NFPA 655
Standard for Prevention of Sulfur Fires and Explosions

1993 Edition

National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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Standard for

Prevention of Sulfur Fires and Explosions

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This edition of NFPA 655, *Standard for Prevention of Sulfur Fires and Explosions*, was prepared by the Technical Committee on Fundamentals of Dust Explosion Prevention and Control and acted on by the National Fire Protection Association, Inc. at its Annual Meeting held May 24-27, 1993, in Orlando, FL. It was issued by the Standards Council on July 23, 1993, with an effective date of August 20, 1993, and supersedes all previous editions.

The 1993 edition of this document has been approved by the American National Standards Institute.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

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 *NFPA Manual of Style* were incorporated into the 1988 edition.

For this 1993 edition, the Committee has 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, as well as editorial revisions to conform to the NFPA *Manual of Style*.

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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 Technical Committee shall have primary responsibility for documents that are generally applicable to all dusts on the fundamentals of dust explosion prevention. This Committee shall also be responsible for documents on the prevention, control, and extinguishment of fires and explosions in dust collection equipment and in pneumatic conveying equipment.

Contents

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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 Appendix A.

Information on referenced publications can be found in Chapter 6 and Appendix B

Chapter 1 General

1-1 Scope.

1-1.1* This standard shall apply to the crushing, grinding, or pulverizing of sulfur and to the handling of sulfur.

1-1.2 This standard shall not apply to the mining or transportation of sulfur.

1-2 Purpose.

1-2.1 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.

1-2.2 This standard shall not be intended to prevent the use of systems, methods, or devices that provide equivalent protection from fire and explosion, providing that suitable data is available to demonstrate equivalency.

1-3 Retroactivity. This standard applies to facilities on which construction is begun subsequent to the date of publication of this standard. When major replacement or renovation of existing facilities is planned, provisions of this standard shall apply.

1-4 Definitions. For the purpose of this standard, the following terms shall have the meanings given below.

Approved. Acceptable to the "authority having jurisdiction."

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

Authority Having Jurisdiction. The "authority having jurisdiction" is the organization, office or individual responsible for "approving" equipment, an installation or a procedure.

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

Labeled. Equipment or materials to which has been attached a label, symbol or other identifying mark of an organization 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.

Listed. Equipment or materials included in a list published by an organization acceptable to the "authority having jurisdiction" and concerned with product evaluation, that maintains periodic inspection of production of listed equipment or materials and whose listing states either that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

NOTE: The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. The "authority having jurisdiction" should utilize the system employed by the listing organization to identify a listed product.

Shall. Indicates a mandatory requirement.

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

Sulfur Dust.* Any finely divided solid sulfur that presents a fire or explosion hazard.

Chapter 2 Handling Finely Divided Sulfur in Bulk

2-1 General.

2-1.1 This chapter shall apply to the production, handling, and processing of finely divided sulfur.

2-1.2 For the purpose of this standard, machinery for crushing and pulverizing sulfur shall be grouped into the following categories:

(a) *Type 1.* Slow-speed primary crushers, such as jaw and roll crushers.

(b) *Type 2.* High-speed primary crushers, such as disk and hammer mills, pulverizers, and fine grinding equipment of all kinds, except Type 4, having a net internal volume of not more than 500 in.^{3} (8193 cm^3).

(c) *Type 3.* Crushers and pulverizers of the Type 2 category, but having an internal volume of more than 500 in.^{3} (8193 cm^3).

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

2-1.3 Operation and maintenance of all crushing and pulverizing machinery shall be under supervision.

2-2 Location, Construction, and Venting of Buildings and Equipment.

2-2.1 Location of Crushing or Pulverizing Machinery and Containers.

2-2.1.1 The enclosed or semienclosed space in which the crushing or pulverizing machinery is located shall be used for no other purpose during the periods when size reduction of sulfur is in progress.

Exception: Containers shall be permitted to be filled with the ground product.

2-2.1.2* Containers shall be removed from the area as soon as possible after being filled. Containers shall not be allowed to accumulate in the area.

2-2.2 Building Construction Requirements for Housing Grinding or Pulverizing Machinery.

2-2.2.1* The enclosed or semienclosed space in which the grinding or pulverizing machinery is located shall be separated from other areas by noncombustible construction. The separating walls shall be designed to withstand the force of an explosion.

2-2.2.2 Openings through floors, walls, and ceilings for necessary pipes, shafts, and conveyors shall be tightly sealed. (*See 2-2.3.1.*)

2-2.3 Protection of Openings.

2-2.3.1 All communications between the space used for grinding and the rest of the building shall be from the outside or via indirect means as described below.

2-2.3.2* Indirect communications through separating walls by means of vestibules or stairways shall be permitted, provided the wall opening to the grinding area is protected by an automatic closing sliding fire door suitable for 3-hr openings, and the opening into the vestibule or stairway is protected by a hinged fire door suitable for 2-hr openings. The two doors shall be installed at right angles to each other. Both doors shall be installed in accordance with NFPA 80, *Standard for Fire Doors and Fire Windows.*

2-2.4* Buildings housing operations that present a dust explosion hazard shall be designed with explosion venting.

2-2.5 All ledges and surfaces on which dust can accumulate shall be avoided in construction. 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.

2-2.6 Explosion prevention or protection shall be provided on all equipment. One of the following methods shall be used:

(a) Equipment can be designed to contain the anticipated explosion pressure.

(b) * Appropriately designed explosion venting can be provided.

(c) An explosion suppression system meeting the requirements of NFPA 69, *Standard on Explosion Prevention Systems,* can be provided.

(d) Inert gas can be used to reduce the oxygen content within the equipment to below the level prescribed by NFPA 69, *Standard on Explosion Prevention Systems.*

2-3* Electrical Wiring and Equipment. All electrical wiring and equipment shall comply with NFPA 70, *National Electrical Code®.* In areas where a dust explosion hazard exists, electrical wiring and equipment shall comply with Article 502 of NFPA 70 .

2-4 Inert Gas.

2-4.1 Use of inert gas is not required for Type 1 machinery.

2-4.2 Type 2 machinery shall be permitted to be operated without inert gas protection if the following requirements are met:

(a) The feed and discharge shall be provided with positive chokes, such as a star feed rotary valve or a screw conveyor with the end flights removed, where directly connected to the machine.

(b) The chokes and all machinery between shall be capable of withstanding an overpressure of 100 lb per in.^{2} (690 kPa).

(c) There shall be an inspection of the machinery at least once per shift during operation to detect abnormalities in operating conditions.

2-4.3 Type 3 machinery shall not be operated without the use of an inert gas system meeting the requirements of NFPA 69, *Standard on Explosion Prevention Systems.* Where the pulverized sulfur is removed from the machinery by blower or exhaust systems, inert gas protection shall extend to all piping and collectors.

2-4.3.1 Under normal operating conditions, the reduction in oxygen content shall be to 12 percent for carbon dioxide systems and to 9.3 percent for nitrogen systems.

2-4.3.2* The inert gas system shall be equipped with sampling and recording instruments to obtain a reliable and continuous analysis of the inert atmosphere in that part or parts of the machinery where the inert atmosphere is normally weakest.

2-4.3.3 Provisions shall be made for automatically shutting down the pulverizing machinery if the oxygen content of the inert atmosphere rises above the maximum levels stated in 2-4.3.1.

2-4.4* Type 4 machinery shall be permitted to be operated without inert gas protection if the following requirements are met:

(a) Manually operated valves shall be installed at each machine for control of feed and air lines.

(b) * The equipment shall be under supervision during operation and shall be shut down for detailed inspection and any necessary cleaning when abnormalities in operation indicate the possibility of fire within the machine.

(c) All valves shall be closed before opening the machine.

2-4.5 Auxiliary dust collectors shall be installed according to the requirements of 2-5.5.

2-5 Conveyors and Collectors.

2-5.1 Only conveyors or spouts with positive seals, such as star feed rotary valves or screw conveyors with the end flights removed, shall be permitted to pass through a fire partition separating crushing or pulverizing rooms from adjacent spaces. The chokes or seals shall be located so as to prevent flame propagation through the wall.

2-5.2 Conveyors used to feed or discharge sulfur to or from grinding machinery shall be in dusttight housings.

2-5.3 Nonferrous buckets or bucket elevators shall be used where they are housed in ferrous casings.

Exception: In cases where the above requirement is not met, steam shall be blown into the elevator boot while the elevator is in operation or an inert gas system meeting the requirements of 2-4.3 shall be used.

2-5.4 Pneumatic conveying systems shall be designed in accordance with NFPA 650, *Standard for Pneumatic Conveying Systems for Handling Combustible Materials.* Each pulverizer shall have a separate and self-contained system.

2-5.5 Dust Collection Systems.

2-5.5.1 Where dust collectors are not protected according to 2-2.6, they shall be isolated in any of the following locations:

(a) On the roof,

(b) Outside and adequately detached from buildings,

(c) In separate rooms provided with explosion venting,

(d) In separate buildings provided with explosion venting,

(e) In isolated penthouses provided with explosion venting.

2-5.5.2 Manifolding of ducts serving dust collection systems shall not be permitted.

Exception No. 1: Dust collection ducts from a single piece of equipment or from multiple pieces of equipment that are not isolated from each other need not be manifolded.

Exception No. 2: Dust collection ducts from single, isolated pieces of equipment shall be permitted to be manifolded if each duct is equipped with a suitable isolation device prior to manifolding. (See NFPA 69, Standard on Explosion Prevention Systems.)

2-5.5.3 Dust collectors shall be constructed of noncombustible materials.

Exception: Filter media need not be of noncombustible material if provided with tight metal enclosures or their equivalent.

2-5.5.4 Recycling of air from dust collectors back to buildings shall not be permitted.

2-6 Prevention of Ignition.

2-6.1* Approved magnetic separators of the permanent magnet or self-cleaning electromagnetic types or approved pneumatic separators shall be installed ahead of all Types 2, 3, and 4 machines. The installation shall be designed to ensure removal of all ferrous material from the sulfur.

2-6.2 All machinery shall be installed and maintained in such a manner that the possibility of frictional sparks is minimized.

2-6.3 Interlocking controls shall be installed to stop the dust feed if the pulverizer stops or if the fans or blowers stop for any reason.

2-6.4* All machinery, conveyors, housings, and collectors shall be thoroughly bonded and grounded to prevent the accumulation of static electricity.

2-6.5 All open flames, smoking, and matches shall be prohibited in enclosures containing crushers and pulverizers. Unprotected hot surfaces, such as steam lines, that can attain temperatures high enough to melt and ignite sulfur dust shall not be exposed in enclosures housing sulfur processing equipment.

Exception: Repairs involving open flames, such as cutting or welding, heat, or hand or power tools, shall be made only after all operations have ceased and all sulfur has been removed from the vicinity or protected in tight noncombustible containers. Cutting and welding procedures shall be carried out according to the requirements of NFPA 51B, Standard for Fire Prevention in Use of Cutting and Welding Processes.

2-6.6 Powder-Operated Tools.

2-6.6.1 Powder-operated tools shall not be used where combustible dust or dust clouds are present. When the use of such tools becomes necessary, all dust-producing machinery in the area shall be shut down, all equipment, floors, and walls shall be cleaned thoroughly, and all accumulations of dust removed.

2-6.6.2 After such work has been completed, a check shall be made to ensure that no cartridges or charges have been left on the premises where they could enter equipment or be accidently discharged after operation of the dust-producing or dust-handling machinery is resumed.

2-7 Housekeeping.

2-7.1* Good housekeeping is of utmost importance. Equipment shall be designed, maintained, and operated in a manner that will minimize the escape of dust. Accumulations of escaped dust shall not be tolerated in the buildings.

2-7.2* Bulk accumulations of fine sulfur shall be removed by soft push brooms and nonsparking scoops or shovels before vacuum cleaning equipment is used.

2-7.3 Cleaning shall be permitted to be done by vacuum sweeping devices. If vacuum apparatus is used, either stationary or portable types shall be properly grounded and checked for electrical continuity from pickup nozzle to piping system. Such equipment, if electrical, shall be of a class approved for use in atmospheres containing sulfur dust. (*See Section 2-3.*)

2-7.4 Blowing down of any surfaces by compressed air shall be prohibited.

2-8 Fire Fighting.

2-8.1* Fog nozzles shall be used when fighting fires in finely divided sulfur.

2-8.2* Steam and inert gases can be used as extinguishing agents for tightly closed containers provided that the sulfur dust is not disturbed.

2-8.3 In all cases, it shall be made certain that the fire is completely extinguished before disturbing the dust and that the sulfur has cooled sufficiently to prevent reignition.

2-8.4* When grinding or other processing equipment is opened for cleaning following an ignition, the feed, discharge, and other openings shall first be closed by suitable metal valves or gates.

2-8.5* At least two self-contained breathing apparatus shall be made available for use in case of sulfur fires. All respiratory equipment shall be inspected at regular intervals and kept in working order at all times.

Chapter 3 Handling Coarse Sizes of Sulfur in Bulk

3-1* Handling in the Open or in Semienclosed Spaces.

3-1.1* Conveying machinery shall be bonded and grounded to prevent the accumulation of static electricity.

3-1.2 Flames, smoking, and matches shall be prohibited in such areas. Cutting and welding operations shall be permitted for repair work, provided due precautions are taken against ignition of dust. (*See NFPA 51, Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes.*)

3-2 Handling in Enclosed Spaces.

3-2.1 Handling of bulk sulfur in enclosed spaces shall be done in such a manner that the formation of dust clouds is minimized.

3-2.2* All enclosures shall be constructed of noncombustible materials and designed so that ledges on which dust can settle are minimized. Where such surfaces are unavoidable, they shall be roofed at a steep angle.

3-2.3 Where sulfur is transferred or dumped from one container to another, dusttight housings with sufficient inward air movement to prevent escape of dust shall be provided. Where mechanical exhaust systems are used to provide this air movement, the systems shall comply with NFPA 91, *Standard for Exhaust Systems for Air Conveying of Materials.*

3-2.4* Handling Sulfur in Elevators and Conveyors.

3-2.4.1 All elevators and conveyors that agitate the sulfur being transported, such as screw conveyors and bucket elevators, shall be enclosed in dusttight casings and shall be equipped with explosion venting.

3-2.4.2 Where bucket elevators are housed in ferrous casings, the buckets or bucket conveyors shall be nonferrous.

Exception: In cases where this is impractical, steam shall be blown into the elevator boot while the elevator is in operation or the elevator shall be protected by an inert gas system.

3-2.5* All metal parts of machinery, casings, bins, and spouts shall be bonded and grounded to prevent the accumulation of static electricity.

3-2.6 All electrical wiring and equipment installed in locations classified as Class II shall comply with Article 502 of NFPA 70, *National Electrical Code.*

3-2.7 All open flames, smoking, and matches shall be prohibited within enclosures where sulfur is handled. Heating shall be by indirect means. Exposed hot surfaces, such as steam lines, shall be avoided within the enclosure.

3-2.8 Care shall be taken to minimize static or settled dust within enclosures and semienclosures. Accumulations of static dust shall be removed promptly and in such a manner as to prevent formation of dust clouds.

3-2.9 Repairs involving the use of flames, heat, or hand or power tools shall be made only after all operations have ceased. Where practical, all sulfur shall be removed or protected in tight containers. Where this is not practical, the sulfur shall be wet down and a hose line with spray nozzle provided.

3-2.10 Powder-operated tools shall not be used unless all dust-producing machinery is shut down, and all equipment, floors, and walls have been carefully cleaned. All bulk sulfur piles or dust accumulations shall be removed or thoroughly wet down. A careful check shall be made to ensure that no cartridges or charges have been left on the premises where they could enter equipment or be accidentally discharged after operation of the dust-producing or dust-handling machinery is resumed.

3-3* Fire Fighting.

3-3.1 Fires in enclosures shall be fought according to the provisions of Section 2-8. Since bulk sulfur contains only a small proportion of fines, coarser hose streams shall be permitted to be used.

3-3.2 Incipient fires in storage piles can be smothered by gently shoveling sulfur onto them.

Chapter 4 Handling of Liquid Sulfur at Normal Handling Temperatures

4-1* General. This chapter applies to the handling of liquid sulfur in the temperature range of 246°F to 309°F (119°C to 154°C).

4-2 Detection of Unsafe Conditions.

4-2.1* Devices for measuring the concentration of combustible gas in the atmosphere over liquid sulfur shall be designed for operation in atmospheres containing hydrogen sulfide. Instruments used for detecting explosive atmospheres shall be capable of measuring the lower explosive limit of hydrogen sulfide, since it is the primary gas evolved from sulfur that can contribute to an explosive atmosphere.

4-2.2 Operations shall be discontinued whenever instruments show a combustible gas concentration of 35 percent or more of the lower explosive limit in the gas space of liquid sulfur containers. Operations shall not be resumed until the instruments indicate a concentration of 15 percent or less of the lower explosive limit.

4-3 Operating Precautions and Equipment Design.

4-3.1 The use of open flames, electric spark-producing equipment, and smoking materials shall be prohibited in the vicinity of liquid sulfur containers.

4-3.2 Liquid sulfur storage tanks shall be designed with fill lines that extend to near the tank bottom so that the incoming sulfur enters the tank below the surface of the sulfur in the tank, thereby minimizing agitation and release of hydrogen sulfide.

4-3.3 Covered storage tanks shall be provided with heated vent systems to provide natural venting of hydrogen sulfide. Vent systems shall be maintained at a temperature above the melting temperature of sulfur.

4-3.4* Sulfur lines and storage tanks shall be bonded and grounded to prevent accumulation of static electricity. Grounding connections shall be provided for the bonding of liquid sulfur tanks and tank cars being loaded or unloaded.

4-3.5* In pits used for melting sulfur and in liquid storage tanks, the liquid level shall not be permitted to expose the heating coils. The liquid level shall always cover the heating coils in pits used for melting sulfur.

4-4 Fire Fighting.

4-4.1* Covered liquid sulfur tanks shall be provided with a steam extinguishing system or an inert gas system in accordance with NFPA 86, *Standard for Ovens and Furnaces*, and NFPA 69, *Standard on Explosion Prevention Systems*.

Exception: Where liquid sulfur containers can be rapidly sealed to exclude air, the SO_2 produced will smother the fire. In such cases, steam extinguishing systems or inert gas systems shall not be required. The system shall be allowed to cool below 309°F (154°C) before reopening.

4-4.2* Where a fixed inerting system is used, thin corrosion-resistant rupture discs shall be placed over the inerting nozzles so that sulfur cannot condense within the nozzle.

4-4.3 Liquid sulfur stored in open containers shall be permitted to be extinguished with a fine water spray. Use of high-pressure hose streams shall be avoided. Quantity of water used shall be kept to a minimum.

Chapter 5 Handling of Liquid Sulfur and Sulfur Vapor at Temperatures above 309°F (154°C)

5-1 General.

5-1.1 This chapter shall apply to liquid sulfur and its vapors when heated in closed containers to temperatures above 309°F (154°C).

5-1.2 The requirements of Chapter 4 shall apply.

5-2 Operating Precautions and Equipment Design.

5-2.1 Equipment shall be designed to be closed as tightly as possible to prevent escape of vapor and to exclude air from the system during operation.

5-2.2 Process equipment shall be provided with adequate explosion rupture discs. The rupture discs shall relieve into vent pipes or ducts that lead directly to the outside of the building or away from the process equipment. The vent pipes or ducts shall be heated to prevent condensation of sulfur vapor.

5-2.3 An adequate supply of a suitable inerting agent such as steam shall be available at all times for blanketing and purging equipment.

5-2.4 All buildings or enclosures for such processes shall be of noncombustible construction.

5-2.5* All electrical wiring and equipment installed in areas handling liquid sulfur shall meet the requirements of Article 501 of NFPA 70, *National Electrical Code*.

5-2.6 Where sulfur is vaporized and subsequently condensed to sulfur dust, handling of the finely divided sulfur from the process shall comply with the requirements of Chapter 2.

Chapter 6 Referenced Publications

6-1 The following documents or portions thereof are referenced within this standard and shall be considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

6-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 51B, *Standard for Fire Prevention in Use of Cutting and Welding Processes*, 1989 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 1992 edition.

NFPA 70, *National Electrical Code*, 1993 edition.

NFPA 80, *Standard for Fire Doors and Fire Windows*, 1992 edition.

NFPA 86, *Standard for Ovens and Furnaces*, 1990 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Materials*, 1992 edition.

NFPA 650, *Standard for Pneumatic Conveying Systems for Handling Combustible Materials*, 1990 editiion.

Appendix A Explanatory Material

This Appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

A-1-1.1 Sulfur differs from most other combustible dusts found in industry in that it has relatively low melting and ignition points. Depending on purity, sulfur melts at or slightly below 246°F (119°C). The ignition temperature of a dust cloud is 374°F (190°C); the ignition temperature of a dust layer is 428°F (220°C). Dilution of sulfur with inert solids is not effective in raising the ignition temperature.

Sulfur is handled and processed in the liquid and vapor states in some cases. The liquid is highly combustible and the vapor is explosive when mixed with air in the proper proportions.

The finely divided sulfur produced during crushing and pulverizing is the most hazardous from an explosion standpoint. Also, mixtures containing finely divided elemental sulfur may be just as hazardous if the sulfur is present in sufficient quantity. Some explosion and fire hazards also accompany the handling and processing of sulfur in bulk in coarse sizes due to the fine dust present.

A-1-4 Sulfur Dust The Committee is aware of data contained in R. K. Eckhoff's book *Dust Explosions in the Process Industries*, Table A1, pg. 582, which reported positive explosion test results of a sulfur dust cloud with a median particle size of 120 microns as being explosible.

A-2-1.2(d) The grinding in Type 4 machines is accomplished by attrition of the particles on themselves. Power for moving the particles is furnished by compressed air or other fluid suitable to the material being pulverized.

A-2-2.1.2 It is not the intent of this requirement to prohibit interim storage of bags, drums, or filled containers.

A-2-2.2.1 The grinding space should preferably be detached. Exterior walls may have to be provided with explosion venting. Steel frame construction, with light, nonbearing exterior walls and light roof, is preferable.

A-2-2.3.2 It is recommended that an emergency escapeway for personnel be provided independently.

A-2-2.4 See NFPA 68, *Guide for Venting of Deflagrations*.

A-2-2.6(b) See NFPA 68, *Guide for Venting of Deflagrations*, for design information on the subject.

A-2-3 Although sulfur is not now included in atmospheres classified as Class II, Group G, it has been the experience of the sulfur industry that such equipment can be suitable. However, consideration should be given to the melting point of sulfur 233°F to 246°F (112°C to 119°C) in the selection of heat-producing electrical equipment.

A-2-4.3.2 Auxiliary instrumentation should be provided for sampling and recording the quality of the inert atmosphere in other parts of the system.

A-2-4.4 The large volumes and high velocities of air and the compactness of the Type 4 unit make inerting usually impractical.

A-2-4.4(b) Flooding with inert gas or steam, combined with delayed opening to permit smothering of any residual fire, is recommended.

A-2-6.1 It must be recognized that magnetic separators will not remove nonferrous tramp material, including stones, brick, and concrete. Every care, using other means, should be taken to ensure excluding such materials from the grinding system.

A-2-6.4 See NFPA 77, *Recommended Practice on Static Electricity*, for information on the subject.

A-2-7.1 It is recommended that the interior of crushing, pulverizing, and packaging rooms or buildings be painted a color that contrasts with the color of the dust.

A-2-7.2 Push brooms should have natural bristles.

A-2-8.1 Straight streams from hoses or extinguishers should not be used, as a cloud of dust can be raised that will explode on contact with the fire.

A-2-8.2 If a container is closed tightly and the volume of oxygen enclosed is not too large, a fire will be smothered by the sulfur dioxide formed.

A-2-8.4 A period of at least 15 minutes should elapse between closing the valves or gates and opening the equipment to smother any residual fire in the equipment. As an added precaution, the equipment should be flooded with inert gas or steam, if available, prior to opening.

A-2-8.5 Gas masks approved for acid gases will not provide adequate protection in a serious sulfur fire. Self-contained breathing apparatus of the pressure demand type should be used.

A-3-1 Clouds of fine sulfur dust arising during the handling of bulk sulfur in the open or in semienclosed spaces are potentially dangerous. Arrangements should be such that they will not contact sources of ignition.

A-3-1.1 See NFPA 77, *Recommended Practice on Static Electricity*, for information on the subject.

A-3-2.2 Direct ventilation of enclosed spaces is recommended.

A-3-2.4 See NFPA 68, *Guide for Venting of Deflagrations*, for information on the subject.

A-3-2.5 See NFPA 77, *Recommended Practice on Static Electricity*, for information on the subject.

A-3-3 Automatic sprinkler protection is recommended for enclosures in which sulfur is stored or handled.

A-4-1 The normal handling temperature of liquid sulfur is 250°F to 309°F (121°C to 154°C), which is slightly above the melting point of 246°F (119°C). At this temperature, the vapor concentration above pure sulfur, free of hydrocarbons or hydrogen sulfide, is too low to form an explosive mixture in air. While the flash point of liquid sulfur varies with purity, it is always higher than the normal handling temperature. For pure sulfur, the flash point is about 370°F (188°C); for relatively impure crude sulfur, the flash point may be as low as 334°F (168°C).

The relatively low ignition temperature of sulfur and the possible presence of hydrogen sulfide are the primary fire and explosion hazards of liquid sulfur. Impure sulfur contains hydrocarbons, which react slowly with liquid sulfur to form hydrogen sulfide. Recovered sulfurs, such as those produced from hydrogen, often contain dissolved hydrogen sulfide. Hydrogen sulfide is quite soluble in liquid sulfur and will be liberated very slowly from a quiescent body of liquid sulfur. However, agitation of the sulfur can cause rapid evolution of hydrogen sulfide, which may create an explosive atmosphere within a storage tank. (In the temperature range at which liquid sulfur is normally handled, the lower explosive limit for hydrogen sulfide in air is about 3.4 percent, compared to 4.3 percent at room temperature.)

Pure sulfur will not generate an explosive atmosphere in the normal temperature range of the liquid.

A-4-2.1 The sensing elements of some explosimeters are not designed for and are adversely affected by hydrogen sulfide-containing atmospheres.

A-4-3.4 See NFPA 77, *Recommended Practice on Static Electricity*, for information on the subject.

A-4-3.5 Pyrophoric iron sulfide compounds may form from impurities in the sulfur. When heating coils are exposed to air, ignition may occur.

A-4-4.1 The inert gas must be applied rapidly enough to displace the ventilation air from the vents. Steam may be generated through the application of water through fog nozzles. Open vents should be available to prevent the buildup of steam pressure.

A-4-4.2 Sulfur flour may cause a dust explosion if it is ejected from the nozzles ahead of the inerting agent.

A-5-2.5 Due to the potential for release of dissolved hydrogen sulfide, molten sulfur handling systems require a Class I, Group C, classification for confined areas.

Appendix B Referenced Publications

B-1 The following documents or portions thereof are referenced within this standard for informational purposes only and thus should not be considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

B-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 51, *Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes*, 1992 edition.

NFPA 68, *Guide for Venting of Deflagrations*, 1988 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 1992 edition.

NFPA 77, *Recommended Practice on Static Electricity*, 1993 edition.

B-1.2 Other Publications.

Eckhoff, R. K., *Dust Explosions in the Process Industries*, Oxford, England:Butterworth-Heinemann Ltd., 1991.