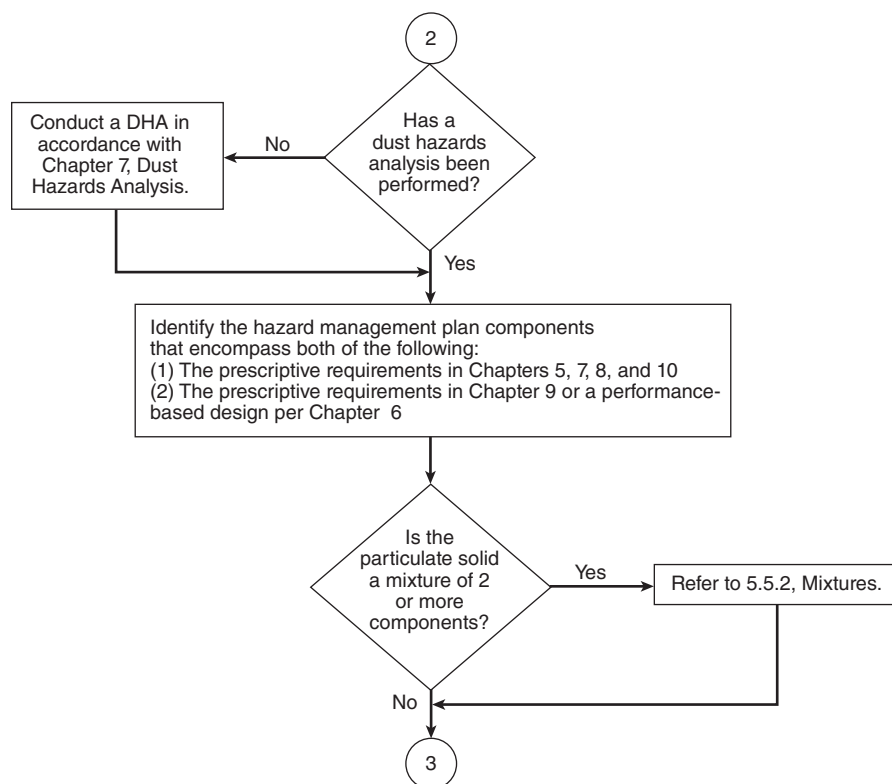


FIGURE 1.3.2 Continued

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

- (1) NFPA 30B
- (2) NFPA 33
- (3) NFPA 36
- (4) NFPA 85
- (5) NFPA 120
- (6) NFPA 400
- (7) NFPA 495
- (8) NFPA 1125

1.3.11 Where an industry- or commodity-specific chapter exists, the industry- or commodity-specific requirements of the appropriate chapter within this standard shall be applied in addition to the fundamental requirements specified in Chapters 1 through 10.

1.4* 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.

1.4.1 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.

1.4.1.1 Where specified, the provisions of this standard shall be retroactive.

1.4.2* 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 that, based on the application of clear criteria derived from the objectives in this standard, the AHJ determines to be necessary to achieve an acceptable degree of risk.

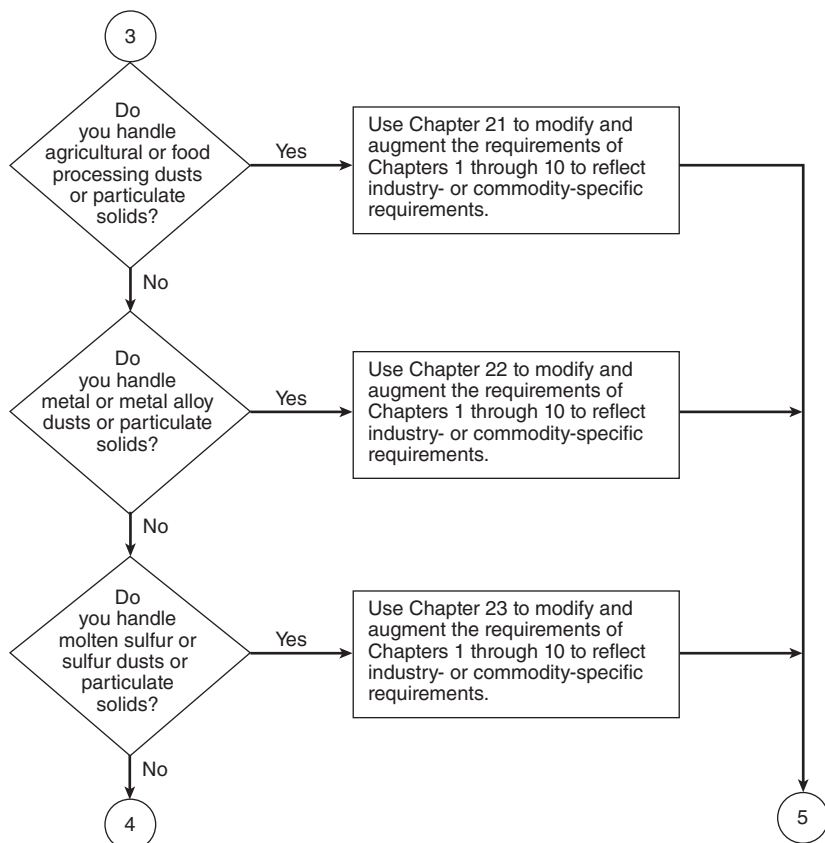
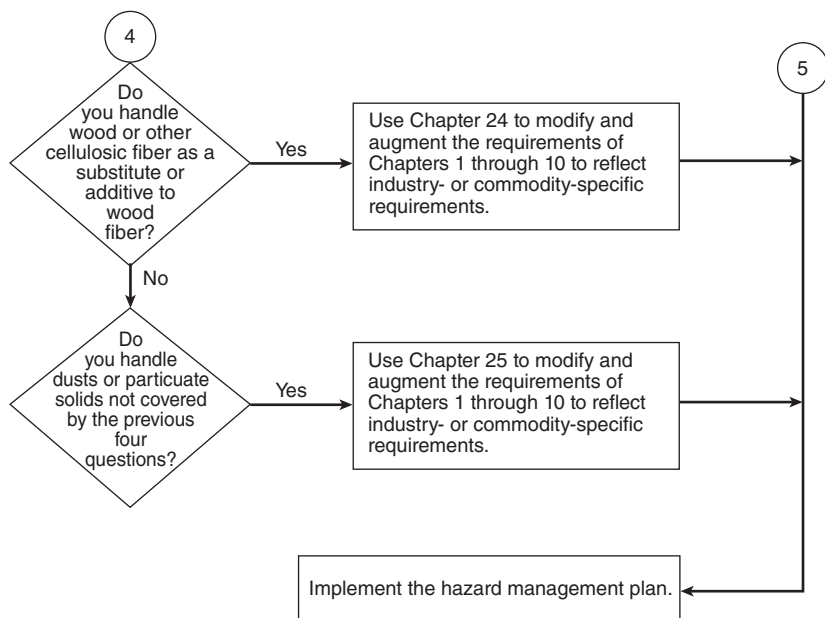
1.4.3 When modifying or adding to an existing facility, equipment, or process, the provisions of this standard shall apply to the affected portion of the facility, equipment, or process.

1.4.4 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 the modification does not result in an unacceptable degree of risk.

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

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

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

FIGURE 1.3.2 *Continued*FIGURE 1.3.2 *Continued*

1.6 Conflicts.

1.6.1 For the purposes of this standard, the industry- or commodity-specific NFPA chapters shall include the following:

- (1) Chapter 21, Agricultural and Food Processing
- (2) Chapter 22, Combustible Metals
- (3) Chapter 23, Sulfur
- (4) Chapter 24, Wood Processing and Woodworking Facilities
- (5) Chapter 25, Combustible Dusts and Particulate Solids Not Otherwise Specified

1.6.2* Where a requirement in an industry- or commodity-specific chapter differs from the requirement specified as a fundamental requirement in Chapters 1 through 10, the requirement in the industry- or commodity-specific chapter shall be permitted to be used.

1.6.3 Where an industry- or commodity-specific chapter specifically prohibits a fundamental requirement specified in Chapters 1 through 10, the prohibition in the industry- or commodity-specific chapter shall be applied.

1.6.4 Where an industry- or commodity-specific chapter neither prohibits nor provides a requirement or says *Reserved*, the fundamental requirements in Chapters 1 through 10 shall be applied.

1.6.5 An industry- or commodity-specific chapter shall be permitted to establish requirements on subjects not specified in Chapters 1 through 10.

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).

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.

1.7.3 Conversion Procedure. SI units shall be converted by multiplying the quantity by the conversion factor and then rounding the result to the appropriate number of significant digits.

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 1, *Fire Code*, 2024 edition.
- NFPA 2, *Hydrogen Technologies Code*, 2023 edition.
- NFPA 10, *Standard for Portable Fire Extinguishers*, 2022 edition.
- NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*, 2024 edition.
- NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, 2025 edition.
- NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems*, 2025 edition.
- NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2025 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 2024 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 2022 edition.

NFPA 17, *Standard for Dry Chemical Extinguishing Systems*, 2024 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, 2025 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection*, 2023 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, 2025 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 2023 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 2024 edition.

NFPA 30B, *Code for the Manufacture and Storage of Aerosol Products*, 2023 edition.

NFPA 31, *Standard for the Installation of Oil-Burning Equipment*, 2024 edition.

NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials*, 2024 edition.

NFPA 34, *Standard for Dipping, Coating, and Printing Processes Using Flammable or Combustible Liquids*, 2024 edition.

NFPA 36, *Standard for Solvent Extraction Plants*, 2025 edition.

NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*, 2024 edition.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, 2024 edition.

NFPA 54, *National Fuel Gas Code*, 2024 edition.

NFPA 58, *Liquefied Petroleum Gas Code*, 2024 edition.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, 2023 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 2024 edition.

NFPA 70®, *National Electrical Code®*, 2023 edition.

NFPA 72®, *National Fire Alarm and Signaling Code®*, 2025 edition.

NFPA 77, *Recommended Practice on Static Electricity*, 2024 edition.

NFPA 80, *Standard for Fire Doors and Other Opening Protectives*, 2025 edition.

NFPA 82, *Standard on Incinerators and Waste and Linen Handling Systems and Equipment*, 2024 edition.

NFPA 85, *Boiler and Combustion Systems Hazards Code*, 2023 edition.

NFPA 86, *Standard for Ovens and Furnaces*, 2023 edition.

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

NFPA 101®, *Life Safety Code®*, 2024 edition.

NFPA 120, *Standard for Fire Prevention and Control in Coal Mines*, 2023 edition.

NFPA 204, *Standard for Smoke and Heat Venting*, 2024 edition.

NFPA 220, *Standard on Types of Building Construction*, 2024 edition.

NFPA 221, *Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls*, 2024 edition.

NFPA 252, *Standard Methods of Fire Tests of Door Assemblies*, 2022 edition.

NFPA 400, *Hazardous Materials Code*, 2025 edition.

NFPA 495, *Explosive Materials Code*, 2023 edition.

NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*, 2024 edition.

NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operations*, 2024 edition.

NFPA 600, *Standard on Facility Fire Brigades*, 2025 edition.

NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, 2022 edition.

NFPA 750, *Standard on Water Mist Fire Protection Systems*, 2023 edition.

NFPA 1081, *Standard for Facility Fire Brigade Member Professional Qualifications*, 2024 edition.

NFPA 1125, *Code for the Manufacture of Model Rocket and High-Power Rocket Motors*, 2022 edition.

NFPA 1660, *Standard for Emergency, Continuity, and Crisis Management: Preparedness, Response, and Recovery*, 2024 edition.

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, 2025 edition.

NFPA 2112, *Standard on Flame-Resistant Clothing for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire*, 2023 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*, 2025 edition.

NFPA 5000®, *Building Construction and Safety Code*®, 2024 edition.

2.3 Other Publications.

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

AMCA Standard 99, *Standards Handbook*, 2016. (Supersedes AMCA Standard 99-0401.)

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

ANSI/ASME B31.1, *Power Piping*, 2022.

ASME B31.3, *Process Piping*, 2022.

Boiler and Pressure Vessel Code, 2023.

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 E11, *Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves*, 2022.

ASTM E136, *Standard Test Method for Assessing Combustibility of Materials Using a Vertical Tube Furnace at 750°C*, 2022.

ASTM E1226, *Standard Test Method for Explosibility of Dust Clouds*, 2019.

ASTM E1515, *Standard Test Method for Minimum Explosible Concentration of Combustible Dusts*, 2014, reapproved 2022.

ASTM E2019, *Standard Test Method for Minimum Ignition Energy of a Dust Cloud in Air*, 2003, reapproved 2019.

ASTM F1002, *Standard Performance Specification for Protective Clothing and Materials for Use by Workers Exposed to Specific Molten Substances and Related Thermal Hazards*, 2015, reapproved 2021.

ISO/ASTM 52900, *Additive Manufacturing — General Principles — Fundamentals and Vocabulary*, 2021.

2.3.4 BSI Publications. BSI British Standards, 12950 Worldgate Drive, Suite 800, Herndon, VA 20170.

BS EN 17348, *Requirements for design and testing of vacuum cleaners for use in potentially explosive atmospheres*, 2022.

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

IEC 61340-4-4, *Electrostatics — Part 4-4: Standard Test Methods for Specific Applications — Electrostatic Classification of Flexible Intermediate Bulk Containers (FIBC)*, 2018.

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

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

2.3.7 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 12.18.6.5 and Section 18.65, "2G Test."

2.3.8 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

UL 4040, *Outline of Investigation for Portable Wet-Type Dust Collectors for Collection of Combustible Metals*, 2016.

UL/CSA 60335-2-69, *Household and similar electrical appliances — Safety — Part 2-69: Particular requirements for wet and dry vacuum cleaners, including power brush for commercial use*, 2022.

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

Recommendations on the Transport of Dangerous Goods: Model Regulations — Manual of Tests and Criteria, 2019.

2.3.10 US Government Publications. US Government Publishing Office, 732 North Capitol Street, NW, Washington, DC 20401-0001.

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

2.3.11 Other Publications.

Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2020.

2.4 References for Extracts in Mandatory Sections.

NFPA 30, *Flammable and Combustible Liquids Code*, 2024 edition.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, 2023 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 2024 edition.

NFPA 70®, *National Electrical Code*®, 2023 edition.

NFPA 77, *Recommended Practice on Electricity*, 2024 edition.

NFPA 221, *Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls*, 2024 edition.

NFPA 499, *Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, 2024 edition.

NFPA 921, *Guide for Fire and Explosion Investigations*, 2024 edition.

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

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

NFPA 2112, *Standard on Flame-Resistant Clothing for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire*, 2023 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*, 2025 edition.

Chapter 3 Definitions

3.1 General.

3.1.1 The definitions contained in this chapter shall apply to the terms used in this standard.

3.1.2 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.

3.1.3 *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 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 phrases “standards development process” or “standards development activities,” the term “standards” includes all NFPA standards, including codes, standards, recommended practices, and guides.

3.3 General Definitions.

3.3.1* **Abort Gate.** A device for the quick diversion of material or air to the exterior of a building or other safe location upon detection of an ignition source in a duct. (CMD-FUN)

3.3.2* **Additive Manufacturing (AM).** The process of joining materials to make parts from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing and formative manufacturing methodologies. [ISO/ASTM 52900, 2021] (CMD-FUN)

3.3.3* **Agricultural Combustible Dust.** Any finely divided solid agricultural material that presents a flash fire hazard or explosion hazard when suspended and ignited in air. (CMD-AGR)

3.3.4 Airflow Control Valve. A device utilized to maintain design pneumatic transport velocities or face velocities at pick up point(s). (CMD-FUN)

3.3.5* **Air-Material Separator (AMS).** A device designed to separate the conveying air/gas from the material being conveyed. (CMD-FUN)

3.3.5.1* **Cyclone.** A device that uses geometry (i.e., shape) and centrifugal force to separate the conveying air/gas from the material being conveyed. (CMD-FUN)

3.3.5.2 Dry-Type Air-Material Separator (AMS). See 3.3.5.3, Dust Collector. (CMD-FUN)

3.3.5.3* **Dust Collector.** A device that uses filter media to separate the conveying air/gas from the material being conveyed. (CMD-FUN)

3.3.5.4* **Enclosureless AMS.** A device using filter media to separate the conveying air/gas from the material being conveyed but without full physical enclosure of the filter media. (CMD-FUN)

3.3.5.5* **Filter Receiver.** A dust collector designed for bulk material flow such as products conveying or a central vacuum system. (CMD-FUN)

3.3.5.6 Media Collector. See 3.3.5.3, Dust Collector. (CMD-FUN)

3.3.5.7 Point-of-Use Dust Collector. A dust collector attached to dust-producing equipment, usually with an integral AMD used to create negative pressure. (CMD-AGR)

3.3.5.8 Portable Air-Material Separator (AMS). A portable device used as a dust collector. (CMD-FUN)

3.3.5.9* **Portable Vacuum Cleaner.** A movable assembly consisting of a vacuum source (AMD), an AMS within an enclosure, and a vacuum hose, used to remove dusts and particles from surfaces. (CMD-FUN)

3.3.5.10* **Wet Scrubber (Wet-Type AMS).** A device that uses liquid to separate the conveying air/gas from the material being conveyed. (CMD-FUN)

3.3.5.11 Wet-Type Air-Material Separator. See 3.3.5.10, Wet Scrubber. (CMD-FUN)

3.3.6* 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. (CMD-FUN)

3.3.7 Aluminum Paste. See 3.3.92.1. (CMD-CMM)

3.3.8 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. (CMD-FUN)

3.3.9 Bucket Elevator. An enclosed vertical conveyor using a belt with buckets or cups attached, with a head pulley and a tail pulley. (CMD-FUN)

3.3.10* Bulk Raw Grain. Grain materials that have not undergone processing or size reduction. (CMD-AGR)

3.3.11 Castings (Metal). An object or finished shape obtained by solidification of a metallic substance in a mold. (CMD-CMM)

3.3.11.1* Heavy Casting (Metal). Castings greater than 25 lb (11.3 kg) with walls of large cross-sectional dimensions [at least 1/4 in. (6.4 mm)]. (CMD-CMM)

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

3.3.13* Chips (Metal). Particles produced from operations cutting or machining metal that are not oxidized and that are not diluted by noncombustible materials. (CMD-CMM)

3.3.14* Combustible Dust. A finely divided combustible particulate solid, including combustible fibers/flyings, that presents a flash fire hazard or explosion hazard when suspended in air or the process-specific oxidizing medium over a range of concentrations. (CMD-FUN)

3.3.15* Combustible Metal. Any metal composed of distinct particles or pieces, regardless of size, shape, or chemical composition, that will burn. (CMD-FUN)

3.3.15.1* Combustible Metal Dust. A combustible metal particulate solid, including combustible fibers/flyings, that presents a fire, flash fire, or explosion hazard when suspended in air or the process-specific oxidizing medium over a range of concentrations. (CMD-CMM)

3.3.15.2 Combustible Metal Particulate. See 3.3.15.1, Combustible Metal Dust. (CMD-CMM)

3.3.15.3* Metal Dust. Metal particulate resulting from a solid state secondary processing operation. (CMD-CMM)

3.3.16* 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. (CMD-FUN)

3.3.17 Combustion Chamber. Enclosure where the combustion takes place and the fuel energy is liberated in the form of heat. (CMD-WOO)

3.3.18 Compartment. A subdivision of an enclosure. (CMD-FUN)

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

3.3.20 Competent Ignition Source. An ignition source that has sufficient energy and is capable of transferring that energy to the fuel long enough to raise the fuel to its ignition temperature. [921, 2024] (CMD-FUN)

3.3.21* Conductive. Possessing the ability to allow the flow of an electric charge. (CMD-FUN)

3.3.21.1 Conductive Dusts. Dusts with a volume resistivity of less than 10^5 ohm-m. (CMD-FUN)

3.3.21.2 Conductive Particulate Solids. Particulate solids with a volume resistivity of less than 10^5 ohm-m. (CMD-FUN)

3.3.22 Conductor. A material or object that allows an electric charge to flow easily through it. [77, 2024] (CMD-FUN)

3.3.23* Critical Process. A process that has the potential to cause harm to personnel, equipment, structures, or product in the event of an uncontrolled failure. (CMD-CMM)

3.3.24* Damage-Limiting Construction. A building construction method that incorporates exterior wall or roof sections, or both, designed to relieve deflagration pressures without jeopardizing the structural integrity of the building and without allowing the deflagration to propagate into adjacent interior spaces. (CMD-FUN)

3.3.25* Deflagration. Propagation of a combustion zone at a velocity that is less than the speed of sound in the unreacted medium. [68, 2023] (CMD-FUN)

3.3.26* Deflagration Hazard. A place or area where there is all of the following:

- (1) A particulate capable of propagating deflagration by virtue of particle size, shape, and chemistry
- (2) A means of suspending the particulate in an oxidizing atmosphere
- (3) Sufficient particulate to exceed the minimum explosible concentration
- (4) A potential competent ignition source or mechanism. (CMD-FUN)

3.3.27 Deflagration Hazard Area.

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

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

3.3.28 Deflagration Index. Value indicated by the use of the variable K_{St} . (See 3.3.68, K_{St} .) (CMD-FUN)

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

3.3.30* Dissipative. A material or a construction that will reduce static charge to acceptable levels. [77, 2024] (CMD-FUN)

3.3.31 Dryer. A piece of processing equipment using temperature or pressure change to reduce the moisture or volatile content of the material being handled. (CMD-FUN)

3.3.32 Duct. Pipes, tubes, or other enclosures used to convey materials pneumatically or by gravity. (CMD-FUN)

3.3.33* Dust Collection System. A combination of equipment designed to capture, contain, and control airborne dust, and pneumatically convey the captured dust to an air-material separator (AMS). (CMD-FUN)

3.3.34* Dust Explosion Hazard. A dust deflagration hazard in an enclosure that is capable of bursting or rupturing the enclosure due to the development of internal pressure from the deflagration. (CMD-FUN)

3.3.35* Dust Hazards 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. (CMD-FUN)

3.3.36* Enclosure. A confined or partially confined volume. [68, 2023] (CMD-FUN)

3.3.37 Eutectic Reaction. (Reserved) (CMD-CMM)

3.3.38* Explosible. Capable of propagating a deflagration when dispersed in air or the process-specific oxidizing media. (CMD-FUN)

3.3.39 Explosion. The bursting or rupture of an enclosure or container due to the development of internal pressure from a deflagration. [69, 2024] (CMD-FUN)

3.3.40* Explosive-Actuated Device. Any tool or special mechanized device that is actuated by explosive materials or that releases and directs work through an explosive charge. (CMD-FUN)

3.3.41 Fibers/Flyings.

3.3.41.1* Combustible Fibers/Flyings. Fibers/flyings where any dimension is greater than 500 μm in nominal size, which can form an explosible mixture when suspended in air at standard atmospheric pressure and temperature. [499, 2024] (CMD-FUN)

3.3.41.2* Ignitable Fibers/Flyings. Fibers/flyings where any dimension is greater than 500 μm in nominal size, which are not likely to be in suspension in quantities to produce an explosible mixture, but could produce an ignitable layer fire hazard. [499, 2024] (CMD-FUN)

3.3.42 Fines (Metal). The portion of a powder composed of particles that are smaller than 45 μm (US Standard Sieve No. 325); also known as the subsieve size fraction. (CMD-CMM)

3.3.42.1 Superfines (Metal). Particles smaller than 10 μm . (CMD-CMM)

3.3.42.2 Ultrafines (Metal). Particles with size generally less than 0.1 μm . (CMD-CMM)

3.3.43* 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. (CMD-FUN)

3.3.44* Fire-Resistive. Meeting the requirements for Type I or Type II construction. (CMD-FUN)

3.3.45* Flame Resistance. The property of a material whereby combustion is prevented, terminated, or inhibited following the application of a flaming or nonflaming source of ignition, with or without subsequent removal of the ignition source. [2113, 2025] (CMD-FUN)

3.3.46 Flake (Metal). A flat or scale-like particulate material that is relatively thin with a large aspect ratio. (CMD-CMM)

3.3.47* Flash Fire. A deflagration that spreads by means of a flame front rapidly through a diffuse fuel, such as dust, gas, or the vapors of an ignitable liquid, without the production of damaging pressure. (CMD-FUN)

3.3.48* Flash Fire. See 3.3.47. (CMD-CMM)

3.3.49 Floor Sweep. A suction hood located on the floor with an opening to allow floor sweepings to enter the dust collection system. (CMD-WOO)

3.3.50 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. (CMD-AGR)

3.3.51 Fuel Object. A combustible object or mass of particulate that can serve as a source of fuel for a fire; sometimes referred to as a *fuel package*. (CMD-FUN)

3.3.52 Fugitive Dusts. Dust that escapes from equipment and containers. (CMD-FUN)

3.3.53* Garments. Clothing including, but not limited to, coveralls, trousers, shirts, and outerwear. [2112, 2023] (CMD-FUN)

3.3.54 Green Material. Wood particulate that has an average moisture content equal to or greater than 25 percent by weight (wet basis). (CMD-WOO)

3.3.55 Grounded (Grounding). Connected (connecting) to ground or to a conductive body that extends the ground connection. [70, 2023] (CMD-FUN)

3.3.56 Handling (Metal). Any activity, including processing, that can expose the metal's surface to air or to any other substance capable of reacting with the metal under the conditions of the exposure. (CMD-CMM)

3.3.57 Hazards Analysis. A documented assessment performed by personnel knowledgeable of the specific hazards of the material and that is acceptable to the AHJ. (CMD-FUN)

3.3.58 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. (CMD-AGR)

3.3.59* Hog (Wood Hog). A machine used to grind or reduce the size of wood, scrap wood, or other feed stock. (CMD-WOO)

3.3.60 Hot Work. Work involving burning, welding, or a similar operation that is capable of initiating fires, flash fires, or explosions. (CMD-FUN)

3.3.61* Hybrid Mixture. An explosible heterogeneous mixture, comprising gas with suspended solid or liquid particulates, in which the total flammable gas concentration is ≥ 10 percent of the lower flammable limit (LFL) and the total suspended particulate concentration is ≥ 10 percent of the minimum explosible concentration (MEC). [68, 2023] (CMD-FUN)

3.3.62* Identified (as applied to equipment). Recognizable as suitable for the specific purpose, function, use, environment, application, and so forth, where described in a particular code requirement. [70, 2023] (CMD-FUN)

3.3.63* Ignitable Liquid. Any liquid or liquid mixture that has a measurable closed-cup flash point. [30, 2024] (CMD-FUN)

3.3.64 Incipient-Stage Fire. A fire that is in the initial or beginning stage and that can be controlled or extinguished by portable extinguishers or small amounts of dry extinguishing agents, without the need for protective clothing or breathing apparatus. (CMD-FUN)

3.3.65* Ingredient Transport System. A pneumatic conveying 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. (CMD-AGR)

3.3.66 Intermediate Bulk Containers.

3.3.66.1* Flexible Intermediate Bulk Container (FIBC). Large bags typically made from nonconductive woven fabric that are used for storage and handling of bulk solids. (CMD-FUN)

3.3.66.1.1 Type A FIBC. An FIBC made from nonconductive fabric with no special design features for control of electrostatic discharge hazards. (CMD-FUN)

3.3.66.1.2 Type B FIBC. An FIBC made from nonconductive fabric where the fabric or the combination of the fabric shell, coating, and any loose liner has a breakdown voltage of less than 6000 volts. (CMD-FUN)

3.3.66.1.3 Type C FIBC. An FIBC made from conductive material or nonconductive woven fabric incorporating interconnected conductive threads of specified spacing with all conductive components connected to a grounding tab. (CMD-FUN)

3.3.66.1.4 Type D FIBC. An FIBC made from fabric and/or threads with special static properties designed to control electrostatic discharge energy without a requirement for grounding the FIBC. (CMD-FUN)

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

3.3.66.2.1 Insulating RIBC. An RIBC constructed entirely of solid plastic or solid plastic and foam composite that cannot be electrically grounded. (CMD-FUN)

3.3.67 Kiln Dryers. Large heated rooms or enclosures intended to reduce or control the moisture content of lumber and hardboard products. (CMD-WOO)

3.3.68* K_{st} . The deflagration index of a dust cloud. [68, 2023] (CMD-FUN)

3.3.69* Limiting Oxidant Concentration (LOC). The concentration of oxidant in a fuel-oxidant-diluent mixture below which a deflagration cannot occur under specified conditions. [69, 2024] (CMD-FUN)

3.3.70 Locations, Hazardous (Classified). [Hazardous (Classified) Locations] Locations where fire or explosion hazards might exist due to flammable gases, flammable liquid-produced vapors, combustible liquid-produced vapors, combustible dusts, combustible fibers/flyings, or ignitable fibers/flyings. [70, 2023] (CMD-FUN)

3.3.71 Locations, Unclassified. (Unclassified Locations) Locations determined to be neither Class I, Division 1; Class I, Division 2; Zone 0; Zone 1; Zone 2; Class II, Division 1; Class II, Division 2; Class III, Division 1; Class III, Division 2; Zone 20; Zone 21; Zone 22; nor any combination thereof. [70, 2023] (CMD-FUN)

3.3.72* Lower Flammable Limit (LFL). The lowest concentration of a combustible substance in a gaseous oxidizer that will propagate a flame, under defined test conditions. [68, 2023] (CMD-FUN)

3.3.73 Management of Change (MOC). A management system that requires the evaluation of proposed changes to process materials, staffing, job tasks, technology, equipment, procedures, and facilities to evaluate the potential safety significance of the change, to identify any additional needed safety controls, and to identify changes to other management systems required to safely implement the change. (See A.8.11.1.) (CMD-FUN)

3.3.74 Marine Tower. Stationary or movable tower used for supporting equipment to load or unload grain. (CMD-AGR)

3.3.75* Mesh Size. The dimensions of a mesh that are specified in ASTM E11, *Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves*. (CMD-FUN)

3.3.76* Metal. Pure metal or alloys having the generally recognized properties of the metal, including the fire or explosion characteristics of the metal in its various forms. (CMD-CMM)

3.3.76.1 Alkali Metals. Cesium, francium, lithium, potassium, rubidium, sodium, and alloys of these metals, such as NaK. (CMD-CMM)

3.3.76.2* Legacy Metals. The metals aluminum, magnesium, niobium, tantalum, titanium, zirconium, and hafnium. (CMD-CMM)

3.3.76.3 Metal Alloy. A multiphase solid that is formed by mixing in the molten state, in which the primary component or matrix phase is a metal and the original composition is retained during size reduction. (CMD-CMM)

3.3.76.4* Metal-Containing Mixture. A physical combination of one or more metals or metal alloys with one or more solid, liquid, or semi-solid chemical elements or compounds. (CMD-CMM)

3.3.77 Metal Vapor Condensate. Solidified particles resulting from the evaporation of metal alloys during the laser powder bed fusion additive manufacturing (AM) process. (CMD-CMM)

3.3.78* 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. (CMD-FUN)

3.3.79* 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. (CMD-FUN)

3.3.80* Mixture. A combination of particulates incorporating more than one material. (CMD-FUN)

3.3.81* Moisture Content (Wet Basis). The maximum percentage of water that can be driven off a sample through drying as a percentage of the original sample weight. (CMD-WOO)

3.3.82* Nanometal Powder. Any metal powder produced with a characteristic size smaller than 500 nanometers (0.5 μm), which can include powders where only a fraction of the material produced is less than 500 nanometers (0.5 μm). (See also 22.14.2.2.) (CMD-CMM)

3.3.83 Nanopowder. See 3.3.125, Ultrafine Particle. (CMD-FUN)

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

3.3.85* Nonconductive. A material or a construction that has the ability to accumulate charge, even when in contact with ground. (CMD-FUN)

3.3.86 Ohm-meter (Ohm-m). The term used to define electrical volume resistivity of a material. (CMD-FUN)

3.3.87 Ohms per Square. The term used to define electrical surface resistivity of a material. (CMD-FUN)

3.3.88 Operational Readiness Review. A management system to verify that all required conditions exist and required safety tasks have been completed so that new, modified, or formerly idled facilities can be safely started up. (CMD-FUN)

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

3.3.90 Owner/Operator. The organization with fiscal responsibility for the operation, maintenance, and profitability of the facility. (CMD-FUN)

3.3.91 Passivation. A controlled process by which a barrier coating is placed on the surface of the metal to inhibit reaction. (CMD-CMM)

3.3.91.1 Oxygen Passivation. A controlled process that exposes the metal powder to oxygen with the goal of forming an oxide of the metal on the particle surface. (CMD-CMM)

3.3.92 Paste. A mixture consisting of a liquid and suspended particles or flakes. (CMD-CMM)

3.3.92.1 Aluminum Paste. Aluminum flake pigment homogeneously incorporated in a solid or liquid carrier in such a way so as to have a nonflowing product without a free-flowing liquid. (CMD-CMM)

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

3.3.93.1 Negative-Pressure Pneumatic Conveying System. A pneumatic conveying system that transports material by utilizing gas at less than atmospheric pressure. (CMD-FUN)

3.3.93.2 Positive-Pressure Pneumatic Conveying System. A pneumatic conveying system that transports material by utilizing gas at greater than atmospheric pressure. (CMD-FUN)

3.3.94* Powder (Metal). Particles of matter intentionally manufactured to a specific size and shape. (CMD-CMM)

3.3.94.1* Aluminum Flake Powder. See 3.3.94.3, Aluminum Powder. (CMD-CMM)

3.3.94.2 Aluminum Granular Powder. See 3.3.94.3, Aluminum Powder. (CMD-CMM)

3.3.94.3* Aluminum Powder. Aluminum powder is divided into three broad classifications: atomized, flake, and granules. (CMD-CMM)

3.3.94.4* Combustible Metal Powder. A combustible particulate metal, regardless of particle size or shape, that is an intentional product and will burn as determined by testing conducted in accordance with Chapter 5 and Section 22.5. (CMD-CMM)

3.3.94.5 Tantalum Powder. Nodular or flake-like tantalum particles that will pass through a 20 mesh screen (850 μm) as discrete particles or as agglomerates of discrete particles. (CMD-CMM)

3.3.94.5.1 Unrefined Tantalum Powder. Any tantalum powder that contains impurities, such that further refinement is required to produce a tantalum product suitable for commercial use. (CMD-CMM)

3.3.95* Powder Production Plant. Facilities or buildings in which the primary product is powder. (CMD-CMM)

3.3.96* Propellant-Actuated Device. Any tool or special mechanized device or gas generator system that is actuated by a smokeless propellant or combustion of a confined fuel-air mixture, or that releases and directs work through a smokeless propellant charge. (CMD-FUN)

3.3.97* Pyrophoric Material. See 3.3.98. (CMD-CMM)

3.3.98 Pyrophoric Material. A material that ignites upon exposure to air at or below 130°F (54.4°C). (CMD-FUN)

3.3.99 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] (CMD-FUN)

3.3.100* Recycling. Processing, reprocessing, resizing, sorting, sifting, or staging of scrap materials formerly in the process stream or in use, that no longer serve their original and/or intended purpose, but continue to have resale value. (CMD-FUN)

3.3.101 Replacement-in-Kind. A replacement that satisfies the design specifications of the replaced item. (CMD-FUN)

3.3.102 Ribbon. A manufactured product or a continuous chip resulting from secondary processing (e.g., boring, grinding, milling, turning), of a ductile material. (CMD-CMM)

3.3.102.1* Magnesium Ribbon. Magnesium metal that is less than 1/8 in. (3.2 mm) in two dimensions or less than 1/20 in. (1.3 mm) in single dimension, also considered a powder for the purpose of this standard. (CMD-CMM)

3.3.103* Risk Assessment. An assessment of the likelihood, vulnerability, and magnitude of the incidents that could result from exposure to hazards. [1250, 2020] (CMD-FUN)

3.3.104 Screening Test. For the purposes of this standard, a test performed to determine whether a material or mixture exhibits fire-, explosion-, or water-reactivity-related characteristics. (CMD-FUN)

3.3.105 Segregation. A hazard management strategy in which a physical barrier is established between the hazard area and an area to be protected. (CMD-FUN)

3.3.106 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. (CMD-FUN)

3.3.107 Size Reduction Equipment(Sulfur). Any machinery that reduces the size of particles by compression, impact, attrition, or similar processes. (CMD-HAP)

3.3.107.1* Attrition-Style Size Reduction Equipment. Pulverizers that do not depend on moving parts for their disintegrating action, such as attrition mills. (CMD-HAP)

3.3.107.2 Compression-Style Size Reduction Equipment. Low-speed primary crushers, such as jaw and roll crushers. (CMD-HAP)

3.3.107.3 Impact-Style Size Reduction Equipment. High-speed primary crushers, such as disk and hammer mills, pulverizers, and fine size reduction equipment of all kinds, except attrition. (CMD-HAP)

3.3.108* Spark. A localized source of thermal or electrical energy capable of igniting combustible material. (CMD-FUN)

3.3.108.1* Capacitive Spark. A short-duration electric discharge due to a sudden breakdown of air or some other insulating material separating two conductors at different electric potentials, accompanied by a momentary flash of light; also known as electric spark, spark discharge, and sparkover. (CMD-FUN)

3.3.108.2* Thermal Spark. A moving particle of solid material that emits radiant energy sufficient to act as an ignition

source due to either its temperature or the process of combustion on its surface. (CMD-FUN)

3.3.109* Spark-Resistant Material. A material that is not prone to generate impact sparks under conditions of use. (CMD-FUN)

3.3.110* Sponge. A porous metal product obtained by processing metal ore prior to being melted. (CMD-CMM)

3.3.111 Spontaneous Heating. Process whereby a material increases in temperature without drawing heat from its surroundings. [921, 2024] (CMD-FUN)

3.3.112 Static Dissipative. See 3.3.30, Dissipative. (CMD-FUN)

3.3.113 Stuck Lumber. Lumber storage piles with 1 in. (2.5 cm) runners perpendicular to the storage at every level. (CMD-WOO)

3.3.114* Sulfur Dust. Finely divided sulfur that presents a fire or deflagration hazard when suspended in air or other oxidizing medium over a range of concentrations regardless of particle size or shape. (CMD-HAP)

3.3.115 Swarf. Particles produced from a cutting, machining, or grinding operation that causes partial oxidation of the parent material or dilution by other inert materials. (CMD-CMM)

3.3.116 Tantalum Powder. See 3.3.94.5. (CMD-CMM)

3.3.117 Tantalum Ultrafines. (Reserved) (CMD-CMM)

3.3.118 Thermal Oil Heating System. A thermal oil heating system is a closed loop circulating system that heats an ignitable (flammable or combustible) fluid and transports it to utilization equipment for the purpose of transferring its heat to the equipment. (CMD-WOO)

3.3.118.1 Nonvaporizing Thermal Oil Heating System. A thermal oil heating system that is designed to operate with the heated oil below its atmospheric boiling point. (CMD-WOO)

3.3.118.2 Vaporizing Thermal Oil Heating System. A thermal oil heating system that is designed to heat the oil above its atmospheric boiling point as it passes through the heater. (CMD-WOO)

3.3.119 Thermal Oil Used as Heat Transfer Fluid. An organic or synthetic fluid that is ignitable (flammable or combustible) and that is used as a medium to transfer heat energy from a heater or vaporizer to a remote heat consumer. (CMD-WOO)

3.3.120* Thermite Reaction. The exothermic reaction between a metal and any metal oxide lower in the electromotive series. (CMD-CMM)

3.3.121 Threshold Housekeeping Dust Accumulation Limit. The maximum quantity of dust permitted to be present before cleanup is required. (CMD-FUN)

3.3.122 Titanium Fines. (Reserved) (CMD-CMM)

3.3.123 Transient Releases. A short duration, episodic release of material from the process equipment that poses a fire, flash fire, or explosion hazard. (CMD-FUN)

3.3.124 Ullage Space. The open space above the surface of the stored solids in a storage vessel. (CMD-FUN)

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

3.3.126 Vent Closure. A pressure-relieving cover that is placed over a vent. [68, 2023] (CMD-FUN)

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

3.3.128 Wall.

3.3.128.1 Fire Barrier Wall. A wall, other than a fire wall, having a fire resistance rating. [221, 2024] (CMD-FUN)

3.3.128.2 Fire Wall. A wall separating buildings or subdividing a building to prevent the spread of fire and having a fire resistance rating and structural stability. [221, 2024] (CMD-FUN)

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

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

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

3.3.132 Wood. The cellulosic material derived from trees, and other cellulosic materials including, but not limited to, wheat straw, flax, bagasse, coconut shells, corn stalks, hemp, rice hulls, and paper or other cellulosic fiber used as a substitute or additive to wood. (CMD-WOO)

3.3.133 Wood Dust. (CMD-WOO)

3.3.133.1* Deflagrable Wood Dust. Wood particulate that will propagate a deflagration flame front, when suspended in air, or the process-specific oxidizing medium, in sufficient concentration, thus presenting a deflagration hazard. (CMD-WOO)

3.3.133.2 Dry Nondeflagrable Wood Dust. Wood particulate having a moisture content of less than 25 percent (wet basis) and a particle size that will not propagate deflagration. (CMD-WOO)

3.3.133.3 Wood-Derived Materials. These materials include but are not limited to sawdust, sanderdust, planer shavings, hoggings, wood flour, and moulder waste. (CMD-WOO)

3.3.134 Zirconium Fines. (Reserved) (CMD-CMM)

Chapter 4 General Requirements

4.1* General. The owner/operator of a facility with potentially combustible dust shall be responsible for the following activities:

- (1) Determining the combustibility and explosibility hazards of materials in accordance with Chapter 5
- (2) Identifying and assessing fire, flash fire, and explosion hazards in accordance with Chapter 7
- (3) Managing the identified fire, flash fire, and explosion hazards in accordance with the objectives in Section 4.2
- (4) Communicating the hazards to affected personnel in accordance with Section 8.8

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

4.2.1 Life Safety.

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

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

4.2.1.3 The facility, processes, and equipment shall be designed, constructed, equipped, and maintained and management systems shall be implemented to reasonably prevent injury from explosions.

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

4.2.2* Mission Continuity. The facility, processes, and equipment shall be designed, constructed, equipped, and maintained and management systems shall be implemented to limit damage to levels that ensure the ongoing mission, production,

or operating capability of the facility to a degree acceptable to the owner/operator.

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

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

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

4.2.4 Compliance Options. The objectives in Section 4.2 shall be deemed to have been met by implementing both of the following:

- (1) The prescriptive requirements in Chapters 5, 7, and 8
- (2)* A hazard management program in conformance with the prescriptive requirements of Chapter 9 and the prescriptive hazard management requirements of the relevant industry- or commodity-specific chapter, or that meets the objectives of Chapter 4 and the relevant industry- or commodity-specific chapter through a performance-based design in accordance with Chapter 6

4.2.5 Where a dust or particulate solid fire, flash fire, or explosion hazard exists within a process system, the hazards shall be managed in accordance with this standard.

4.2.6 Where a dust or particulate solid fire, flash fire, or explosion hazard exists within a building or building compartment, the effects of the fire, flash fire, or explosion shall be managed in accordance with this standard.

4.2.7 Where an industry- or commodity-specific chapter addresses hazards not associated with combustible dusts or particulate solids, those hazards shall be managed in accordance with this standard.

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.

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.

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 4.2.4.

5.2 Screening for Combustibility or Explosibility.

5.2.1* Where the owner or operator does not have prior knowledge of combustibility or explosibility, the analysis of representative samples in accordance with the requirements of 5.4.1 and 5.4.3 shall be conducted to determine if the material is in a combustible or explosible form.

5.2.2* The determination of combustibility or explosibility shall be permitted to be based upon historical facility data or published data that are deemed to be representative of current materials and process conditions.

5.2.3* Test results, historical data, and published data shall be documented and, when requested, provided to the authority having jurisdiction (AHJ).

5.2.4* The absence of previous incidents shall not be used as the basis for deeming a particulate to not be combustible or explosible.

5.2.5 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.

5.3* Self-Heating and Reactivity Hazards. Where self-heating, thermal instability, water reactivity, or chemical reactivity hazards exist, the process, storage, and transport conditions shall be controlled to prevent a fire, explosion, or toxic exposure.

5.3.1 Self-Heating Hazard Evaluations.

5.3.1.1 A documented self-heating hazard evaluation shall be performed where one or more of the following conditions is present:

- (1) Bulk storage or transport of combustible particulate solids in quantities of 1000 kg (2203 lb) or larger
- (2) More than 10 kg (22 lb) of material is present in dryer discharge bins and hoppers at elevated temperatures
- (3) A potential self-heating scenario has been identified in the DHA

5.3.1.2 The self-heating hazard evaluation method shall be according to 5.3.1.2.1 or according to 5.3.1.2.2 and 5.3.1.2.3.

5.3.1.2.1 A documented review shall be conducted of experience storing and transporting the bulk material in quantities comparable to or larger than those used in the facility, at temperatures comparable to or higher than the expected storage or transport temperatures, and for durations comparable to or longer than the expected storage or transport duration.

5.3.1.2.2* Laboratory tests shall be conducted to determine self-heating potential and rate.

5.3.1.2.3* A theoretically based scaling analysis shall be conducted using the laboratory test data to determine the critical temperatures for self-heating at the scale being used at the facility.

5.3.2 Thermal Instability Hazard Evaluations.

5.3.2.1 A thermal instability hazard evaluation shall be conducted when one or more of the following conditions exist:

- (1) More than 1000 kg (2200 lb) of combustible particulate are stored for longer than 8 hours in a bin or hopper or bulk pile at a temperature higher than 30°C (104°F).
- (2) More than 100 kg (220 lb) of particulate product are in an oven or dryer for more than 1 hour.
- (3) A scenario where heated material can reside for extended periods of time in process equipment has been identified in the DHA.

5.3.2.2 The thermal instability hazard evaluation method shall be according to either 5.3.2.2.1 or 5.3.2.2.2.

5.3.2.2.1 A documented review of pertinent reactivity literature, safety data sheets, and operating experience shall be conducted, identifying the reactivity of the material, thermal decomposition onset temperature, and, where possible, the reaction byproducts including gases that could be toxic, corrosive, or flammable.

5.3.2.2.2* Temperature sensitivity testing shall be conducted at temperatures that would correspond to the highest possible temperature the material could attain based on exposure conditions determined from the DHA.

5.3.3 Water Reactivity Hazard Evaluations.

5.3.3.1 A water reactivity hazard evaluation shall be conducted when one or both of the following conditions exist:

- (1) A water-based fire suppression system is used for the combustible particulate material.
- (2) Particulate product or dust is exposed to process water, condensed water vapor, or outdoor precipitation.

5.3.3.2 The water reactivity hazard evaluation method shall be according to either 5.3.3.2.1 or 5.3.3.2.2.

5.3.3.2.1* A documented review of pertinent reactivity literature, reactivity screening software, and operating experience shall be conducted, identifying the reactivity of the material and, where possible, the reaction byproducts including gases that could be toxic, corrosive, or flammable.

5.3.3.2.2 Water reactivity testing shall be conducted using the *UN Recommendations on the Transport of Dangerous Goods, Model Regulations — Manual of Tests and Criteria* water reactivity Test N.5 for potential Division 4.3 water-reactive materials that emit flammable gases, or another test acceptable to the AHJ.

5.3.4 Chemical Reactivity Hazard Evaluations.

5.3.4.1 A chemical reactivity hazard evaluation shall be conducted when particulate product or dust could be exposed to an incompatible material or a reactivity scenario has been otherwise identified in the DHA.

5.3.4.2 The chemical reactivity hazard evaluation method shall be according to either 5.3.4.2.1 or 5.3.4.2.2.

5.3.4.2.1 A documented review of pertinent reactivity literature, reactivity screening software, and operating experience

shall be conducted, identifying the reactivity of the material and, where possible, the reaction byproducts including gases that could be toxic, corrosive, or flammable. (See A.5.3.3.2.1.)

5.3.4.2.2* Calorimetry testing shall be used for determining potential chemical reactivity hazards.

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.

5.4.1 Determination of Combustibility (Fire Hazard Potential).

5.4.1.1 Where the combustibility is not known, determination of fire hazards of a layer of material shall be determined by one of the following tests:

- (1)* A 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,” Section 33.2.4.3.1.
- (2)* Other fire/combustibility test methods that provide an equivalent result for a powder layer acceptable to the authority having jurisdiction.

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.

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.

5.4.2* Determination of Flash Fire Potential. (Reserved)

5.4.3 Determination of Explosibility.

5.4.3.1 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

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

5.4.3.3* When determining explosibility, it shall be permitted to test the as-received sample.

5.4.3.4 It shall be permitted to assume a material is explosible, forgoing the requirements of 5.4.3.1.

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.

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.

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.

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. (See A.5.4.3.3.)

5.4.4.4* Where the material does not remain homogeneously mixed, 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 to provide data as needed to comply with the requirements of this chapter.

5.5.1.2 Representative samples of dusts shall be identified and collected for testing according to the sampling plan.

5.5.1.3 The sampling plan shall 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

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.

5.5.2.1 Mixtures with a metallic particulate component and not excluded by the criteria of 22.1.1.6.2 shall be treated as a metallic combustible dust in accordance with the relevant sections of Chapter 22.

5.5.2.2 Mixtures consisting of more than 50 percent by mass wood or wood-based particulate with a metallic particulate component and excluded by the criteria of 22.1.1.6.2 shall be treated as a wood dust in accordance with the relevant sections of Chapter 24.

5.5.2.3 Mixtures consisting of more than 50 percent by mass agricultural particulate to be used in foodstuffs with a metallic particulate component and excluded by the criteria of 22.1.1.6.2 shall be treated as an agricultural dust in accordance with the relevant sections of Chapter 21.

5.5.2.4 Any mixture that does not fall under 5.5.2.1 through 5.5.2.3 shall be treated as a chemical dust in accordance with Chapter 25.

5.5.2.5 Where the mixture contains both combustible and noncombustible materials, the combustible components shall be used as the basis for the mixture classification.

5.5.2.6* Where components with different chemical compositions do not remain homogeneously mixed, the properties of the individual constituents shall be considered separately.

5.5.3* Representative Samples.

5.5.3.1 Samples collected from each location shall be representative of material used in the process or equipment or found on surfaces at that location.

5.5.4 Sample Collection. Dust samples shall be collected in a safe manner without introducing an ignition source, dispersing dust, or creating or increasing the risk of injury to workers.

5.5.4.1* Samples shall be uniquely identified.

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.

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 and the prescriptive requirements of the relevant industry- or commodity-specific chapter. [See A.4.2.4(2).]

6.1.3 Approved Qualifications. The performance-based design shall be prepared by a qualified person knowledgeable about the affected systems and their associated hazards.

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.

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 6.1.4.1 through 6.1.4.13.

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.

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.

6.1.4.3 Performance Criteria. Performance criteria, with sources, shall be documented.

6.1.4.4 Occupant Characteristics. Assumptions about occupant characteristics shall be documented.

6.1.4.5 Design Fire, Flash Fire, and Explosion Scenarios. Descriptions of combustible dust or particulate solid fire, flash fire, and explosion design scenarios shall be documented.

6.1.4.6 Input Data. Input data to models and assessment methods shall be documented.

6.1.4.7 Output Data. Output data from models and assessment methods shall be documented.

6.1.4.8 Safety Factors. The safety factors utilized shall be documented.

6.1.4.9 Prescriptive Requirements. Retained prescriptive requirements shall be documented.

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.

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.

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.

6.1.4.12 Performance Evaluation. The performance evaluation summary shall be documented.

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 reapproval in cases of remodeling, modification, renovation, change in use, or change in established assumptions

6.1.5* Re-evaluation. Performance-based designs and documentation shall be updated and subject to reapproval if any of the assumptions on which the original design was based are changed.

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, flash fire, or explosion scenario, an assumption, or a building design specification.

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

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 8.11.

6.1.7.1* This maintenance shall include complying with originally documented design assumptions and specifications.

6.1.7.2* Any variation from the design shall be acceptable to the AHJ.

6.2 Risk Component and Acceptability.

6.2.1 The specified performance criteria of Section 6.3 and the specified fire, flash fire, and explosion scenarios of Section 6.4 shall be permitted to be modified by a documented risk assessment.

6.2.2 The AHJ shall be provided with sufficient documentation to support the validity and relevance of the risk assessment methodology when requested by the AHJ.

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.

6.3.1* Life Safety. The life safety objectives of 4.2.1 with respect to a fire, flash fire, or explosion hazard shall be achieved if either of the following conditions is met:

- (1) Ignition has been prevented.
- (2) Under all fire, flash fire, or explosion scenarios, no person, other than those in the immediate proximity of the ignition, is exposed to untenable conditions due to the fire, flash fire, or explosion; and for fire or explosion scenarios, 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.

6.3.2* Structural Integrity. The structural integrity objectives embodied in 4.2.1 and 4.2.2 with respect to fire, flash 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, flash fire, and explosion scenarios.

6.3.3 Mission Continuity. The mission continuity objectives of 4.2.2 shall be achieved when damage to equipment and the facility has been limited to a level of damage acceptable to the owner/operator.

6.3.4 Mitigation of Fire Spread, Explosions, or Releases of Hazardous Materials. When limitation of fire, flash fire, and explosion 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, flash fire, or explosion from propagating from one process system to an adjacent process system or to the building interior.

6.3.5 Effects of Explosions. Where the mitigation 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

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.

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.

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.

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.

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.

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.

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.

6.4.2 Flash Fire and Explosion Scenarios.

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

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

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 a flash fire and explosion scenario.

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 a flash fire and explosion scenario.

6.4.2.5* Where combustible dust can cause other flash fire or explosion hazards, those hazards shall be included as flash fire or explosion scenarios.

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, flash fire, and explosion scenario established for the design, with the assessment conducted through the use of appropriate calculation methods acceptable to the AHJ.

6.5.2 The design professional shall establish numerical performance criteria for each of the documented performance objectives established for the design.

6.5.3 For each scenario, 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 sensitivity analysis, given the assumptions.

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

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

Chapter 7 Dust Hazards Analysis (DHA)

7.1* General Requirements.

7.1.1 Retroactivity.

7.1.1.1 The requirements of this chapter and the corresponding X.7 sections of the industry- and commodity-specific chapters shall be applied retroactively.

7.1.1.2* A DHA shall be completed for all new and existing processes and facility compartments.

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.

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

7.1.4 The DHA shall be reviewed and updated at least every 5 years.

7.2 Criteria.

7.2.1* Overview. The DHA shall evaluate the fire, flash fire, and explosion hazards and provide recommendations to manage the hazards in accordance with Section 4.2.

7.2.2* Qualifications. The DHA shall be performed or led by a qualified person who possesses documented experience and education regarding methods for performing a DHA and the assessment and identification of mitigation or elimination options for the fire, flash fire, explosion, and related hazards of the specific type or types of combustible dusts involved in the facility.

7.2.3* Documentation.

7.2.3.1 The results of the DHA review shall be documented, including any necessary action items requiring change to the process materials, process operations, equipment, safety systems, or facilities associated with the process.

7.2.3.2 The results of the DHA shall be maintained for the life of the process.

7.3 Methodology.

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, flash fire, and explosion scenarios shall include the following:
 - (a) Identification of safe operating ranges
 - (b)* Identification of the safeguards that are in place to manage fire, flash fire, and explosion events
 - (c) Recommendation of additional safeguards where warranted, including a plan for implementation

7.3.2 Material Evaluation.

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. (*See A.5.1.*)

7.3.3 Process Systems.

7.3.3.1* Each part of the process system where combustible dust is present or where combustible particulate solids could cause combustible dust to be present shall be evaluated, and the evaluation shall address the following:

- (1) Potential intended and unintended combustible dust transport between parts of the process system
- (2) Potential fugitive combustible dust emissions into a building or building compartments
- (3) Potential flame and pressure propagation between parts of the process system or interconnected systems
- (4) Potential flame and pressure propagation from the process system to the surrounding building or building compartment

7.3.3.2 Each part of the process that could potentially contain all of the following conditions shall be considered a fire hazard and shall be documented as such:

- (1) Combustible particulate solids
- (2) Air or other oxidizing atmosphere
- (3) A competent ignition source

7.3.3.3* Each part of the process that could potentially contain all of the following conditions shall be considered a dust flash fire or explosion hazard and shall be documented as such:

- (1) A combustible particulate solid of sufficiently small particle size and sufficient quantity
- (2) Air or other oxidizing atmosphere
- (3) A competent ignition source
- (4) A credible suspension mechanism

7.3.3.4 Where multiple parts of a process system present essentially the same hazard, a single evaluation shall be permitted to be conducted as representative of all similar parts of the process system.

7.3.4 Building or Building Compartments.

7.3.4.1 Each building or building compartment where combustible dust is present shall be evaluated.

7.3.4.1.1 Where multiple buildings or building compartments present essentially the same hazard, a single evaluation shall be permitted to be conducted as representative of all similar buildings or building compartments.

7.3.4.1.2 The evaluation shall address potential combustible dust migration between buildings or building compartments.

7.3.4.1.3 The evaluation shall address potential flame and pressure propagation between buildings or building compartments.

7.3.4.2* Each building or building compartment that could potentially contain all of the following conditions shall be considered a fire hazard and shall be documented as such:

- (1) Combustible particulate solids
- (2) Air or other oxidizing atmosphere
- (3) A competent ignition source

7.3.4.2.1* The evaluation of the dust flash fire or explosion hazard in a building or building compartment shall include a comparison of actual or intended dust accumulation to the threshold housekeeping dust accumulation limit that would

present a potential for flash fire exposure to personnel or compartment failure due to explosive overpressure.

7.3.4.2.2 The threshold housekeeping dust accumulation limit and nonroutine dust accumulation levels (e.g., from a process upset) shall be in accordance with relevant industry- or commodity-specific requirements identified in Chapters 21 through 24.

7.3.4.3 Each building or building compartment that could potentially contain all of the following conditions shall be

considered a dust flash fire or explosion hazard and shall be documented as such:

- (1) A combustible particulate solid of sufficiently small particle size
- (2) Air or other oxidizing atmosphere
- (3) A competent ignition source
- (4) A credible suspension mechanism

Chapter 8 Management Systems

8.1* Retroactivity. This chapter and the corresponding X.8 sections of the industry- and commodity-specific chapters shall be applied retroactively to new and existing facilities and processes where the DHA has determined that a combustible dust or particulate solid fire, flash fire, or explosion hazard exists.

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

8.3* Operating Procedures and Practices.

8.3.1* The owner/operator shall establish written procedures for operating its facility and equipment to prevent or mitigate fires, flash fires, and explosions from combustible dusts or combustible particulate solids.

8.3.2* Operating and maintenance procedures shall address personal protective equipment (PPE), including flame-resistant garments, in accordance with the workplace hazard assessment required by Section 8.6.

8.3.3 Portable Appliances.

8.3.3.1* A written policy shall be established to regulate the use of portable appliances.

8.3.3.2* The policy shall identify locations where specific portable appliances are permitted or prohibited.

8.3.4* The owner/operator shall establish safe work practices to address hazards associated with maintenance and servicing operations.

8.3.4.1 The safe work practices shall apply to employees and contractors.

8.3.5* A periodic walk-through of operating areas shall be conducted, on a schedule established by the owner/operator, to verify that operating procedures and safe work practices are being followed.

8.3.6 The owner/operator shall perform a documented review of operating procedures as often as necessary, but at least annually, to ensure that they remain current and accurate.

8.4 Housekeeping.

8.4.1 General. Housekeeping shall be performed in accordance with Section 8.4 as modified by the corresponding sections in the industry- or commodity-specific chapters.

8.4.2 Methodology.

8.4.2.1 Procedure.

8.4.2.1.1* Documented housekeeping and inspection programs shall be developed, implemented, and updated as required.

8.4.2.1.2* The methods used for cleaning surfaces shall be selected on the basis of reducing the potential for creating a combustible dust cloud.

8.4.2.1.2.1 Vacuuming shall be the preferred method of cleaning.

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

8.4.2.1.3 Cleaning methods to be used shall be based on the characteristics of the material and quantity of material present.

8.4.2.2 Vacuum Cleaning Method.

8.4.2.2.1* Portable Vacuum Cleaners.

8.4.2.2.1.1 Portable vacuum cleaners with a dirty side volume greater than 8 ft³ (0.2 m³) shall comply with 9.8.2 and 9.8.3.

8.4.2.2.1.2* Regardless of industry, when metal particles, dusts, or powders are being cleaned, Chapter 22 shall be the reference source for proper use and limitations of both dry and wet portable vacuum cleaners.

8.4.2.2.1.3* Where used, portable vacuum cleaning devices shall be incorporated into the DHA.

8.4.2.2.1.4 Hoses and vacuum tools shall be appropriate for use and be static dissipative or conductive.

8.4.2.2.1.5 All conductive and static-dissipative components, including wands and attachments, shall be bonded and grounded.

8.4.2.2.1.6 Portable vacuum cleaners shall not be used on processes generating hot embers or sparks.

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

8.4.2.2.1.8* Portable vacuum cleaners that meet the following minimum requirements shall be permitted to be used to collect combustible particulate solids in unclassified locations:

- (1) Materials of construction shall comply with 9.6.6.1.
- (2) Hoses shall be conductive or static dissipative.
- (3) All conductive and static dissipative components, including wands and attachments, shall be bonded and grounded.
- (4) The fan or blower shall be on the clean side of the primary filtration media or wet separation chamber.
- (5) The vacuum cleaner shall not be operated without filter media in place.
- (6) Electrical motors shall not be located on the dirty side of the primary filtration media or wet separation chamber unless listed for Class II or Class III, Division 1, as appropriate, or Zone 20 or Zone 21 locations.
- (7)* Where liquids or wet materials are picked up by the vacuum cleaner, paper filter elements shall not be used.

8.4.2.2.1.9 Portable air-operated vacuum cleaners that meet the following minimum requirements shall be permitted to be used to collect combustible particulate solids in unclassified and electrically hazardous (classified) areas, provided the following are met:

- (1) Materials of construction comply with 9.6.6.1.
- (2) Hoses are conductive or static dissipative.
- (3) All conductive and static dissipative components, including wands and attachments, are bonded and grounded.
- (4) Where liquids or wet materials are picked up by the vacuum cleaner, paper filter elements are not used.
- (5)* The design of the vacuum cleaner is suitable for use in a hazardous (classified) location.

8.4.2.2.1.10* In combustible dust hazardous (classified) locations, vacuum cleaners shall be listed for combustible dust hazardous (classified) locations.

8.4.2.2.1.11 Where flammable vapors or gases are present in combustible dust hazardous (classified) locations, electrically powered vacuum cleaners shall be listed for both flammable vapors or gases and combustible dust hazardous (classified) locations.

8.4.2.2.2 Centralized Vacuum Cleaning Systems. A centralized vacuum cleaning system remotely installed beyond the hazardous (classified) location in conformance with Section 9.4 shall be permitted to be used for vacuuming in combustible dust hazardous (classified) locations and where flammable vapors or gases are present in combustible dust hazardous (classified) locations.

8.4.2.3* Sweeping, Shoveling, Scoop, and Brush Cleaning Method. The use of scoops, brooms, and brushes for sweeping and shoveling shall be subject to the requirements of the industry- or commodity-specific chapters.

8.4.2.4* Water Washdown Cleaning Method.

8.4.2.4.1 The use of water washdown shall be a permitted cleaning method subject to the requirements of the industry- or commodity-specific chapters.

8.4.2.4.2* Where the combustible dust being removed is a water-reactive material, additional precautions shall be taken to control the associated hazards.

8.4.2.5 Water Foam Washdown Systems. (Reserved)

8.4.2.6 Compressed Air Blowdown Method.

8.4.2.6.1* Blowdowns using compressed air shall be permitted to be used as a cleaning method in accordance with the provisions of 8.4.2.6.2.

8.4.2.6.2* Where blowdown using compressed air is used, the following precautions shall be followed:

- (1) Prior to using compressed air, vacuum cleaning, brushing, sweeping, or water washdown methods are used to clean surfaces that can be safely accessed.
- (2) Dust accumulations in the area after vacuum cleaning, brushing, sweeping, or water washdown do not exceed the threshold housekeeping dust accumulation limit.
- (3)* Compressed air hoses are equipped with pressure relief nozzles limiting the discharge pressure to 30 psi (207 kPa).
- (4)* All electrical equipment, including lighting, potentially exposed to airborne dust in the area during cleaning is rated appropriately for dust in accordance with *NFPA 70*.
- (5) All ignition sources and hot surfaces capable of igniting a dust cloud or dust layer are shut down or removed from the area.
- (6) After blowdown is complete, residual dust on lower surfaces is cleaned prior to re-introduction of potential ignition sources.
- (7) Where metal or metal-containing dust or powder is not excluded by the criteria of 22.1.1.6.2, the requirements of Chapter 22 apply.
- (8) All fire protection equipment is in service.

8.4.2.7 Steam Blow Down Method. (Reserved)

8.4.3 Training. Employee and contractor training shall include housekeeping procedures, required personal protective equipment (PPE) during housekeeping, and proper use of housekeeping equipment.

8.4.4 Equipment. (Reserved)

8.4.5 Vacuum Trucks. This section shall apply where the DHA has determined a fire, flash fire, or explosion hazard exists.

8.4.5.1* Vacuum trucks shall be grounded and bonded.

8.4.5.2 Vacuum truck hoses and couplings shall be static dissipative or conductive and bonded and grounded.

8.4.5.3 Vacuum trucks shall be empty and clean prior to arrival on site.

8.4.6 Frequency and Goal.

8.4.6.1* Housekeeping frequency and accumulation goals shall be established to ensure that the accumulated fugitive dust levels on surfaces do not exceed the threshold housekeeping dust accumulation limit.

8.4.6.2 The threshold housekeeping dust accumulation limit shall be in accordance with the industry- or commodity-specific chapters in this standard. (*See 1.3.2.*)

8.4.6.3* Provisions for unscheduled housekeeping shall include specific requirements establishing time to clean local dust spills or transient releases.

8.4.7 Auditing and Documentation.

8.4.7.1* Housekeeping effectiveness shall be assessed based on the results of routine scheduled cleaning and inspection, not including transient releases.

8.4.7.2 Where the facility is intended to be operated with less than the dust accumulation in conformance with 8.4.6.1, a planned inspection process shall be implemented to evaluate dust accumulation rates and the housekeeping frequency required to maintain dust accumulations below the threshold dust mass/accumulation.

8.4.7.3 Corrective actions for identified issues from the housekeeping program shall be tracked to ensure completion.

8.4.7.4 The owner/operator shall retain documentation that routine scheduled cleaning occurs in accordance with the frequency and accumulation goals established in 8.4.6.1.

8.5 Hot Work.

8.5.1* In addition to the requirements of NFPA 51B, all hot work activities shall comply with the requirements in 8.5.2 through 8.5.6.

8.5.2* The area affected by hot work shall be thoroughly cleaned of combustible dust prior to commencing any hot work.

8.5.3 The area affected by the work shall be free from visible airborne combustible dust.

8.5.4 Equipment that contains combustible dust and is located within the hot work area shall be shut down, shielded, or both.

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

8.5.6 Floor and wall openings within the hot work area shall be covered or sealed.

8.5.7 Use of Portable Equipment. Use of portable electrical equipment that does not comply with the electrical classifica-

tion of the area where it is to be used shall be authorized and controlled in accordance with the hot work procedure as outlined in Section 8.5.

8.5.8* Propellant-Actuated Devices and Explosive-Actuated Devices.

8.5.8.1 Propellant-actuated devices and explosive-actuated devices shall not be used in areas where combustible dust or dust clouds are present.

8.5.8.2 When the use of propellant-actuated devices or explosive-actuated devices becomes necessary, the area shall be prepared in accordance with 8.5.1 through 8.5.6.

8.5.8.3 A check shall be made after the work is completed to ensure that no cartridges or charges are left in the premises where they could enter equipment or be accidentally discharged after operation of the dust-producing or dust-handling machinery is resumed.

8.6 Personal Protective Equipment (PPE).

8.6.1* PPE Applicability.

8.6.1.1 Flame-resistant garments designed in accordance with NFPA 2112 shall be permitted to be used as part of the personnel protection strategy against localized flash fire exposures, only.

8.6.1.2* Flame-resistant garments shall not be permitted to be the sole safeguard against a propagating deflagration through suspended dust accumulations throughout a building compartment.

8.6.2 Workplace Hazard Assessment.

8.6.2.1* An assessment of workplace hazards shall be conducted as described in NFPA 2113.

8.6.2.2 When the assessment in 8.6.2.1 has determined that flame-resistant garments are needed, personnel shall be provided with and wear flame-resistant garments.

8.6.2.3* When flame-resistant clothing is required for protecting personnel from flash fires, it shall comply with the requirements of NFPA 2112.

8.6.2.4 In addition to flame-resistant garments complying with NFPA 2112, the organization shall consider factors in selecting flame-resistant garments including, but not limited to, the following:

- (1)* Thermal protective characteristics of the fabric and materials over a range of thermal exposures (e.g., to evaluate the effect of delayed egress)
 - (2)* Physical characteristics of the fabric and materials
 - (3)* Garment construction and components (e.g., pockets, types of closures)
 - (4)* Avoidance of static charge buildup
 - (5)* Design type of the garment
 - (6)* Type of conditions under which the garments will be worn
 - (7)* Comfort properties of the fabric, materials, and garment
 - (8)* Cleaning and maintenance considerations
- [2113:4.3.1]

8.6.2.5 Flame-resistant garments shall be selected, procured, inspected, worn, and maintained in accordance with NFPA 2113.

8.6.2.6* The employer shall implement a policy regarding care, cleaning, and maintenance for flame-resistant garments.

8.6.3 Limitations of PPE Application (Flame-Resistant Garments).

8.6.3.1* When flame-resistant garments are required by 8.6.2.1, flame-resistant or nonmelting undergarments shall be used in accordance with NFPA 2113.

8.6.3.2* When determined by 8.6.2.1 that flame-resistant garments are needed, only flame-resistant outerwear shall be worn over flame-resistant garments.

8.6.4 Limitations of PPE to Combustible Dust Flash Fires. (Reserved)

8.6.5 Face, Hands, and Footwear Protection. (Reserved)

8.7 Inspection, Testing, and Maintenance.

8.7.1* Equipment affecting the prevention, control, and mitigation of combustible dust fires, flash fires, and explosions shall be inspected, tested, and maintained in accordance with one of the following:

- (1) The applicable NFPA standard and the manufacturers' recommendations
- (2) Where there is no applicable NFPA standard, the 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 in accordance with the applicable NFPA standards
- (2) Dust control equipment
- (3) Housekeeping equipment
- (4)* Potential ignition sources
- (5) Electrical, process, and mechanical equipment
- (6)* Instrumentation, including process interlocks
- (7) Lubrication of bearings
- (8)* Tramp metal detection and removal devices

8.7.3 The owner/operator shall establish 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, flash fires, and explosions.

8.7.4* Where equipment deficiencies that affect the prevention, control, and mitigation of dust fires, flash fires, 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* Inspection, testing, and maintenance activities that affect the prevention, control, and mitigation of dust fires, flash fires, and explosions shall be documented.

8.7.6 A periodic walk-through review of operating areas shall be conducted, on a schedule established by the owner/operator per the requirement in 8.7.3, to verify that the equipment is in safe operating condition.

8.7.7 A qualified person shall conduct inspection and testing, then document the findings and recommendations.

8.8 Training and Hazard Awareness.

8.8.1* 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.

8.8.2* General safety training and hazard awareness training for combustible dusts and solids shall be provided to all affected employees, to include the following elements:

- (1) The hazards present in the working environment
- (2) Emergency response plans, including evacuation routes
- (3) Site safety rules

8.8.2.1* Job-specific training shall ensure that employees are knowledgeable about fire, flash fire, and explosion hazards of combustible dusts and particulate solids in their work environment, including the following elements as applicable:

- (1) Hazards specific to the work area and equipment, including hazards associated with fire and explosion suppression equipment
- (2) Equipment operation procedures, including safe start-up/shutdown, response to upset conditions, and emergency shutdown
- (3) Inspection, testing, and maintenance procedures
- (4) The necessity for proper functioning of related fire and explosion protection systems
- (5) Procedures in response to emergencies, including emergency notification and permissible methods for fighting incipient fires in the work area
- (6) The location and operation of fire protection equipment, manual pull stations and alarms, emergency phones, first-aid supplies, and safety equipment
- (7) Safe handling, use, storage, and disposal of hazardous materials
- (8) Housekeeping requirements including proper cleaning methods
- (9) Personal protective equipment requirements and proper use
- (10) Reporting of incidents

8.8.2.2 Employees shall be trained before taking on job-related responsibilities.

8.8.2.3* Where explosion protection systems or emergency shutdown systems are installed, training of affected personnel shall include the operations and potential hazards presented by such systems.

8.8.3 Refresher training shall be provided at least every three years after initial training or as required by the applicable industry- or commodity-specific chapters of this standard, whichever is shorter.

8.8.4 The training shall be documented.

8.9 Contractors.

8.9.1 Owner/operators shall ensure the requirements of Section 8.9 are met.

8.9.2 Only qualified 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, flash fires, and explosions.

8.9.3* Contractor Training.

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

8.9.3.2* The training provided to contractors shall be equivalent to the training that would be provided to employees who could operate the same equipment.

8.9.3.3* Contractors working on or near a given process shall be made aware of the potential hazards from and exposures to fires, flash fires, and explosions.

8.9.3.4 Contractors shall be trained and required to comply with the facility's safe work practices and policies in accordance with 8.3.4.

8.9.3.5 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.

8.9.3.6 Contractors shall receive refresher training annually.

8.9.3.7 Contractor training shall be documented.

8.10* Incident Investigation.

8.10.1 The owner/operator shall have a system to ensure that incidents that result in a fire, flash fire, or explosion are reported and investigated.

8.10.2* Events that could have resulted in fires, flash fires, or explosions under different circumstances but where property losses or injuries were not experienced shall be investigated.

8.10.3 Once the scene has been released to the owner/operator, incident investigations shall be promptly initiated by management personnel or by a designee who has a working knowledge of the facility and processes.

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

8.10.5 A system shall be established to address and resolve the findings and recommendations.

8.10.6* The investigation findings and recommendations shall be reviewed with affected personnel.

8.11* Management of Change.

8.11.1* Written procedures shall be established and implemented to manage proposed changes to process materials, staffing, job tasks, technology, equipment, procedures, and facilities.

8.11.2 The procedures shall ensure that the following are addressed prior to any change:

- (1)* The technical basis for the proposed change
- (2)* Safety and health implications
- (3) Whether the change is permanent or temporary, including the authorized duration of temporary changes
- (4) Modifications to operating, maintenance, and emergency response procedures
- (5) Employee training requirements
- (6) Authorization requirements for the proposed change

- (7) Results of characterization tests used to assess the hazard, if conducted
- (8) Implementation of any recommendations required for safe operation of the change before startup
- (9) Confirmation that the change has been implemented per design prior to startup

8.11.3* Implementation of the management of change procedure shall not be required for replacements-in-kind.

8.11.4* Process and technology documentation shall be updated to incorporate the change.

8.12* Operational Readiness Review (ORR).

8.12.1* The owner/operator shall perform an operational readiness review before the start-up of the following:

- (1) New facilities
- (2) Modified facilities when the modification is significant enough to require change in the process and technology information required by 8.13.1(5)
- (3) Facilities that have been shut down for minor maintenance activities
- (4) Facilities that are periodically shut down as part of normal operations
- (5)* Facilities that have been shut down for extended periods of time

8.12.2* The scope and detail of the operational readiness review shall consider the nature and duration of the shutdown and shall confirm the following prior to start-up of the facility:

- (1) For new facilities:
 - (a) Construction and equipment are in accordance with design specifications.
 - (b) A DHA has been performed in conformance with Chapter 7, and action items have been resolved or implemented before startup.
 - (c) Accurate, up-to-date safety, operating (including startup), maintenance, and emergency procedures are in place.
 - (d) Affected personnel have been trained on relevant procedures.
 - (e) Inspection and testing of safety systems and equipment have been conducted.
- (2) For modified facilities:
 - (a) A management of change review has been conducted in conformance with Section 8.11, and action items have been resolved or implemented before startup.
 - (b) Construction and equipment are in accordance with design specifications.
 - (c) Accurate, up-to-date safety, operating (including startup), maintenance, and emergency procedures are in place.
 - (d) Affected personnel have been trained on relevant procedures.
 - (e) Inspection and testing of safety systems and equipment have been conducted.
- (3) For facilities that have been shut down for minor maintenance:
 - (a) Construction and equipment are in accordance with design specifications.

- (b) A joint inspection by maintenance and operations personnel has verified that the maintenance has been correctly completed.
- (c) Accurate, up-to-date startup procedures are in place.
- (4) For facilities that have been shut down as part of normal operations:
 - (a) A walk-through inspection has verified that the facility is ready for start-up.
 - (b) Accurate, up-to-date startup procedures are in place.
- (5) For facilities that have been shut down for extended periods of time:
 - (a) A DHA has been performed or updated in conformance with Chapter 7, and action items have been resolved or implemented before startup.
 - (b) Construction and equipment are in accordance with design specifications.
 - (c) Accurate, up-to-date safety, operating (including startup), maintenance, and emergency procedures are in place.
 - (d) Affected personnel have been trained on relevant procedures.
 - (e) Inspection and testing of safety systems and equipment have been conducted.

8.12.3* The operational readiness review shall be documented and the documentation retained in conformance with 8.13.1(7).

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 hazards analyses and resolution of DHA recommendations
- (5)* Process and technology information
- (6)* Management of change documents
- (7) Operational readiness review documents for start-up associated with 8.12.2(1), 8.12.2(2), and 8.12.2(5).
- (8) Emergency response plan documents
- (9)* Contractor records

8.14 Management Systems Review.

8.14.1 The owner/operator shall be responsible for maintaining and evaluating the ongoing effectiveness of the management systems required by this standard.

8.14.2 The owner/operator shall evaluate the effectiveness of the management systems required by this standard by conducting a periodic review of each management system.

8.15* Employee Participation. Owner/operators shall establish and implement a system to consult with and actively involve affected personnel and their representatives in the implementation of this standard.

Chapter 9 Hazard Management: Mitigation and Prevention

9.1* Inherently Safer Designs. (Reserved)

9.2 Risk Assessment.

9.2.1* A documented risk assessment shall be permitted to determine the required protections in Chapter 9.

9.2.2 Upon request, the AHJ shall be provided with sufficient documentation to support the validity and relevance of the risk assessment methodology permitted in Chapter 9.

9.3 Building Design.

9.3.1* Construction. The type of construction shall be in accordance with the building code adopted by the AHJ.

9.3.2 Building or Building Compartment Protection.

9.3.2.1* Each building or building compartment where a dust or particulate solid fire, flash fire, or explosion hazard exists shall be protected from the consequence of fire, flash fire, or explosion.

9.3.2.2* If a building or building compartment contains a dust explosion hazard outside of equipment, such areas shall be provided with deflagration venting to a safe area in accordance with NFPA 68.

9.3.2.2.1 Venting to relieve pressure shall be located through an outside wall or roof.

9.3.2.2.2* The fireball, blast hazards, and missile hazards that are created by deflagration venting shall not expose personnel or property assets outside of the compartment being protected.

9.3.3 Life Safety. Building configuration and appurtenances shall comply with the life safety requirements of the building and fire prevention codes adopted by the AHJ.

9.3.3.1 Where a dust or particulate solid fire, flash fire, or explosion hazard exists in a building or building compartment outside of equipment, building configuration and appurtenances shall comply with the life safety requirements of the building and fire prevention codes for a hazardous occupancy adopted by the AHJ.

9.3.3.2* Where a dust explosion hazard exists in a building or building compartment and an enclosed means of egress is provided, the egress enclosure shall be designed to withstand potential external overpressure from the explosion.

9.3.4 Construction Features to Limit Accumulation.

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

9.3.4.2* Building spaces inaccessible to routine housekeeping shall be sealed to prevent dust accumulation.

9.3.4.3* Enclosed building spaces that are difficult to access for routine housekeeping shall be designed to facilitate routine inspection for the purpose of determining the need for periodic cleaning.

9.3.5 Separation of Hazard Areas from Other Hazard Areas and from Other Occupancies.

9.3.5.1 General. Areas where a dust or particulate solid fire, flash fire, or explosion hazard exists in a building or building

compartment (excluding hazards within equipment) shall be segregated, separated, or detached from other occupancies to minimize damage from a fire, flash fire, or explosion.

9.3.5.2 Use of Segregation.

9.3.5.2.1 Where physical barriers are erected for the purpose of limiting fire spread, they shall be designed in accordance with NFPA 221 or the building code adopted by the AHJ.

9.3.5.2.2 Physical barriers erected to segregate fire hazard areas, including seals at all penetrations and openings of floors, walls, ceilings, or partitions, shall have a minimum fire resistance rating based on the fire duration stated in the applicable fire code.

9.3.5.2.3 Where physical barriers, including all penetrations and openings of floors, walls, ceilings, or partitions, are erected to segregate dust explosion hazard areas, they shall be designed in accordance with NFPA 68 to preclude failure of those barriers during a dust explosion.

9.3.5.2.4 Where physical barriers, including floors, walls, ceilings, or partitions, are erected to prevent the migration of dust, all penetrations and openings shall be sealed.

9.3.5.3 Use of Separation.

9.3.5.3.1* Separation shall be permitted to be used to limit the dust or particulate solid fire, flash fire, or explosion hazard areas within a building when it is supported by a documented evaluation.

9.3.5.3.2* The required separation distance between the dust or particulate solid fire, flash fire, or explosion 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, including during abnormal or transient operations
- (4) Building and equipment design
- (5) Nature of surrounding exposures

9.3.5.3.3* Where separation is used to limit the dust or particulate solid fire, flash fire, or explosion hazard area determined in Chapter 7, the minimum separation distance shall not be less than 35 ft (11 m).

9.3.5.3.4 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.

9.3.5.3.5 Housekeeping shall be promptly undertaken if the color of the underlying surface is not discernible.

9.3.5.3.6* 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 or particulate solid fire, flash fire, or explosion hazard area.

9.3.5.4 Use of Detachment.

9.3.5.4.1 Detachment shall be permitted to be used to limit the dust hazard area to a physically separated building.

9.3.5.4.2* The required detachment distance between the dust flash fire or explosion hazard area and surrounding exposures shall be determined by a documented 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, including during abnormal or transient operations
- (4) Building and equipment design
- (5) Nature of surrounding exposures

9.4 Equipment Design.

9.4.1 General.

9.4.1.1* Where used to handle combustible particulate solids, systems shall be designed by and installed under the supervision of qualified persons who are knowledgeable about these systems and their associated hazards.

9.4.1.2* Where it is necessary to make changes to existing equipment or systems, all changes shall be managed in accordance with the management of change requirements in Section 8.11.

9.4.2 Design for Dust Containment.

9.4.2.1 All components of enclosed systems that handle combustible particulate solids shall be designed to contain the dust to prevent creation of fugitive combustible dust hazards external to the equipment.

9.4.2.2* Where the equipment cannot be designed to prevent the escape of dust from the intended process zone, dust control shall be provided. (*See also 9.4.3.*)

9.4.2.3 Openings provided specifically for inspection or necessary process intake or discharge shall be permitted, provided they too do not permit fugitive dust release.

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

9.4.3.1 General Requirements.

9.4.3.1.1* The system 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.

9.4.3.1.2* Equipment controlling the operation of the system shall be installed in a location where the operator is safe from the pressure and thermal effects of an explosion in the system.

9.4.3.1.3 Systems That Convey Hybrid Mixtures. Where the combined percentage of the lower flammable limit (LFL) of flammable vapors and the percentage of the minimum explosible concentration (MEC) of combustible dusts exceeds 25 percent within the airstream, protection shall be provided in accordance with 9.8.2.2(1) through 9.8.2.2(6).

9.4.3.1.4* Operations.

9.4.3.1.4.1 Sequence of Operation. Pneumatic conveying, dust collection, and centralized vacuum cleaning systems shall be designed with the operating logic, sequencing, and timing outlined in 9.4.3.1.4.2 and 9.4.3.1.4.3.

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

9.4.3.1.4.3 Shutdown.

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

(B) The requirements of 9.4.3.1.4.3(A) shall not apply during emergency shutdown of the process, such as by activation of an emergency stop button or by activation of an automatic safety interlocking device.

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

9.4.3.1.5 Airflow Control Valves.

9.4.3.1.5.1 Airflow control valves that are installed in pneumatic conveying, dust collection, or centralized vacuum cleaning systems shall provide a tight shutoff.

9.4.3.1.5.2 Airflow control valves shall be sized to allow passage of the design airflow when the valve is fully open.

9.4.3.1.5.3 The position of airflow control valves shall be visually or electronically indicated.

9.4.3.1.5.4* Manually adjusted airflow control valves, dampers, or gates, shall have a means of being secured so as to prevent subsequent unauthorized adjustment once the system is set.

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

9.4.3.2* Specific Requirements for Pneumatic Conveying Systems.

9.4.3.2.1* The design of the pneumatic conveying system shall address required performance parameters and properties of the materials being conveyed.

9.4.3.2.2* Where a pneumatic conveying system or any part of such a system operates as a positive-pressure-type system and the air-moving device's gauge discharge pressure is 15 psi (103 kPa) or greater, the components exposed to that pressure under normal or upset conditions shall be designed in accordance with the applicable pressure vessel or process piping code.

9.4.3.2.3* Pneumatic conveying systems conveying combustible particulate solids and posing an explosion hazard shall be protected in accordance with Section 9.8.

9.4.3.3* Specific Requirements for Dust Collection Systems.

9.4.3.3.1* At each collection point, the system shall be designed to achieve the minimum velocity required for capture, control, and containment of the dust source.

9.4.3.3.2* The hood or pickup point for each dust source shall have a documented minimum air volume flow based upon the system design.

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

9.4.3.3.4* The addition of branch lines shall not be made to an existing system without first confirming that the entire system will maintain the required and balanced airflow.

9.4.3.3.5* Dust collection systems that remove material from operations that could generate flames, sparks, or hot material under normal operating conditions shall provide a means to prevent propagation of these flames, sparks, or hot materials to the AMS or creation of a fire or explosion hazard within the ductwork.

9.4.3.3.6* The AMS selected for the system shall be designed to allow for the characteristics of the combustible dust being separated from the airflow or gas flow.

9.4.3.3.7* Air-moving devices (AMDs) shall be of appropriate type and sufficient capacity to maintain the required rate of air/gas flow in all parts of the system.

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

9.4.3.4* Specific Requirements for Centralized Vacuum Cleaning Systems.

9.4.3.4.1* The system shall be designed to assure minimum conveying velocities at all times whether the system is used with a single or multiple simultaneous operators.

9.4.3.4.2* The hose length and diameter shall be sized for the application and operation.

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

9.4.3.4.4* Where ignition-sensitive materials are collected, vacuum tools shall be constructed of metal or static dissipative materials and provide proper bonding to the hose.

9.4.3.4.5* Vacuum cleaning hose shall be static dissipative or conductive and bonded to the central vacuum system.

9.4.4 AMS.

9.4.4.1 General.

9.4.4.1.1 The discharge conveying system shall be designed to handle the maximum material flow separated from the air stream.

9.4.4.1.2* Controls shall be provided to prevent accumulation in the AMS that could interfere with the operation of the AMS or associated explosion protection systems.

9.4.4.2* Dry AMS. Where an explosion hazard exists, AMSs with a dirty side volume of the air-material separator is greater than 8 ft³ (0.2 m³), or greater shall be protected in accordance with Section 9.8.

9.4.4.3 Wet AMS. See 9.4.4.5.3.

9.4.4.4 Enclosureless AMS. See 9.4.4.5.4.

9.4.4.5 AMS Locations.

9.4.4.5.1 Where an explosion hazard exists, AMSs with a dirty-side volume of 8 ft³ (0.2 m³) or greater shall be located outside of buildings.

9.4.4.5.2 The requirement of 9.4.4.5.1 shall not apply to the following:

- (1) AMSs that are protected in accordance with 9.8.2
- (2) AMSs that are allowed by an industry- or commodity-specific chapter

9.4.4.5.3 Wet air-material separators shall be permitted to be located inside when all of the following criteria are met:

- (1) A means is provided to prevent startup or continued operation if the flow rate of the scrubbing medium is less than the designed minimum flow rate.
- (2) The scrubbing medium is not an ignitable (flammable or combustible) liquid.
- (3) The separator is designed to prevent the formation of a combustible dust cloud within the air-material separator.
- (4) The design of the separator addresses any reaction between the separated material and the scrubbing medium.

9.4.4.5.4 Enclosureless AMS shall not be permitted to be located indoors unless specifically allowed by an industry- or commodity-specific NFPA chapter.

9.4.4.6 AMS Clean Air Exhaust.

9.4.4.6.1 Exhaust air from the final AMS shall be discharged outside of buildings to a restricted area separated from clean air intakes for the building.

9.4.4.6.2* Air/gas from AMSs shall be permitted to be recirculated directly back to the pneumatic conveying system.

9.4.4.6.3* Recycling of AMS exhaust to buildings or building compartments shall be permitted when all the following conditions are met:

- (1) Gases or vapors are not present in either the intake or the recycled air in concentrations above applicable industrial hygiene exposure limits or 1 percent of the lower flammable limit (LFL), whichever is lower.
- (2)* Combustible particulate solids are not present in the recycled air in concentrations above applicable industrial hygiene exposure limits.
- (3)* The oxygen concentration of the recycled air stream is between 19.5 percent and 23.5 percent by volume.
- (4) Provisions are incorporated to prevent transmission of flame and pressure effects from a deflagration in an AMS back to the facility unless a risk assessment indicates that those effects do not pose a threat to the facility or the occupants.
- (5) Provisions are incorporated to prevent transmission of smoke and flame from a fire in an AMS back to the facility unless a risk assessment indicates that those effects do not pose a threat to the facility or the occupants.
- (6) The system includes a method for detecting AMS malfunctions that would reduce collection efficiency and allow increases in the amount of combustible particulate solids returned to the building.
- (7) The building or building compartment to which the recycled air is returned meets the housekeeping requirements of 8.4.6.

- (8) Recycled-air ducts are inspected at least annually and cleaned if dust accumulations are present.

9.4.4.6.4 Recycling of AMS exhaust to buildings or building compartments shall be permitted for enclosureless AMS as permitted by 9.4.4.5.4 and the industry- or commodity-specific chapter of this standard.

9.4.4.7 AMS Construction.

9.4.4.7.1 AMSs shall be constructed of noncombustible materials.

9.4.4.7.2 Filter media and filter media support frames shall be permitted to be constructed of combustible material.

9.4.4.7.3 Where isolated from an AMS by a valve, portable containers intended to receive materials discharged from the AMS shall be permitted to be constructed of combustible material.

9.4.4.7.4* AMSs shall be constructed to minimize internal ledges or other points of dust accumulation.

9.4.4.7.5* AMS units with angled bottom construction shall use a slope that is sufficient to promote material flow to the discharge.

9.4.4.7.6* AMS units with flat bottom construction shall be provided with a positive method to direct collected material to the discharge.

9.4.4.7.7 Where provided to permit inspection, cleaning, and maintenance, access doors and access openings shall meet the following requirements:

- (1) They shall be designed to prevent dust leaks.
- (2) They shall be permitted to be used as deflagration vents if they are specifically designed for both purposes.
- (3)* They shall be bonded and grounded.
- (4)* If not designed to be used as deflagration vents, they shall be designed to the same strength as the AMS.

9.4.5 Air-Moving Devices (Fans and Blowers).

9.4.5.1 AMDs shall conform to the requirements of NFPA 91, except as amended by the requirements of this chapter.

9.4.5.2* Where an explosion hazard exists, systems shall be designed in such a manner that combustible particulate solids do not pass through an AMD.

9.4.5.3* The requirement of 9.4.5.2 shall not apply to systems protected by an approved explosion prevention or isolation system to prevent the propagation of the flame front from the fan to other equipment in accordance with 9.8.2.2(1), 9.8.2.2(5), 9.8.2.2(6), or 9.8.3.

9.4.5.4* Where an AMD is located in the dirty air stream and the dust/air stream concentration is higher than 10 percent of the MEC, fans and blowers shall be of Type A or Type B spark-resistant construction per AMCA Standard 99, *Standards Handbook*, or Type C spark-resistant construction protected with spark detection and extinguishment located downstream of the fan.

9.4.6 Duct Systems.

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

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

9.4.6.3* When ducts pass through a physical barrier erected to segregate dust or particulate solid fire, flash fire, or explosion hazards, physical isolation protection shall be provided to prevent propagation of fire, flash fire, or explosions between segregated spaces.

9.4.6.4 Access Doors.

9.4.6.4.1 Access doors, openings, or removable sections of ductwork shall be provided to allow inspection, cleaning, maintenance, and fire department access.

9.4.6.4.2 Access doors, openings, or removable sections of ductwork shall be designed and maintained to prevent dust leaks and preserve the integrity of the duct.

9.4.6.4.3 Access doors, openings, or removable sections of ductwork that are not specifically designed for deflagration venting shall not be considered as providing that function.

9.4.6.4.4* Access doors, openings, or removable sections of ductwork shall be bonded and grounded.

9.4.7* Sight Glasses.

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

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

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

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

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

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

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

9.4.8 Abort Gates.

9.4.8.1 Construction.

9.4.8.1.1 Abort gates shall be constructed of noncombustible materials.

9.4.8.1.2 Abort gates shall be actuated by spark detection or equivalent automatic detection in the duct or pipe upstream of the device.

9.4.8.1.3 The detection system and abort gate shall respond to prevent sparks, glowing embers, or burning materials from passing beyond the abort gate.

9.4.8.1.4 The abort gate shall be installed so that it diverts airflow to an access-restricted area to safely discharge combustion gases, flames, burning solids, or process gases or fumes.

9.4.8.2 Local Reset.

9.4.8.2.1 An abort gate shall be provided with a reset located proximate to the device.

9.4.8.2.2 Automatic or remote reset provisions shall not be permitted.

9.4.8.3 Integrity of Actuation Circuits.

9.4.8.3.1 All fire protection abort gates shall be connected to the fire detection control panel via Class A or Class D circuits as described in *NFPA 72*.

9.4.8.3.2 When the abort gate is connected via a Class A circuit, supervision shall include the continuity of the abort gate releasing device, whether that device is a solenoid coil, a detonator (explosive device) filament, or other such device.

9.4.9 Bulk Storage Enclosures.

9.4.9.1 General.

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

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

9.4.9.2* Construction. Where bulk storage enclosures, whether located inside or outside of buildings, are built of materials that could contribute to the fire load, the design of fire protection shall take that into consideration.

9.4.9.3 Fixed Bulk Storage Location.

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

9.4.9.3.2 Fixed bulk storage enclosures with explosion hazards shall be permitted to be located inside buildings where one of the following applies:

- (1) Fixed bulk storage enclosures are protected in accordance with 9.8.2.
- (2)* Fixed bulk storage enclosures are less than 8 ft³ (0.2 m³).

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

9.4.9.5 Access Doors and Openings. Where provided to permit inspection, cleaning, and maintenance, access doors and access openings shall meet the following requirements:

- (1) They shall be designed to prevent dust leaks.
- (2) They shall be permitted to be used as deflagration vents if they are specifically designed for both purposes.
- (3)* They shall be bonded and grounded.
- (4) If not designed to be used as deflagration vents, they shall be designed to the same strength as the AMS.

9.4.10* Size Reduction. Where a fire or explosion hazard would otherwise result, before material is processed by size reduction equipment, foreign materials shall be excluded or removed as required by 9.6.11.

9.4.11* Particle Size Separation.

9.4.11.1 Particle separation devices shall be designed to control fugitive dust emissions per Section 9.5.

9.4.11.2 Flexible connectors shall be in conformance with 9.6.6.1.4.

9.4.12 Pressure Protection Systems.

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

9.4.12.2 Pressure Relief Devices.

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

9.4.12.2.2 The requirement of 9.4.12.2.1 shall not apply to systems that are designed for a gauge pressure of less than 15 psi (103 kPa) and are provided with safety interlocks designed to prevent overpressure in accordance with ISA 84.00.01, *Functional Safety: Application of Safety Instrumented Systems for the Process Industry Sector*.

9.4.12.2.3 The requirement of 9.4.12.2.1 shall not apply to systems that are designed for a gauge pressure of less than 15 psi (103 kPa) and are capable of containing the maximum pressure attainable.

9.4.12.2.4* Pressure relief devices shall not be vented to an area where a dust or particulate solid fire, flash fire, or explosion hazard exists in accordance with 7.3.4.

9.4.13 Mechanical Feeding Devices. For requirements on mechanical feeding devices, see industry- or commodity-specific chapters.

9.4.14 Bucket Elevators. For requirements on bucket elevators, see industry- or commodity-specific chapters.

9.4.15 Conveyors and Spouts. For requirements on conveyors, see industry- or commodity-specific chapters.

9.4.16 Mixers and Blenders. For requirements on mixers and blenders, see industry- or commodity-specific chapters.

9.4.17* Dryers.

9.4.17.1 Drying Media.

9.4.17.1.1 Drying media that come into contact with material being processed shall not be recycled to rooms or buildings.

9.4.17.1.1.1* Recycling of exhaust from a dryer system to buildings or building compartments shall be permitted when all the following conditions are met:

- (1) Gases or vapors are not present in either the intake or the recycled air in concentrations above applicable industrial hygiene exposure limits or 1 percent of the LFL, whichever is lower.
- (2)* Combustible particulate solids are not present in the recycled air in concentrations above applicable industrial hygiene exposure limits.
- (3)* The oxygen concentration of the recycled air stream is between 19.5 percent and 23.5 percent by volume.
- (4) Provisions are incorporated to prevent transmission of flame and pressure effects from a deflagration in a dryer system back to the facility unless a risk assessment indicates that those effects do not pose a threat to the facility or the occupants.
- (5) Provisions are incorporated to prevent transmission of smoke and flame from a fire in a dryer system back to the

facility unless a risk assessment indicates that those effects do not pose a threat to the facility or the occupants.

- (6) The system includes a method for detecting and mitigating dryer system malfunctions that would allow increases in the amount of combustible particulate solids returned to the building.
- (7) The building or building compartment to which the recycled air is returned meets the housekeeping requirements of 8.4.6.
- (8) Recycled-air ducts are inspected at least annually and cleaned if dust accumulations are present.

9.4.17.1.2* Where a combustible dust hazard exists in the dryer or recycled air stream during the drying process, those hazards shall be controlled.

9.4.17.1.3 Dryers shall be constructed of noncombustible materials.

9.4.17.1.4 Interior surfaces of dryers shall be designed to minimize combustible material accumulations and facilitate cleaning.

9.4.17.1.4.1* Dryer cleaning methods, frequency, and the required level of cleanliness shall be documented.

9.4.17.1.5 Access doors or openings shall be provided in the dryer system and connected conveyors to permit inspection, cleaning, maintenance, and the effective use of portable extinguishers or hose streams.

9.4.17.1.6 Heated dryers shall comply with NFPA 86.

9.4.17.1.7* Heated dryers shall have operating controls arranged to maintain the temperature of the drying chamber within the prescribed limits.

9.4.17.1.8* Heated dryers and their auxiliary equipment shall be equipped with an excess-temperature-limit safety interlock, independent of the operating controls, arranged to supervise the following:

- (1) Heated air supply to the drying chamber
- (2) Airstream at the discharge of the drying chamber

9.4.18 Transfer Points. (Reserved)

9.5 Dust Control.

9.5.1 General.

9.5.1.1 Continuous suction or some other means to control fugitive dust emissions shall be provided for processes where hazardous quantities of combustible dust is liberated in normal operation.

9.5.1.2 Where continuous suction is used, the dust shall be conveyed to air-material separators designed in accordance with 9.4.3.

9.5.2* Liquid Dust Suppression Methods for Dust Control.

9.5.2.1 Where liquid dust suppression is used to prevent the accumulation of dust or to reduce its airborne concentration, the liquid dust suppressant shall not result in adverse reaction with the combustible dust.

9.5.2.2 Where liquid dust suppression is used, controls and monitoring equipment shall be provided to ensure the liquid dust suppression system is functioning properly.

9.5.3* Fans for Continuous Dust Control. It shall be permitted to install and use fans to limit dust accumulation in elevated areas and other areas that are difficult to access for housekeeping.

9.5.3.1 Fans shall be appropriate for the electrical classification in the areas where they are used.

9.5.3.2 Fans shall be provided in sufficient numbers and locations as required to keep the target areas below threshold accumulation levels.

9.5.3.3 Fans shall be in operation whenever the equipment generating the dusts is in operation.

9.5.3.4 Fans shall be interlocked to automatically shut down in the event of automatic fire suppression system operation.

9.5.3.5 Dust dispersed by the fans shall not create an explosive dust cloud.

9.5.3.6 The location and range of motion of the fans shall be designed to prevent flow impingement on open equipment containing entrainable dust.

9.5.3.7 Areas that will be swept by the fans shall be below threshold accumulation levels prior to placing or returning the fans in operation.

9.5.3.8* These fans shall be used in conjunction with the housekeeping program to remove dust from the facility.

9.5.3.9 These systems shall not be used where they can relocate dust into unsealed concealed spaces where the dust can accumulate and pose a fire, flash fire, or explosion hazard.

9.5.3.10 These systems shall not be used where areas above suspended ceilings are used as return air plenums for HVAC systems.

9.5.3.11 Periodic inspections shall be performed to ensure that dust accumulations are maintained below the threshold dust layer thicknesses determined in 8.4.6.

9.6 Ignition Source Control.

9.6.1* Retroactivity. Unless otherwise specified, the requirements of Section 9.6 shall be applied retroactively.

9.6.2 Hot Work. See Section 8.5.

9.6.3 Hot Surfaces.

9.6.3.1 This section shall not be required to be applied retroactively.

9.6.3.2* In areas where a dust explosion hazard or dust flash fire hazard exists, the temperature of exposed surfaces shall be maintained below 80 percent (in degrees Celsius) of the lower of the dust layer ignition temperature or the dust-cloud ignition temperature.

9.6.4 Bearings.

9.6.4.1 This section shall not be required to be applied retroactively.

9.6.4.2* Bearings that are directly exposed to a combustible dust atmosphere or that are subject to dust accumulation, either of which poses a dust ignition hazard, shall be monitored for overheating.

9.6.4.3 The owner/operator shall establish frequencies for monitoring bearings in 9.6.4.2.

9.6.4.4* It shall be permitted to eliminate bearing monitoring based on a risk assessment in accordance with Section 9.2.

9.6.5 Hazardous (Classified) Locations for Electrical Installations.

9.6.5.1* The identification of the possible presence and extent of hazardous (classified) locations shall be made based on the criteria in Articles 500 and 506 of *NFPA 70*.

9.6.5.1.1* The locations and extent of hazardous (classified) locations shall be documented, and such documentation shall be preserved for access at the facility.

9.6.5.2 Electrical equipment and wiring within hazardous (classified) locations shall comply with *NFPA 70*.

9.6.5.3* Preventive maintenance programs for electrical equipment and wiring in hazardous (classified) locations shall include provisions to verify that dusttight electrical enclosures are not experiencing visible dust accumulation.

9.6.5.4* Electrical equipment exposed to a process-specific oxidizing medium, other than air, shall only use dust exclusion protection methods unless supported by a documented risk assessment.

9.6.6* Electrostatic Discharges.

9.6.6.1 Conductive Equipment.

9.6.6.1.1 Particulate handling equipment shall be conductive unless the provisions of 9.6.6.1.2 are applicable.

9.6.6.1.2 Nonconductive system components shall be permitted where all of the following conditions are met:

- (1)* Hybrid mixtures and flammable gas/vapor atmospheres are not present.
- (2)* Conductive particulate solids are not handled.
- (3)* The nonconductive components do not result in isolation of conductive components from ground.
- (4)* The breakdown strength across nonconductive sheets, coatings, membranes, or pipe/vessel wall with thickness less than 0.3 in. (8 mm) does not exceed 4 kV, and the breakdown strength across nonconductive woven materials does not exceed 6 kV, when used in high surface charging processes.

9.6.6.1.3* Bonding and grounding with a resistance of less than 1.0×10^6 ohms to ground shall be provided for conductive components.

9.6.6.1.4* Flexible Connectors.

9.6.6.1.4.1* This section shall not be required to be applied retroactively.

9.6.6.1.4.2* Flexible connectors used for pneumatic conveying, dust collection, or vacuum cleaning, regardless of length, shall have an end-to-end resistance of less than 1.0×10^6 ohms even where an internal or external bonding wire connects the equipment to which the flexible connector is attached.

9.6.6.1.4.3* Flexible connectors used for gravity or mechanical conveying, regardless of length, shall have an end-to-end resistance of less than 1.0×10^8 ohms even where an internal or

external bonding wire connects the equipment to which the flexible connector is attached.

9.6.6.1.4.4* Where flammable vapors are not present, flexible connectors with a resistance equal to or greater than 1.0×10^8 ohms shall be permitted under either of the following conditions:

- (1) The dust has an MIE greater than 2000 mJ.
- (2) The maximum powder transfer velocity is less than 2000 ft/min (10 m/sec).

9.6.6.2* Maximum Particulate Transport Rates. For requirements on this subject, see industry- or commodity-specific chapters.

9.6.6.3* Grounding of Personnel.

9.6.6.3.1* Where an explosible atmosphere exists and is subject to ignition from an electrostatic spark discharge from ungrounded personnel, personnel involved in manually filling or emptying particulate containers or vessels shall be grounded during such operations.

9.6.6.3.2 Personnel grounding shall not be required where both of the following conditions are met:

- (1) Flammable gases, vapors, and hybrid mixtures are not present.
- (2)* The minimum ignition energy of the dust cloud is greater than 30 mJ.

9.6.6.4* Flexible Intermediate Bulk Containers (FIBCs). FIBCs shall be permitted to be used for the handling and storage of combustible particulate solids in accordance with the requirements in 9.6.6.4.1 through 9.6.6.4.7.

9.6.6.4.1* Electrostatic ignition hazards associated with the particulate and objects surrounding or inside the FIBC shall be included in the DHA required in Chapter 7.

9.6.6.4.2* Type A FIBCs shall be limited to use with noncombustible particulate solids or combustible particulate solids having an MIE greater than 1000 mJ.

9.6.6.4.2.1 Type A FIBCs shall not be used in locations where flammable vapors are present.

9.6.6.4.2.2* Type A FIBCs shall not be used with conductive dusts.

9.6.6.4.3* Type B FIBCs shall be permitted to be used where combustible dusts having an MIE greater than 3 mJ are present.

9.6.6.4.3.1 Type B FIBCs shall not be used in locations where flammable vapors are present.

9.6.6.4.3.2 Type B FIBCs shall not be used for conductive dusts. (See A.9.6.6.4.2.2.)

9.6.6.4.4* Type C FIBCs shall be permitted to be used with combustible particulate solids and in locations where Class I Group C/D or Zone Group IIA/IIB flammable vapors or gases, as defined by *NFPA 70*, are present.

9.6.6.4.4.1 Conductive FIBC elements shall terminate in a grounding tab, and resistance from these elements to the tab shall be less than or equal to 10^7 ohms.

9.6.6.4.4.2 Type C FIBCs shall be grounded during filling and emptying operations with a resistance to ground of less than 25 ohms.

9.6.6.4.4.3 Type C FIBCs shall be permitted to be used for conductive dusts where a means for grounding the conductive dusts is present.

9.6.6.4.5* Type D FIBCs shall be permitted to be used with combustible particulate solids and in locations where Class I Group C/D or Zone Group IIA /IIB flammable vapor or gases, as defined by *NFPA 70*, having an MIE greater than 0.14 mJ are present.

9.6.6.4.5.1* Type D FIBCs shall not be permitted to be used for conductive particulate solids.

9.6.6.4.6* Type B, Type C, and Type D FIBCs shall be tested and verified as safe for their intended use by a recognized testing organization in accordance with the requirements and test procedures specified in IEC 61340-4-4, *Electrostatics — Part 4-4: Standard Test Methods for Specific Applications — Electrostatic Classification of Flexible Intermediate Bulk Containers (FIBC)*, before being used in hazardous environments.

9.6.6.4.6.1 Intended use shall include both the product being handled and the environment in which the FIBC will be used.

9.6.6.4.6.2 Materials used to construct inner baffles, other than mesh or net baffles, shall meet the requirements for the bag type in which they are to be used.

9.6.6.4.6.3* Where used, inner liners shall be suitable to maintain the electrostatic characteristics of the bag types in which they are used.

9.6.6.4.6.4 Documentation of test results shall be made available upon request of the AHJ.

9.6.6.4.6.5 FIBCs that have not been tested and verified for type in accordance with IEC 61340-4-4, *Electrostatics — Part 4-4: Standard Test Methods for Specific Applications — Electrostatic Classification of Flexible Intermediate Bulk Containers (FIBC)*, shall not be used for combustible dusts or in flammable vapor atmospheres.

9.6.6.4.7* Deviations from the requirements in 9.6.6.4.1 through 9.6.6.4.6 for safe use of FIBCs shall be permitted based on a documented risk assessment in accordance with Section 9.2.

9.6.6.5 Rigid Intermediate Bulk Containers (RIBCs).

9.6.6.5.1* Conductive RIBCs shall be permitted to be used for dispensing into any flammable vapor, gas, dust, or hybrid atmospheres provided that the RIBCs are electrically grounded.

9.6.6.5.2* Nonconductive RIBCs shall not be permitted to be used for applications, processes, or operations involving combustible particulate solids or where flammable vapors or gases are present unless a documented risk assessment of the electrostatic hazards is completed in accordance with Section 9.2.

9.6.7 Open Flames and Fuel-Fired Equipment.

9.6.7.1* Production, maintenance, or repair activities that can produce a combustible dust cloud shall not be conducted within 35 ft (11 m) of an open flame or pilot flame.

9.6.7.2 Fuel-fired space heaters drawing local ambient air shall not be located within hazardous (classified) locations.

9.6.7.3 Fuel-fired process equipment shall be operated and maintained in accordance with the pertinent NFPA standard for the equipment, including NFPA 31, NFPA 54, NFPA 85, and NFPA 86.

9.6.7.4 Inspections and preventive maintenance for fuel-fired process equipment shall include verification that there are no significant combustible dust accumulations within or around the equipment.

9.6.7.5 Unless the equipment is operated within the limits of 9.6.3.2, provisions shall be made to prevent the accumulation of combustible dust on heated surfaces of heating units.

9.6.7.6 In facility locations that have been identified as being dust flash fire or explosion hazard areas or hazardous (classified) locations, heating units shall be provided with a source of combustion air ducted directly from the building exterior or from an unclassified location.

9.6.8 Industrial Trucks.

9.6.8.1 Industrial trucks shall be listed or approved for the electrical classification of the area, as determined by 9.6.5, and shall be used in accordance with NFPA 505.

9.6.8.2* Where industrial trucks in accordance with NFPA 505 are not commercially available, a documented risk assessment in accordance with Section 9.2 shall be permitted to be used to specify the fire and explosion prevention features for the equipment being used.

9.6.9 Process Air and Media Temperatures.

9.6.9.1* Heated process equipment containing combustible dust shall have operating controls arranged to maintain the temperature of equipment interiors within the prescribed limits as documented by the DHA.

9.6.10* Self-Heating. Where a self-heating hazard is identified, provisions shall be in place for managing the consequences of self-heating in storage silos or bins.

9.6.10.1 Material that has self-heating characteristics shall be managed or stored to control self-heating or have self-heating detection provisions.

9.6.10.2 Where a self-heating hazard is identified, provisions shall be in place for managing the consequences of self-heating in storage silos or bins.

9.6.11 Friction and Impact Sparks.

9.6.11.1 Means shall be provided to prevent foreign material from entering the system when such foreign material presents an ignition hazard.

9.6.11.2* Foreign materials, such as tramp metal, that are capable of igniting combustible material being processed shall be removed from the process stream.

9.6.11.3* Where introduction of tramp materials cannot be prevented, explosion protection shall be provided for all equipment subject to the explosion hazard.

9.6.11.4* Clearances and alignment of high-speed moving parts in equipment that is processing combustible particulates