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Standard for

the Prevention of

SULFUR FIRES AND EXPLOSIONS

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The National Fire Protection Association was organized in 1896 to promote the science and improve the methods of fire protection and prevention, to obtain and circulate information on these subjects and to secure the cooperation of its members in establishing proper safeguards against loss of life and property by fire. Its membership includes two hundred national and regional societies and associations (list on outside back cover) and seventeen thousand individuals, corporations, and organizations. Anyone interested may become a member; membership information is available on request.

This pamphlet is one of a large number of publications on fire safety issued by the Association including periodicals, books, posters and other publications; a complete list is available without charge on request. All NFPA standards adopted by the Association are published in six volumes of the **National Fire Codes** which are re-issued annually and which are available on an annual subscription basis. The standards, prepared by the technical committees of the National Fire Protection Association and adopted in the annual meetings of the Association, are intended to prescribe reasonable measures for minimizing losses of life and property by fire. All interests concerned have opportunity through the Association to participate in the development of the standards and to secure impartial consideration of matters affecting them.

NFPA standards are purely advisory as far as the Association is concerned, but are widely used by law enforcing authorities in addition to their general use as guides to fire safety.

Definitions

The official NFPA definitions of shall, should and approved are:

SHALL is intended to indicate requirements.

SHOULD is intended to indicate recommendations, or that which is advised but not required.

APPROVED refers to approval by the authority having jurisdiction.

Units of measurements used here are U. S. standard. 1 U. S. gallon = 0.83 Imperial gallons = 3.785 liters.

Approved Equipment

The National Fire Protection Association does not "approve" individual items of fire protection equipment, materials or services. The standards are prepared, as far as practicable, in terms of required performance, avoiding specifications of materials, devices or methods so phrased as to preclude obtaining the desired results by other means. The suitability of devices and materials for installation under these standards is indicated by the listings of nationally recognized testing laboratories, whose findings are customarily used as a guide to approval by agencies applying these standards. Underwriters' Laboratories, Inc., Underwriters' Laboratories of Canada and the Factory Mutual Laboratories test devices and materials for use in accordance with the appropriate standards, and publish lists which are available on request.

SULFUR FIRES AND EXPLOSIONS

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This standard, adopted at the NFPA Annual Meeting, June 1-5, 1959, was first presented by the Committee on Dust Explosion Hazards as a progress report in 1938 and tentatively adopted in 1939. The 1939 draft was revised and adopted by the Association in 1940. Amendments recommended by the committee were adopted by the NFPA in 1946, 1947 and an extensive revision was adopted in 1959. It was approved as American Standard by the American Standards Association in 1943 and reapproved with amendments in 1946. ASA No. Z12.12. The current edition is being submitted to the ASA for approval.

Amendments Adopted in 1959

Extensive revisions were primarily editorial in nature, and the general pattern of the requirements is essentially unchanged.

* Serving in a personal capacity.

STANDARD FOR THE PREVENTION OF SULFUR FIRES AND EXPLOSIONS

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CHAPTER 1. INTRODUCTION

11. Scope and Application.

1101. The standard applies only to buildings erected and equipment installed subsequent to the adoption of this Standard.

1102. This standard is designed for application to new installations and when making alterations or extensions to existing equipment. Although it is not retroactive, it is recommended as an advisory guide for operators who may wish to avail themselves of the information herein, to improve existing plants.

1103. For the purpose of this standard sulfur is considered to be a flammable solid at temperatures below the melting point and a flammable, volatile liquid at higher temperatures. This standard is issued as a guide to eliminate or reduce the hazard of explosion and fire inherent in the processing and handling of sulfur in industry. It applies to the crushing, grinding or pulverizing of sulfur, and to certain specific operations in handling of sulfur; it does not apply to the mining or transportation of sulfur.

1104. The finely divided sulfur produced during crushing and pulverizing is the most hazardous from an explosion standpoint. Chapter 2 of this standard gives safety precautions for the production, handling, and processing of this fine material. The requirements of Chapter 2 apply also to the preparation and handling of mixtures containing finely divided elemental sulfur in sufficient quantity to render the dust of the mixture flammable as determined by industrial experience or approved laboratory test; this application is limited to mixtures in which sulfur is the only flammable constituent.

1105. Some explosion and fire hazards accompany the handling and processing of sulfur in bulk in coarse sizes because of the fine dust present with the coarser material. Chapter 3 gives recommended safety practices for handling such bulk material.

1106. Sulfur is handled and processed in liquid and vapor forms in some cases. The liquid is highly flammable and the vapor is explosive when mixed with air in the proper proportions. Recommended safety precautions in handling sulfur in the liquid and vapor phases are given in Chapter 4.

12. Properties of Sulfur.

1201. Sulfur differs from most other flammable dusts found in industry by having relatively low melting and ignition points. Depending on the purity, sulfur melts at or slightly below 119°C. (246°F.), and the ignition temperature of dust clouds varies upward from approximately 190°C. (374°F.).

NOTE: Sulfur should not be handled or stored in the presence of chlorates, nitrates and other oxidizing materials. (See NFPA No. 49, the Table of Common Hazardous Chemicals.*)

13. Qualifications of Personnel.

1301. The installation, operation, and maintenance of machinery for handling sulfur and particularly for crushing or pulverizing it, should be under the supervision of persons qualified by experience in the design, construction, and operation of such equipment, with particular reference to the material that will be handled.

14. Definitions.

In this Standard the following words are used as defined below:

SHALL is intended to indicate requirements.

SHOULD is intended to indicate recommendations, or that which is advised but not required.

MAY shall be understood as permissive.

APPROVED refers to approval by the authority having jurisdiction.

*See Appendix for availability.

CHAPTER 2. CRUSHING AND PULVERIZING

21. General.

2101. Chapter 2 of this standard applies to the production, handling and processing of finely divided sulfur.

2102. Machinery for crushing and pulverizing sulfur is grouped in this standard into the following four types:

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

Type 2. High-speed primary crushers (such as disk and hammer crushers), pulverizers, and fine grinding equipment of all kinds, except Type 4, having a free internal volume of not more than 500 cubic inches.

Type 3. Crushers and pulverizers similar to Type 2 but having an internal volume greater than 500 cubic inches. This does not include pulverizers described as Type 4.

Type 4. Pulverizers that do not depend upon moving parts for their disintegrating action. The grinding in this type pulverizer is largely accomplished by the 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.

2103. Operation and maintenance of all crushing and pulverizing machinery shall be under competent supervision.

22. Location, Construction and Explosion Venting of Buildings.

2201. The provisions of Article 22 of this standard apply to the production of finely divided sulfur in enclosures or in semienclosed spaces. Sections dealing with venting of buildings apply to enclosures only.

2202. The enclosure or semienclosed space in which any of the four types of machinery described in Section 2102 is used for preparation or air classification of finely divided sulfur shall be used for no other purpose during the period when grinding is in progress, except that containers may be filled with the ground product. Such filled containers shall not be kept in the space with the grinding machinery, but shall be removed as soon as practicable after being filled and no accumulation of filled containers shall be allowed in the space

used for grinding. The grinding space should preferably be detached, but where this is not practicable it shall be separated from other enclosed or semienclosed spaces by a masonry or concrete fire wall containing, if possible, no openings other than those necessary for the passage of pipes, shafting, and conveyors. (See Section 2501 for limitation on conveyors.) Where this type of construction is used, care shall be taken to vent other walls of the enclosure so that the fire wall will not be destroyed by the force of an explosion. Where a fire wall is not required but separation is desired a strong steel frame carrying metal lath and cement plaster on both sides may be substituted for masonry or concrete.

2203. Where feasible, all communications between the space used for grinding and the rest of the building shall be from the outside. In cases where this method of access is not feasible in enclosed spaces, indirect communications through separating walls by means of vestibules or stairways may be permitted, provided the wall opening is protected by an automatic sliding fire door approved for Class A situations and the vestibule or stairway opening by a heavy closed hinged fire door approved for Class B situations and at right angles to the sliding door, or there is provided other suitable protected indirect communication approved by the authority having jurisdiction. It is recommended that an emergency escapeway for personnel be provided independently. (See NFPA No. 80, Standard for the Installation of Fire Doors and Windows.*)

2204. All enclosures in which fine grinding is done shall be constructed of noncombustible materials. Steel frame construction, with light nonbearing exterior walls and light roof, is preferable.

2205. Buildings housing operations where dust hazards exist shall have approved explosion vents, or at least one exterior wall constructed of thin glass or similar material offering no greater resistance to explosions than thin glass. Door openings along loading platforms shall be of light construction if they are to be considered as venting areas. Windows should be equipped with explosion venting hardware. Refer to NFPA No. 68, Explosion Venting Guide,* for further information on venting, including vent ratio recommendations.

*See Appendix for availability.

2206. Interior and overhead ledges on which dust may accumulate shall be avoided in construction throughout. Where unavoidably present they shall be filled in or roofed with noncombustible material at an angle not less than 45 degrees from the horizontal.

23. Electrical Equipment.

2301. Electrical equipment in spaces containing grinding equipment shall be of a class approved for use in atmospheres containing sulfur dust.

NOTE: Although sulfur is not now included in atmospheres classified as Class II Group G, it has been the experience of the sulfur industry that electrical equipment meeting the requirements for installation in Class II Group G locations is satisfactory. (See NFPA No. 70, the National Electrical Code.*)

2302. Provision shall be made for remote control of electric current for both light and power serving spaces in which there is production, handling and processing of finely divided sulfur.

24. Inert Gas.

2401. Use of inert gas is not required with Type 1 machinery.

2402. Type 2 machinery may be operated without inert gas provided that:

(a) The feed and discharge are provided with positive chokes (such as star feeder revolving damper, or screw conveyor with end flights removed from conveyor) where directly connected to the machine.

(b) The chokes and all machinery between are capable of withstanding a bursting pressure of 100 pounds per square inch.

(c) There is frequent inspection of the machinery during operation to detect abnormalities in operating conditions.

2403. When grinding or other processing equipment must be opened for cleaning following an ignition in it, the feed, discharge and other openings shall first be closed by

*See Appendix for availability.

suitable metal valves or gates. A period of at least 15 minutes should elapse between closure and opening to smother any residual fire in the machine. As an added precaution the equipment should be flooded with inert gas, if available, or with steam, prior to its being opened for inspection and cleaning.

2404. Type 3 pulverizing equipment shall not be operated without use of inert gas as defined and recommended by NFPA No. 69, Inerting for Fire and Explosion Prevention.* Where the pulverized sulfur is removed from this machinery by blower or exhaust systems, inert gas shall be used in all piping and collectors, as in the grinding equipment itself. The percentage of oxygen in the circulating atmosphere shall be kept below 11 (eleven) per cent, and complete coverage of the system is essential.

NOTE: Inerting by reduction in oxygen content is usually accomplished by introducing flue gas made by burning a suitable fuel. The composition of the resulting "inert" mixture varies with the kind of fuel used. Control, by analysis for carbon dioxide (CO_2), is common practice. Therefore, it is recommended that, to hold the oxygen content of the circulating atmosphere under 11 per cent, the CO_2 content therein must be over 9 per cent, if from coal; over 7.5 per cent, if from fuel oil; or over 6 per cent, if from natural gas.

2405. The inert gas system shall be equipped with suitable sampling and recording instruments to obtain a reliable and continuous analysis of the inert gas in that part, or parts, of the equipment where because of pressure conditions, the inertness is normally weakest. Auxiliary instruments should be provided for sampling and recording the quality of the inertness in other parts of the system.

2406. Provision shall be made for the automatic stopping of the machinery when the oxygen content of the gas rises above 11 per cent.

2407. Type 4 machinery (air mills), may be operated without the use of inert gas. The large volume of air, high velocities of air, and compact mill units, combine to make inerting with inert gas usually impractical. When inert gas is not used the following requirements shall apply:

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

*See Appendix for availability.

(b) The equipment shall be under competent observation during operation, and shall be shut down for detailed inspection (and for cleaning if necessary) when abnormalities in operation indicate the possibility of fire within the machine. All valves shall be closed before opening the machine. Flooding with inert gas or with steam, combined with delayed opening to permit smothering of any residual fire, is recommended.

(c) Auxiliary dust collectors shall be installed according to the requirements of Section 2504.

25. Conveyors and Collectors.

2501. Only conveyors or spouts with positive seals or chokes such as star feeder, revolving damper, or screw conveyor with end flights removed, shall be permitted to pass through a fire wall separating crushing or pulverizing rooms from adjoining enclosed spaces. The chokes or seals shall be located in a position to prevent the propagation of flame through the fire wall.

2502. During normal operation of the plant, conveyors used to feed or discharge sulfur to or from grinding machinery shall be in dust-tight housings.

2503. Nonferrous buckets or bucket conveyors should be used where they are housed in ferrous casings. In cases where this is impracticable steam should be blown into the elevator boot while the elevator is in operation, or the system should be operated with inert gas as required in Sections 2404–2406.

2504. When pneumatic conveying systems are used, each pulverizer shall have a separate and self-contained system. Collectors shall be in a separate enclosure or entirely outside the building. Cloth-type collectors shall be protected from mechanical damage by tight metal housings which shall be liberally vented directly to the atmosphere.

2505. Pressure relief vents shall be used liberally on all pulverizing equipment, blower and exhaust systems, elevator heads, and bins into which they discharge. All vent pipes shall lead to outside air by the most direct route. Construction shall be such as to prevent sparks from other operations entering open vent pipes. Such vents, on systems protected by inert gas, may be closed at the normal exit point by suitable covers which will retain the inertness of the system, but which will open freely to vent explosion pressures.

26. Prevention of Ignition.

2601. Approved magnetic separators of the permanent magnet or self-cleaning electro-magnetic types or approved pneumatic separators shall be installed ahead of all crushers and pulverizers of Types 2, 3, and 4. The installation shall be of sufficient size and proper design to insure the removal of all ferrous material from the sulfur to be ground.

NOTE: It must be recognized that magnetic separators will not remove nonferrous tramp material, including stones, brick and concrete. Every care, with other means, should be taken to ensure exclusion of these materials from the grinding system.

2602. All machinery shall be installed and maintained in such condition that the possibility of frictional sparks or heat is reduced to a minimum.

2603. All machinery, conveyors, housings, and collectors shall be thoroughly bonded and grounded in accordance with the recommendations of NFPA No. 77, Static Electricity,* to prevent the accumulation of static electricity.

2604. All open flames, smoking, and matches shall be prohibited in enclosures containing crushers and pulverizers, except as noted in Section 2605. Uncovered hot surfaces, such as steam lines, etc. which may attain temperatures high enough to melt and ignite sulfur dust shall not be exposed in enclosures housing sulfur processing equipment.

2605. Repairs involving flame, heat or use of 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 which will not come in contact with any open flame, spark or other source of heat.

2606. Gun-type tools using powder or cartridges for driving pegs or pins into concrete, brick, steel, etc., shall not be used where flammable dust or dust clouds are present. When the use of this type of equipment becomes necessary all dust producing machinery in the area shall be shut down, all equipment, floors and walls shall be carefully cleaned, and all dust accumulations removed. A careful check shall be made to be sure that no cartridges or charges are left on the premises where they could enter equipment or be accidentally discharged after operation of the dust producing or handling machinery is resumed.

*See Appendix for availability.

27. Housekeeping.

2701. Good housekeeping is of utmost importance. Equipment shall be designed, maintained, and operated in a manner which will minimize the escape of dust. Accumulations of escaped dust shall not be tolerated in the buildings. It is recommended that the interior of crushing, pulverizing and packaging departments be painted a color which is in contrast with that of the dust.

2702. Bulk accumulations of fine sulfur shall be removed by soft push brooms, and nonsparking scoops or shovels, before vacuum sweeping equipment is used.

2703. The cleaning of surfaces may be by vacuum sweeping devices. If vacuum apparatus is used, either stationary or portable type shall be properly grounded and regularly 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.

NOTE: Although sulfur is not now included in atmospheres classified as Class II Group G, it has been the experience of the sulfur industry that electrical equipment meeting the requirements for installation in Class II Group G locations is satisfactory. (See NFPA No. 70, the National Electrical Code.*)

2704. Blowing down of any surfaces by compressed air is prohibited.

28. Fire Fighting.

2801. The use of pressure liquid streams from hoses or extinguishers should be avoided when fighting fire in finely divided sulfur, as a cloud of dust may be raised which will explode in contact with the fire. Fog nozzles may be used. Finely divided water sprays or mists that settle on the sulfur without disturbing it are suitable. Steam and inert gases are excellent extinguishers for use in containers that can be closed tightly, provided that they are introduced in such manner that the sulfur dust is not disturbed. 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. In all cases it should be certain that the fire is fully extinguished before disturbing the dust.

*See Appendix for availability.

2802. It is recommended that two or more gas masks approved for use in acid gases be kept in every establishment which may have to combat a sulfur fire in an enclosure. They should be inspected at regular intervals and kept in working order at all times. Persons who may wear them should be instructed in their use and limitations. Also, at least two air-supplied masks or self-contained breathing apparatus should be available.

CHAPTER 3. HANDLING COARSE SIZES OF SULFUR IN BULK

31. In the Open or in Semienclosed Spaces.

3101. Clouds of fine dust arising during the handling of bulk sulfur in the open or in semienclosed spaces are potentially dangerous and arrangements should be such that they will not come in contact with sources of ignition. Industrial experience indicates that conveying machinery should be bonded and grounded in accordance with the recommendations of NFPA No. 77, Static Electricity,* to prevent the accumulation of static electricity. Flames, smoking and matches should be prohibited in such areas. Cutting and welding equipment may be permitted for repair work when used with due precaution against ignition of dust. (See NFPA No. 51, Standard for the Installation and Operation of Gas Systems for Welding and Cutting.*) Sulfur ignites easily and sparks from locomotives, or other sources, start fires easily. In general, any sources of ignition, including hot surfaces such as steam lines, should be avoided.

32. In Enclosed Spaces.

3201. Handling bulk sulfur in enclosures shall be conducted in such manner as to minimize the formation of clouds of sulfur dust in air.

3202. All enclosures should be of noncombustible construction and so designed as to present a minimum of ledges on which dust may lodge. Where such surfaces are unavoidable, they should be roofed at a steep angle to reduce deposition of dust. Direct ventilation to outdoors is recommended.

3203. It is recommended that nonsparking tools be used wherever sulfur is shoveled or otherwise moved by hand, particularly where the tools may come in contact with concrete, stone, or steel.

3204. Dust may arise at points where sulfur is dumped from one container or carrier to another. Care should be taken to prevent scattering of such dust. Dust-tight housings or hoods with sufficient inward air movement to prevent escape of dust into the surrounding enclosure are recommended

*See Appendix for availability.

where such installation is feasible. Where mechanical exhaust systems are used to provide this air movement, they shall conform to NFPA No. 91, Standard for the Installation of Blower and Exhaust Systems for Dust, Stock and Vapor Removal or Conveying.* The provisions of this Section apply to dumping into or drawing from bins.

3205. All elevators and conveyors which agitate the sulfur being transported (such as bucket elevators and screw conveyors) shall be enclosed in dust-tight casings, and shall be equipped with explosion relief vents. All vent pipes shall lead to outside air by the most direct route with provision against entrance of sparks at the end of the vent. Nonferrous buckets or bucket conveyors should be used where these are in ferrous casings. In cases where this is impracticable steam should be blown into the elevator boot while the elevator is in operation, or the system should be operated with inert gas.

3206. All metal parts of machinery and casings thereof, together with metal parts of bins and spouts, shall be adequately bonded and grounded to prevent the accumulation of static electricity in accordance with the recommendations of NFPA No. 77, Static Electricity.*

3207. All electrical wiring and equipment installed at points where clouds of dust may be formed, shall be of a class approved for use in atmospheres containing sulfur dust.

NOTE: Although sulfur is not now included in atmospheres classified as Class II Group G, it has been the experience of the sulfur industry that electrical equipment meeting the requirements for installation in Class II Group G locations is satisfactory.

3208. All open flames, smoking, and matches shall be prohibited within enclosures. Heating shall be by indirect means, as by steam or preheated air. Exposed hot elements, such as steam lines should be avoided within the enclosure.

3209. Care shall be taken to minimize the presence of static or settled dust within enclosures and semienclosures and to remove dust accumulations when formed, irrespective of their location. The means of removing dust shall be such as to prevent scattering of the dust deposit.

3210. Repairs involving flame, heat or use of hand or power tools shall be made only after all operations have ceased

*See Appendix for availability.

and all sulfur has been removed from the vicinity, or protected in tight containers which will not come in contact with any open flame, spark or other source of heat.

3211. Gun-type tools using powder or cartridges for driving pegs or pins into concrete, brick, steel, etc., shall not be used where flammable dust or dust clouds are present. When the use of this type of equipment becomes necessary all dust-producing machinery in the area shall be shut down, all equipment, floors and walls shall be carefully cleaned, and all dust accumulations removed. A careful check shall be made to be sure that no cartridges or charges are left on the premises where they could enter equipment or be accidentally discharged after operation of the dust producing or handling machinery is resumed.

33. Fire Fighting.

3301. In enclosures the statements of Article 28 are applicable with modifications to meet the particular conditions encountered. As bulk sulfur contains only a small proportion of extreme fines, coarser sprays are permissible. Incipient fires in storage piles can frequently be smothered by gently shoveling more sulfur on them to exclude air. It is recommended that automatic sprinkler systems be installed in all enclosures in which sulfur is stored or handled.

3302. Permanent sprinkler systems should not be constructed of brass, copper or copper alloys. It is recommended that the sprinkler should be of a type that will not become plugged with sulfur dust. Such dust, if overheated before water pressure is applied, might fuse and then solidify in a manner to stop the flow of water.

CHAPTER 4. SULFUR IN THE LIQUID AND VAPOR PHASES

41. Liquid Sulfur.

4101. As a precaution against fire, open flames, electric sparks, and other sources of ignition, including smoking and matches, should be excluded from the vicinity of molten sulfur. The flash point of liquid sulfur varies with purity, and with the test method. Normally, for pure sulfur, the flash point will be approximately 188°C. (370°F.).* Liquid from relatively impure (dark) crude sulfur may have a flash point as low as 168°C. (335°F.).*

4102. Fires in vats or other containers of liquid sulfur can be extinguished by saturated steam, carbon dioxide, or water sprayed over the surface of the liquid. Pressure hose streams which may scatter the burning liquid should be avoided. It is recommended that the quantity of water used be kept to a minimum.

4103. A fire in liquid sulfur can be extinguished readily by closing the container to exclude air; formation of sulfur dioxide quickly exhausts the oxygen in the enclosure and smothers the fire. Where containers of liquid sulfur are of sufficiently small size to permit such action, it is recommended that they be so arranged that they can be sealed rapidly to exclude air in case of fire. Any covers used for this purpose should be constructed entirely of noncombustible material.

4104. Adequate venting by steam-jacketed vent pipes shall be provided in all covered liquid sulfur storage tanks to release any hydrocarbon vapors or hydrogen sulfide gas which may be released from the sulfur. Tanks should be equipped with a filling line designed to permit the liquid to enter the tank below the surface of the liquid inside the tank in a manner that will minimize agitation of the sulfur stream entering the tank, and the sulfur in storage.

42. Sulfur Vapor.

4201. Whenever sulfur in the liquid state is heated to temperatures above its flash point ignitable sulfur vapors are present. The vapor pressure increases with temperature rise

*Flash point determined by modified open cup method.