

NFPA® 655

Standard for Prevention of Sulfur Fires and Explosions

2012 Edition



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NFPA® 655
Standard for
Prevention of Sulfur Fires and Explosions
2012 Edition

This edition of NFPA 655, *Standard for Prevention of Sulfur Fires and Explosions*, was prepared by the Technical Committee on Handling and Conveying of Dusts, Vapors, and Gases. It was issued by the Standards Council on December 13, 2011, with an effective date of January 2, 2012, and supersedes all previous editions.

This edition of NFPA 655 was approved as an American National Standard on January 2, 2012.

Origin and Development of NFPA 655

This standard was first presented to the Association as a progress report in 1938 by the Committee on Dust Explosion Hazards. It was tentatively adopted in 1939. After some revision, it was officially adopted in 1940. Amendments were adopted in 1946, 1947, 1959, 1968, and 1971.

In 1976, responsibility for the document was transferred to the Technical Committee on Fundamentals of Dust Explosion Prevention and Control. The Technical Committee completely revised the 1971 edition to effect minor technical amendments and to editorially revise the document to comply with the NFPA *Manual of Style*.

Due to limited technological changes in this subject area between 1982 and 1988, the Committee reconfirmed the text as it had appeared in the 1982 version. Editorial changes and changes to allow the document to adhere more closely to the 1986 edition of the NFPA *Manual of Style*, were incorporated into the 1988 edition.

For the 1993 edition, the Committee made minor revisions to Chapter 2 for handling finely divided sulfur in bulk and minor revisions to the fire-fighting procedures to be used when fighting fires involving sulfur.

The 2001 edition contained editorial changes associated with incorporation of the 2000 edition of the *Manual of Style for NFPA Technical Committee Documents*. The Committee also made minor revisions to Chapter 6 to address operating precautions for pits and tank sections and to clarify protection for covered liquid sulfur storage tanks.

The 2007 edition included a complete revision of the standard, which was highlighted by the addition of three new chapters and the revision of Chapter 4, which combined the requirements applicable to both finely divided and coarse sulfur. These chapters reflected the Committee's efforts to expand the dust hazard control requirements within the standard. The new chapters — Chapter 7, Fugitive Dust Control and Housekeeping; Chapter 8, Training and Procedures; and Chapter 9, Inspection and Maintenance — were based upon dust hazard evaluation and control processes found in NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*, 2006 edition. This edition also contained new requirements applicable to intermediate bulk containers (IBCs).

Revisions to the 2012 edition of NFPA 655 focus on updates to the requirements in Chapter 4 for solid sulfur to coordinate with combustible dust hazard assessment and control. Key changes include:

- (1) Definitions for *dust flash fire hazard area* and *dust explosion hazard area* have been added.
- (2) Methods to determine where hazardous dust conditions exist have been added to be consistent with NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*.
- (3) Housekeeping requirements have been updated to include preferred methods and guidance on cleaning frequency.
- (4) Requirements for contractors and subcontractors have been added.
- (5) Personal protection equipment (PPE) requirements related to flash fire hazard protection have been added.
- (6) Fire-fighting requirements have been modified to reflect changes in equipment.
- (7) References have been updated.
- (8) Annex commentary regarding flexible intermediate bulk containers (FIBC) use and cautions against static hazards have been added.

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



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NFPA 655**Standard for****Prevention of Sulfur Fires and Explosions****2012 Edition**

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

Chapter 1 Administration**1.1 Scope.**

1.1.1* This standard shall apply to the size reduction of sulfur and to the handling of sulfur in any form.

1.1.2 This standard shall not apply to the mining of sulfur, recovery of sulfur from process streams, or transportation of sulfur.

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

1.1.4 This standard shall be used in conjunction with the requirements of NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*. Where conflicts exist, the requirements of NFPA 655, *Standard for Prevention of Sulfur Fires and Explosions*, shall apply.

1.2 Purpose. The purpose of this standard shall be to provide requirements to eliminate or reduce the hazards of explosion and fire inherent in the processing and handling of sulfur.

1.3 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.

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

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

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

1.3.3.1 This standard shall apply to facilities on which construction is begun subsequent to the date of publication of the standard. When major replacement or renovation of existing facilities is planned, provisions of this standard shall apply.

1.4 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.

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

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

Chapter 2 Referenced Publications

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

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

NFPA 17, *Standard for Dry Chemical Extinguishing Systems*, 2009 edition.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, 2009 edition.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, 2007 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 2008 edition.

NFPA 70®, *National Electrical Code*®, 2011 edition.

NFPA 72®, *National Fire Alarm and Signaling Code*, 2010 edition.

NFPA 80, *Standard for Fire Doors and Other Opening Protectives*, 2010 edition.

NFPA 101®, *Life Safety Code*®, 2012 edition.

NFPA 220, *Standard on Types of Building Construction*, 2012 edition.

NFPA 221, *Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls*, 2012 edition.

NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*, 2008 edition.

NFPA 600, *Standard on Industrial Fire Brigades*, 2010 edition.

NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*, 2006 edition.



NFPA 780, *Standard for the Installation of Lightning Protection Systems*, 2011 edition.

NFPA 2113, *Standard on Selection, Care, Use, and Maintenance of Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire*, 2012 edition.

2.3 Other Publications.

2.3.1 ISA Publications. The Instrumentation, Systems, and Automation Society, 67 Alexander Drive, Research Triangle Park, NC 27709.

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

2.3.2 U.S. Government Publications. U.S. Government Printing Office, Washington, DC 20402.

Title 29, Code of Federal Regulations, 1910. 242(b).

2.3.3 Other Publications.

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

2.4 References for Extracts in Mandatory Sections.

NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*, 2006 edition.

NFPA 2113, *Standard on Selection, Care, Use, and Maintenance of Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire*, 2012 edition.

Chapter 3 Definitions

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

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

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

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

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

3.2.5 Shall. Indicates a mandatory requirement.

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

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

3.3 General Definitions.

3.3.1 Dust Collector. Any device designed to separate the conveying gas stream from the solid being conveyed.

3.3.2 Deflagration Hazard Area.

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

3.3.2.2 Dust Flash Fire Hazard Area. An area where combustible dust accumulation on exposed or concealed surfaces, outside of equipment or containers, can result in personnel injury from thermal dose during a dust deflagration, as well as any areas where dust clouds of a hazardous concentration exist during normal operation. A propagating deflagration yields a flash fire through the hazard area.

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

3.3.4* Flash Fire. A fire that spreads rapidly through a diffuse fuel, such as dust, gas, or the vapors of an ignitable liquid, without the production of damaging pressure. [2113, 2012]

3.3.5 Intermediate Bulk Containers.

3.3.5.1 Flexible Intermediate Bulk Container (FIBC).

3.3.5.1.1 Type A FIBC. A standard insulating flexible intermediate bulk container (FIBC). [654, 2006]

3.3.5.1.2 Type B FIBC. A flexible intermediate bulk container (FIBC) where the fabric or the combination of the fabric shell, coating, and any loose liner has a breakdown voltage of less than 6000 volts. [654, 2006]

3.3.5.1.3 Type C FIBC. A flexible intermediate bulk container (FIBC) where the fabric is interwoven with an electrically interconnected conductive fiber and provided with a tab for connection to grounding systems. [654, 2006]

3.3.5.1.4 Type D FIBC. A flexible intermediate bulk container (FIBC) constructed from fabric and/or threads with special static properties designed to control electrostatic discharge incendivity, without grounding. [654, 2006]

3.3.5.2* 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. [654, 2006]

3.3.5.2.1 Insulating RIBC. An RIBC constructed entirely of solid plastic or solid plastic and foam composite that cannot be electrically grounded. [654, 2006]

3.3.6 Size Reduction Machinery. Any machinery that reduces the size of sulfur particles by grinding, pulverizing, crushing, or similar processes.

3.3.6.1 Type 1. Low-speed primary crushers, such as jaw and roll crushers.

3.3.6.2 Type 2. High-speed primary crushers, such as disk and hammer mills, pulverizers, and fine size reduction equipment of all kinds, except Type 4, having a net internal volume of not more than 500 in.³ (8193 cm³).

3.3.6.3 Type 3. Crushers and pulverizers of the Type 2 category, but having an internal volume of more than 500 in.³ (8193 cm³).

3.3.6.4* Type 4. Pulverizers that do not depend on moving parts for their disintegrating action, such as attrition mills.

3.3.7* 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.

Chapter 4 Handling Solid Sulfur in Bulk

4.1 General.

4.1.1 This chapter shall apply to the handling and processing of solid sulfur at size reduction facilities.

4.1.2 The objectives in this chapter shall be achieved by either of the following means:

- (1) The prescriptive provisions in accordance with this chapter
- (2) The performance-based provisions in accordance with Chapter 5 of NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*, and Sections 4.7, 4.8, and 4.9 of this standard

4.1.3 Operation and maintenance of all size reduction machinery shall be under supervision.

4.1.4 Those portions of the size reduction facility where deflagration hazard areas are deemed to exist in accordance with Section 4.2 shall be protected from the effects of these hazards in accordance with Section 4.3 and Chapter 7.

4.2 Identification of Deflagration Hazard Areas.

4.2.1 Those portions of size reduction facility where dust accumulations exist shall be evaluated to determine if a dust explosion hazard or flash fire hazard exists.

4.2.2 Building, rooms, compartments, and other interior spaces shall be assessed in accordance with 4.2.4 and 4.2.5, unless the colors of the surfaces underlying the dust accumulations are readily discernible.

4.2.3 The process equipment shall be assessed in accordance with 4.2.9.

4.2.4 Dust explosion hazard areas and dust flash fire hazard areas shall be deemed to exist where dust clouds of a hazardous concentration exist.

4.2.5 Unless the method in 4.2.5.3 is being used, dust explosion hazard areas and dust flash fire hazard areas shall be deemed to exist when the total accumulated dust on any sur-

faces exceeds the thresholds calculated in 4.2.5.1 or 4.2.5.2, respectively.

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

$$M_{basic-exp} = 0.01 \cdot A_{floor} \cdot H$$

where:

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

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

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

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

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

$$M_{basic-fire} = 0.05 \cdot A_{floor}$$

where:

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

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

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

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

4.2.5.3 Layer Depth Criterion Method.

4.2.5.3.1* For materials with bulk density less than 75 lb/ft³, the layer depth criterion of 1/32 in. shall be permitted to be increased according to the following equation:

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

4.2.5.3.2 The footprint area shall be determined as the lesser of the building/room area or 21,500 ft² (2000 m²).

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

- (1) The total area of dust accumulations exceeding the layer depth criterion is greater than 5 percent of the footprint area.
- (2) The total volume of dust accumulations is greater than the layer depth criterion multiplied by 5 percent of the footprint area.

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

4.2.7 Dust accumulation amounts shall reflect the conditions that exist just prior to routinely scheduled cleaning and shall not include short-term accumulations cleaned in accordance with Chapter 7.

4.2.8 Personnel exposed to a dust explosion hazard or dust flash fire hazard shall be protected in accordance with 8.2.3.

4.2.9 A dust explosion hazard area shall be deemed to exist in process equipment where all the following conditions are possible:

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



4.3 Building Construction.

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

4.3.1.1 Where local, state, and national building codes are more restrictive, modifications shall be permitted for conformance to these codes.

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

4.3.1.3 Spaces inaccessible to housekeeping shall be sealed in order to prevent dust accumulation.

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

4.3.1.5 Fire Doors.

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

4.3.1.5.2 Fire doors shall be installed according to NFPA 80, *Standard for Fire Doors and Other Opening Protectives*, and shall normally be in the closed position.

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

4.3.1.7 Penetrations. Where floors, walls, ceilings, and other partitions have been erected to control the spread of deflagrations, penetrations in these structures shall be sealed dusttight in normal operation and protected to maintain their fire resistance rating and physical integrity in a deflagration.

4.3.1.8 Fire Resistance Rating.

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

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

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

4.3.1.9* Floor-ceiling assemblies, roof assemblies, and load-bearing walls that are exposed to dust explosion hazards shall be designed so as to preclude failure during an explosion. (See NFPA 68, *Standard on Explosion Protection by Deflagration Venting*.)

4.3.2 Location of Size Reduction Machinery and Containers.

4.3.2.1 Where size reduction machinery is located in an enclosed or partially enclosed space, that space shall be used only for the size reduction process and the filling of containers with the reduced material when size reduction of sulfur is in progress.

4.3.2.2* Containers shall be removed from the area as soon as possible after being filled.

4.3.3 Building Construction Requirements for Housing Size Reduction Machinery.

4.3.3.1 Where Type 1 equipment is located outdoors, it shall be permitted to transfer reduced material in enclosed down-

stream equipment, provided either of the following conditions exists:

- (1) The transferred material is continuously wetted with water sufficient to prevent ignition.
- (2) An inert gas isolation system is provided between the Type 1 equipment and the enclosed downstream equipment.

4.3.3.2* Where size reduction machinery is located in an enclosed or partially enclosed space, that space shall be segregated from other areas by noncombustible walls designed to withstand the force of a vented sulfur dust explosion. (See NFPA 68, *Standard on Explosion Protection by Deflagration Venting*.)

4.3.4 Protection of Openings.

4.3.4.1 All pathways between the space used for size reduction and the rest of the building shall be from the outside or via indirect means as described in 4.3.4.2.

4.3.4.2* Indirect pathways through segregating walls by means of vestibules or stairways shall be permitted, provided the wall opening to the size reduction area is protected by an automatic-closing fire door suitable for 3-hour openings, and the opening into the vestibule or stairway is protected by an automatic-closing fire door suitable for 2-hour openings.

4.3.4.2.1 The two automatic-closing fire doors shall be installed at right angles to each other.

4.3.4.2.2 Both fire doors shall be installed in accordance with NFPA 80, *Standard for Fire Doors and Other Opening Protectives*.

4.3.5 Buildings or enclosures containing a dust explosion hazard area shall be constructed with deflagration venting designed in accordance with NFPA 68, *Standard on Explosion Protection by Deflagration Venting*.

4.3.6 Horizontal Surfaces.

4.3.6.1 All ledges and surfaces on which dust can accumulate shall be avoided in construction.

4.3.6.2 Where such surfaces cannot be avoided, they shall be filled in or roofed with noncombustible material at an angle of not less than 45 degrees.

4.3.7* Explosion Protection for Equipment. The design of explosion protection for equipment shall incorporate one or more of the methods of protection in 4.3.7(1) through 4.3.7(4).

- (1) Oxidant concentration reduction in accordance with NFPA 69, *Standard on Explosion Prevention Systems*, and Section 4.5 of this standard
 - (a) Under normal operating conditions, the limiting oxidant concentration (LOC) shall be permitted to be as follows:
 - i. 12.0 percent where carbon dioxide is used as the inert
 - ii. 9.3 percent where nitrogen is used as the inert
 - (b) Where oxygen monitoring is used, it shall be installed in accordance with ANSI ISA 84.00.01, *Functional Safety: Instrumented Systems for the Process Industry Sector*.
- (2) Deflagration venting in accordance with NFPA 68, *Standard on Explosion Protection by Deflagration Venting*
- (3) Deflagration pressure containment in accordance with NFPA 69, *Standard on Explosion Prevention Systems*
- (4) Deflagration suppression systems in accordance with NFPA 69, *Standard on Explosion Prevention Systems*