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DUST EXPLOSION HAZARDS

Subject:

Sulphur Dust Explosions and Fires

1940

This report will be considered at the annual meeting in Atlantic City, May 8-11, 1940, when all those interested will have opportunity to participate in the discussion. Written criticisms may be filed with the chairman previous to the meeting. The report in its present form is not official and may be altered by the Association before adoption.

National Fire Protection Association
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Report of Committee on Dust Explosion Hazards.

(Sectional Committee, American Standards Association)

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[This report has been submitted to ballot of the committee, which consists of twenty-seven voting members, who have unanimously voted affirmatively.]

The committee presents for final adoption a code for the prevention of sulphur dust explosions and fires, which was first presented as a progress report in 1938 (Proceedings 1938, page 431) and tentatively adopted in 1939 (Proceedings 1939, page 307). Changes made in the present report modify the provisions on the use of inert gas for fire and explosion prevention, and certain related matters. The only other changes from the 1939 draft are of a minor editorial character.

In order to complete the treatment of sulphur in this code provisions on the vapor and liquid phases of sulphur are included. Such provisions have been cleared through the N.F.P.A. Committees on Hazardous Chemicals and Explosives, and on Flammable Liquids.

The subcommittee responsible for the original development of this report is as follows:

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CODE FOR THE PREVENTION OF SULPHUR DUST EXPLOSIONS AND FIRES.

Definitions.

In this code certain words are used with the following definitions:

SHALL indicates requirements.

SHOULD indicates recommendations, or that which is advised but not required.

APPROVED refers to approval by the authority having jurisdiction in the enforcement of this code.

The terms ADEQUATELY and SECURELY shall be interpreted as conditions subject to the approval of the inspection department having jurisdiction.

The term ENCLOSURE is used to designate any room or space completely surrounded by walls, roof, and floor. If there is a roof, but no walls, the space is said to be SEMIENCLOSED. All other arrangements of space are said to be OPEN.

Section 1. Introduction.

101. This code is issued as a guide to eliminate or reduce the hazard of explosion and fire inherent in the processing and handling of sulphur in industry. It applies to the crushing, grinding, pulverizing and to certain specific operations in handling of sulphur; it does not apply to mining of sulphur or to transportation in common carriers. This code is designed for application to new installations and when making alterations or extensions to existing equipment. It is not retroactive.

102. The finely divided sulphur produced by crushing and pulverizing is the most hazardous from an explosion standpoint. Section 2 of this code gives safety precautions for the production, handling, and processing of this fine material. The requirements of Section 2 apply also to the prepara-

tion and handling of all mixtures containing finely divided elemental sulphur 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 sulphur is the only flammable constituent.

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

104. Sulphur 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 sulphur in the liquid and vapor phases are given in Section 4.

105. Sulphur is distinguished from most other flammable dusts found in industry by being a chemical element and by having low melting and boiling points. Sulphur melts at 113° C. (235° F.) or 119° C. (246° F.), depending on its crystalline form. The ignition temperature is approximately 261° C. (502° F.)[1]; at this temperature the liquid has a vapor pressure of 0.02 atmosphere. The boiling point is 444.5° C. (832° F.).

106. The installation, operation, and maintenance of machinery for handling sulphur 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.

Section 2. Crushing and Pulverizing.

201. Section 2 of this code applies to the production, handling and processing of finely divided sulphur.

202. Machinery for crushing and pulverizing sulphur is grouped in this code 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.

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

210. Location, Construction and Ventilation of Buildings.

211. The provisions of subsection 210 of this code apply to the production of finely divided sulphur in enclosures or in semienclosed spaces. Paragraphs dealing with venting of buildings apply to enclosures only.

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[1]Value given by Texas Gulf Sulphur Co.

212. The enclosure or semienclosed space in which any of the four types of machinery described in par. 202 is used for preparation or air classification of finely divided sulphur 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 par. 241 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 prevention of spread of fire is not of primary importance, a strong steel frame carrying metal lath and cement plaster on both sides may be substituted for masonry or concrete.

213. 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 inspection department having jurisdiction. (See N.F.P.A. Standards for the Protection of Openings in Walls and Partitions.[2]) It is recommended that an emergency escapeway for personnel be provided independently.

214. 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.

215. To vent possible explosions, a portion of the exterior walls of enclosures equal to not less than 15 per cent of the enclosing walls, or one square foot of wall area for each 80 cubic feet of volume, whichever gives the larger area, shall be approved venting sash or other approved openings designed to open freely under a pressure of 50 pounds per square foot. To avoid opening by high wind, they should not be affected by a pressure of less than 25 pounds per square foot.

216. Ordinary steel window sash having a "center-pivoted" ventilating section can be adapted as an explosion-venting window if the pivoted section is hinged at the top and the fixed glass scored as described in par. 217. The pivoted section should be held closed lightly with a friction-type fastener.

217. The diagonal scoring of double-strength clear glass window lights on the outside with a diamond, starting the scratches about 2 inches from the corners, and leaving a 2-inch gap in the center, reduces the strength of the lights to about one-fifth, so that the scored glass will probably be blown out without severe damage to the steel frame. Wired glass should only be used when necessary as a protection against fire exposure. If used, it shall be in a sash hinged at the top so that it will readily swing out in case

[2]Obtainable from the National Fire Protection Association, 60 Batterymarch Street, Boston, Mass., or the National Board of Fire Underwriters, 85 John Street, New York.

of an explosion. The venting areas should be distributed as uniformly as possible over the exterior walls, but care must be exercised so as to vent the explosion in the direction or directions of minimum potential damage.

218. Additional venting area may be provided by using a roof covering that is as light as practicable, fire resistant, so arranged that it will be easily blown off by an internal explosion, and at the same time weatherproof under normal conditions.

219. 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 incombustible material at an angle not less than 45 degrees from the horizontal.

220. Electrical Equipment.

221. All electrical wiring and equipment in spaces containing grinding machinery shall be in accordance with the requirements of the National Electrical Code for Class II Hazardous Locations.[8]

222. Power for operation of crushers and pulverizers shall be controlled remotely at a readily accessible location as well as at each machine.

230. Inert Gas.

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

232. 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.

233. When a machine must be opened and cleaned following an ignition in it, the feed and discharge shall first be closed by metal valves or gates. It is recommended that a period of 15 minutes elapse between shutting down the machine and opening it to smother any residual fire. It is also recommended that the equipment be flooded with inert gas after it has been shut down and prior to its being opened for inspection and cleaning.

234. Type 3 machinery shall not be operated without use of inert gas as provided in Safety Code for the Use of Inert Gas for Fire and Explosion Prevention issued by the National Fire Protection Association.[8] The percentage of oxygen in the circulating air shall be kept below 11 (eleven) per cent. Where the pulverized sulphur is removed from this machinery by blower or exhaust systems, inert gas shall be used in all piping and collectors as in the machinery itself.

NOTE. Reduction in oxygen content is usually accomplished by the addition of flue gas resulting from the combustion of fuel of some kind. In some cases composition of the mixture is controlled by analysis for carbon dioxide. The amount of carbon dioxide that will be present when the oxygen content is reduced to 11 per cent varies with the kind of fuel used, and the following

[8]Obtainable from the National Fire Protection Association, 60 Batterymarch Street, Boston, Mass., or the National Board of Fire Underwriters, 85 John Street, New York.

percentages of carbon dioxide are recommended when dilution is by flue gas from different types of fuel:

Fuel	*Carbon Dioxide*
Coal	9.0%
Fuel oil	7.5%
Natural gas	6.0%

235. The inert gas system shall be equipped with suitable sampling and recording apparatus to obtain a reliable and continuous analysis of the inert gas in various portions of the equipment including the end of the system.

NOTE: This is important, as the gas pressures are not the same throughout the system, and where a partial vacuum exists, inward leakage of air may create an explosive mixture.

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

237. Type 4 machinery may be operated without the use of inert gas. If inert gas is used with this type of machinery, the regulations pertaining to Type 3 equipment shall apply. If inert gas is not used the following requirements shall apply:

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

(b) The machinery shall be inspected frequently during operation to detect abnormalities in operation and shall be shut down for detailed inspection and (if necessary) for cleaning should there be any indication of an explosion in it. All valves shall be closed before opening the machine, and flooding with inert gas combined with delay to permit smothering of residual fire is recommended.

(c) Auxiliary dust collectors shall be installed according to the requirements of paragraph 244.

240. Conveyors and Collectors.

241. 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.

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

243. 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 paragraphs 234-236.

244. 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.

245. 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 vent pipes.

250. Prevention of Ignition.

251. All sulphur fed to crushers and pulverizers of classes 2, 3, and 4 shall pass over or under an electromagnet having sufficient power to remove all tramp iron from it. The sulphur shall be spread out in a layer of sufficient thinness to expose all iron to the action of the magnet.

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

253. All machinery, conveyors, housings, and collectors shall be thoroughly bonded and grounded in accordance with the recommendations of the National Fire Protection Association Committee on Static Electricity, to prevent the accumulation of static electricity. This includes cloth bags used in collectors.

254. All open flames, smoking, and matches shall be prohibited in enclosures containing crushers and pulverizers, except as noted in paragraph 255.

255. Repairs involving flame or heat shall be made only after all operations have ceased and all sulphur has been removed from the vicinity, or protected in tight containers which will not come in contact with any open flames.

260. Housekeeping.

261. Good housekeeping is a factor of utmost importance. All floors, walls, ledges, and other surfaces of crushing and pulverizing rooms shall be kept clean and free from deposits of static or settled dust. Well designed equipment reduces necessary cleaning, but it is not always possible to maintain absolutely tight systems. Vacuum cleaning is preferable although soft push brooms may be used. When vacuum cleaners are employed bulk accumulation of sulphur shall be removed by soft push brooms and nonsparking scoops or shovels before the vacuum sweeping equipment is used. Portable vacuum-cleaning systems shall be used with care. Trailing cables shall be kept in good condition and so disposed that possibility of damage during operation is at a minimum. Where possible it is recommended that during use the metal parts of the cleaner be grounded by connection to the steel building frame or piping that extends into the ground. Dust collecting bags shall not be emptied near a source of ignition nor in a manner that will scatter the dust. Vacuum cleaning systems using fixed pipes shall have a properly vented dust collector outside the building and removable containers designed to permit disposal of bulk accumulations with a minimum of handling. All metal parts shall be thoroughly grounded. Blowing down dust with compressed air is prohibited. Adequate lighting shall be provided to reveal dust deposits, and it is recommended that all surfaces above the floor be whitewashed or painted white.

270. Fire Fighting.

271. The use of pressure liquid streams from hoses or extinguishers should be avoided when fighting fire in finely divided sulphur, as a cloud of dust may be raised which will explode in contact with the fire. Finely divided water sprays or mists that settle on the sulphur 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 sulphur 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 sulphur dioxide formed. In all cases it should be certain that the fire is fully extinguished before disturbing the dust.

272. 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 sulphur 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.

Section 3. Handling Coarse Sizes of Sulphur in Bulk.

300. In the Open or in Semienclosed Spaces.

301. Clouds of fine dust arising during the handling of bulk sulphur 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 grounded (in accordance with the recommendations of the National Fire Protection Association Committee on Static Electricity) to prevent static electricity acting as a source of ignition in such cases. Flames, smoking and matches should be prohibited in such areas except when needed for repair work and then used with due precaution against ignition of dust. Sulphur ignites easily and sparks from locomotives start fires easily. In general, having any sources of ignition in the vicinity of sulphur during normal operations should be avoided.

310. In Enclosed Spaces.

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

312. 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.

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

314. Dust may arise at points where sulphur 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 where such installation is feasible. Where mechanical exhaust systems are used to provide this air movement, they shall conform to the N.F.P.A. Standards for the Installation of Blower and Exhaust Systems for Dust, Stock, and Vapor Removal.[4] The provisions of this paragraph apply to dumping into or drawing from bins.

[4]Obtainable from the National Fire Protection Association, 60 Batterymarch Street, Boston, Mass., or the National Board of Fire Underwriters, 85 John Street, New York.

315. All elevators and conveyors which agitate the sulphur 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. Non-ferrous 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.

316. All metal parts of machinery and casings thereof, together with metal parts of bins and spouts, shall be adequately grounded to prevent the accumulation of static electricity in accordance with the recommendations of the National Fire Protection Association Committee on Static Electricity.

317. All electrical wiring and equipment installed at points where clouds of sulphur dust may be formed, shall comply with the requirements of the National Electrical Code for Class II Hazardous Locations.

318. All open flames, smoking, and matches shall be prohibited within enclosures. Heating shall be by indirect means, as by steam or preheated air.

319. 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.

320. Repairs involving riveting, oxyacetylene cutting and welding, or other sources of flame or high temperature, shall be conducted only after the surrounding space has been thoroughly cleaned and all sulphur removed from the interior of the machine or container to be repaired.

330. Fire Fighting.

331. In enclosures the statements of par. 270 are applicable with modifications to meet the particular conditions encountered. As bulk sulphur contains only a small proportion of extreme fines, coarser sprays are permissible. Incipient fires in storage piles can frequently be smothered by shoveling more sulphur on them to exclude air. It is recommended that automatic sprinkler systems be installed in all enclosures in which sulphur is stored or handled.

Section 4. Sulphur in the Liquid and Vapor Phases.

400. Liquid Sulphur.

401. 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 sulphur.