FILE NAME: BF Goodrich (BFG)

DATE: 1938

DOC#: BFG057

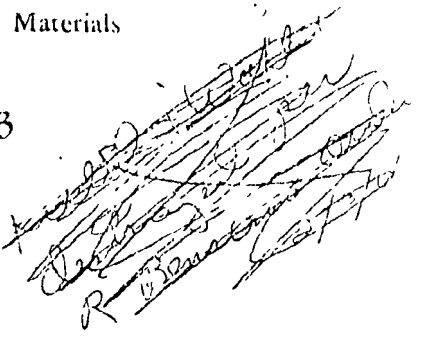
DOCUMENT DESCRIPTION: Report from NSC Industrial Safety Series - Compounding Materials Used in the Rubber Industry

Compounding Materials Used in the Rubber Industry

Part II—Dry Inorganic Substances; Gums, Oils, Resinous Materials and Waxes; Liquids and Gases

Industrial Safety Series No. RU-3

Published by the National Safety Council
20 North Wacker Drive, Chicago



1 This pamphlet is the second of a series of two on "Compounding Materials Used in the Rubber Industry." The first pamphlet, No RU-1, is confined to the classification of organic accelerators, anti-oxidants and dry organic compounds. This pamphlet is confined to the following three groups of compounding materials

Dry inorganic substances
Gums, oils, resinous materials and waxes
Liquids and gases

2 An attempt has been made to list herein alphabetically, in the three above groups, practically all of the usual compounding ingredients used in the manufacture of rubber which are not covered in Pamphlet No. RU-1. It should be realized, however, that new compounding ingredients are constantly being developed and in some cases new and unusual uses are being made of the present ingredients. A brief description of each compounding ingredient is given, together with its use in the rubber industry, its relative health hazards and recommendations for its safe handling from a health viewpoint. Many of the solvents used in compounding rubber are flammable, certain of the dry substances used present a dust explosion hazard, and the use of various oils involves the element of spontaneous ignition. However, the fire hazards of the substances listed are not discussed in detail as those hazards are fully covered in other publications.

This pamphlet is a compilation of experience in accident prevention. It should not be assumed, however, that it includes every acceptable procedure in the field covered. It must not be confused with federal, state or insurance requirements, or with American Standard safety codes.

Dry Inorganic Compounds

3 Most of the compounds in this group are of a soft mineral powder type, of a particle size less than two hundred mesh, many of less than three hundred mesh, or finer. Few of them contain hard or abrasive particles such as silica or corundum. Only a few are toxic. On the whole they are comparatively free from health hazards. However, they are all more or less dusty when handled carelessly, and the ordinary dust hazard is always present. Good storage bins, conveyors, hooded mills, and efficient exhaust systems will readily eliminate the dust hazards and in most cases prevent harm from the toxic or silica bearing compounds. (See also National Safety Council Health Practices Pamphlet No. 4, "Dust," and Safe Practices Pamphlets No. 32, "Exhaust Systems," and No. 64, "Respiratory Protective Equipment.")

4 There are several compounds, however, that should receive special consideration, such as lead or silica-bearing compounds. These are so designated in the following list of materials.

Aluminum Flake

5. A fine cream-colored powder, consisting primarily of aluminum silicate, used as a filler in rubber. It is non-gritty and non-toxic but rather dusty in handling.

Ammonium Carbonate

6. A white crystaline or lumpy powder having a pungent odor of ammonia. It readily decomposes and gives off an irritating odor during mixing. It is used in sponge rubbers. It is slightly toxic, but there is little health hazard as it is handled in the rubber industry.

Antimony Sulphides

7. There are two types, the golden and the red antimony sulphides used for coloring rubber articles. Some grades contain a considerable percentage of free sulphur and calcium sulphate. They are slightly toxic, irritating to the skin and the mucous membranes. Careful handling is required. (See also Industrial Data Sheet D-Chem. 22, "Antimony and Its Compounds.")

Asbestine

8. A fibrous variety of magnesium silicate used in rubber as a filler especially in packings and gaskets. It is white powder, non-gritty and non-toxic. It should be borne in mind, however, that many of these silicates, when not pure, may contain traces of silica and dust should be kept down.

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Asbestos

6. A fibrous magnesium silicate used in many types of rubber goods, especially of the packing and gasket type and where the rubber must withstand considerable heat. It may be obtained in many lengths of fiber, from an inch long to almost a powder, and is usually grayish white in appearance. Suitable exhaust systems or respiratory protective equipment are usually needed to prevent the inhalation of dust by the workers.

Barium Dust

10. A trade name for barium sulphate.

Barium Sulphate

11. A heavy white powder used for reinforcing rubber and also as a filler. It is insoluble in most solvents. It is non-absorbable and non-toxic. There is no hazard in handling, aside from that of dust.

Barytes

12. Commercial name for natural deposits of barium sulphate.

Beckton White

13. A trade name for lithopone.

Bentonite

14. Bentonite is a fine colloidal clay obtained from natural deposits. It consists of a fine grayish-white powder, similar in many characteristics to other clays. Bentonite, however, has the peculiar property of readily hydrolysing when brought in contact with water and swelling to form a jelly-like structure. Small amounts cause a tremendous thickening of water solutions. On account of these properties it is used as a thickening agent and stabilizer for water dispersions of rubber. Because of its activity and absorptive properties when brought into contact with water, care should be taken to prevent inhalation or swallowing of the dust.

Blanc Fixe

15. A trade name for precipitated barium sulphate.

Blue Lead

16. A grayish blue powder used as a mild accelerator and for compounding. A mixture of active lead compounds, and very toxic. (See lead compounds.)

Cadmium Yellow

17. A fine light-yellow powder of cadmium sulphide, used for coloring rubber. It is slightly toxic. It can cause irritation of mucous membranes and also gastritis. Careful handling is required, hands must be kept clean and dust at a minimum in the workplace.

Calcined Magnesia

18. (See magnesium oxide.)

Calcium Chloride

19. White to brownish deliquescent crystals or lumps which are easily soluble in water. This material is not added to the rubber, but is dissolved in water and used as a bath for vulcanizing rubber articles. It is irritating to the skin but non-toxic.

Carbon Black

20. An exceedingly fine dusty black powder. It is used in quantities for tires and many lines of rubber goods as a reinforcing ingredient. The dust is difficult to cope with but is non-toxic.

Carbonate of Ammonia

21. (See ammonium carbonate.)

Carbonate of Magnesia

22. (See magnesium carbonate.)

Caustic Soda

23. Same as sodium hydroxide. It is a white moisture-absorbent substance, usually in the form of sticks, flakes or lumps, and easily soluble in water. It is used as a bath or wash for rubber articles to cleanse, remove bloom, and grease. It is very caustic, disintegrates organic tissue, and should be handled with great care to keep it from contact with the skin and eyes. (See also National Safety Council Safe Practices Pamphlet No. 25, "Acids and Caustics," and Industrial Data Sheet D-Chem. 2, "Handling Caustic Soda.")

Chalk

24. (See whiting.)

China Clays

25. (See clays.)

Chrome Green

26. A green mineral powder used for coloring rubber. The most satisfactory green for rubber work is the oxide Cr_2O_3, which is inert and non-toxic. There are, however, so-called "chrome greens," which are not pure chromium oxide but are mixtures of blue and yellow pigments made up of compounds other than chromium. Such pigments might have toxic properties, especially if they contain lead salts. Such greens are usually unsatisfactory for heat vulcanization of rubber, since they lose their color under high temperatures. Nevertheless, the purity of chrome green should be determined before giving it a clean "bill of health."

Chrome Yellow

27. A deep-yellow powder used for coloring rubber. This is a chromate of lead, although there are also chromates of zinc and barium. The lead salt is the one usually used for rubber and is quite toxic because of the lead it contains. It should be handled with the same precautions as other lead compounds. (See lead compounds.)

Clays

28. There are innumerable clays, varying in colors and ranging from white to black. Those used for rubber compounding are usually the white variety, ranging from white to cream or buff. Most of the clays are fine smooth powders, varying greatly in both chemical and physical properties. They are of natural origin and chemically a hydrous aluminum silicate. They are used as fillers and for reinforcing. The clays are usually non-gritty and non-toxic. A suitable exhaust system or respirator is usually required to protect the respiratory organs.

Crimson Antimony

29. Another name for red antimony sulphide.

Diatomaceous Earth (Celite)

30. A soft earthy rock composed of the siliceous skeletons of small aquatic plants called diatoms. It grinds to a fine powder, extremely light and fluffy, used for filler in rubber compounds. It is non-toxic, but care should be taken to keep down excessive dust. A suitable exhaust system or respirator may be needed.

Emery

31. A fine abrasive powder used with rubber for making erasers and

ary wheels. Basically, it is an aluminum oxide. It is non-toxic but sharp and dangerous to inhale. In its use the same precautions as for silica are required. (Also called corundum.)

Fossil Flour

32 (See diatomaceous earth.)

French Chalk

33 (See talc.)

Fuller's Earth

34 A clay relatively high in magnesia. It is used as a filler in rubber goods and is non-gritty and non-toxic. (See also clays.)

Golden Antimony

35 (See antimony sulphides.)

Graphite

36 A grayish-black soft greasy powder. Used for lubricating rubber moulds and as a filling material for such compounds as gaskets, packings, etc. It is an impure form of native carbon and is also produced artificially. It is non-toxic, but respiratory protection is usually necessary in its use.

Ground Glass

37 A fine powdered glass used for compounding rubber to make erasers and other rubber abrasive utensils. The same precautions should be observed as for silica. It is non-toxic but should not be handled with bare hands because it may cause minute skin lacerations that may become infected.

Gypsum

38 A grayish-white powder used for compounding rubber. It consists of a pulverized natural hydrous calcium sulphate. It is non-gritty and non-toxic, but respiratory protection is necessary in its use.

Hard Rubber Dust

39 A fine ground hard rubber, grayish to black in color, very light and fluffy, and sticks to whatever it touches. Ordinarily it consists mostly of vulcanized hard rubber, which is rubber and sulphur, but it may also contain other mineral or organic substances used in compounding rubber. Dust should be kept down, but the material is not toxic. Finely ground rubber dust is explosive when mixed with air.

Heavy Magnesia

40 Heavy calcined magnesia, or magnesium oxide. (See magnesium oxide.)

Hypo

41 Lead hypo-sulphite. (See lead compounds.)

Iron Oxide

42. The red oxide of iron. (See red oxide.)

Infusorial Earth

43. (See diatomaceous earth.)

Kaolin

44. A white china clay. (See clays.)

Kieselguhr

45. (See diatomaceous earth.)

Light Magnesia Oxide

46. The light calcined magnesium oxide. (See magnesium oxide.)

Note: Magnesium carbonate is often spoken of incorrectly as light magnesia.

Lamp Black

47. A black carbon pigment obtained by burning oils and oily residues. Carbon black is often miscalled "lamp-black." Its characteristics are similar to carbon black (see carbon black). It is not used to any great extent. It is not toxic.

Lead Compounds

48. Before the advent of organic accelerators, the lead compounds were the most widely used accelerators of vulcanization. Some are still used in large quantities. The usual lead compounds used in rubber compounding are: Blue lead, lead thiosulphate, hyposulphite or hypo, lead oleate, lead oxide or litharge, sublimed white lead, and basic white lead. Blue lead, lead thiosulphate, and hypo are no longer used to any great extent. There are active compounds of lead which react readily with sulphur at vulcanizing temperatures to speed up vulcanization. They are more or less active compounds and are readily assimilated if taken into the system, either through breathing or through food contaminated by contact with dirty hands or clothing.

49 *Lead oleate* is still used to a considerable extent both as an accelerator and for extruded and moulded goods. It gives a good finish and eliminates bloom in certain types of stocks. It is an active poison and should be treated with care. It is a soft, waxy substance, and so there is no danger of dust, the real danger being from sticking to hands and clothing. It can be handled with safety if cleanliness is carefully observed.

50 *Lead oxide or litharge* is probably the most extensively used lead compound and the one most to be feared. It is an orange-to-brown-colored powder. The dust is very fine, but being heavy, settles quickly. Those handling this material should wear suitable respiratory protective equipment if there is the slightest danger of inhaling any dust or getting dust in the mouth or saliva. It is dangerous to handle tobacco, gum, fruit or any food until after the hands and face have been thoroughly washed. Mixing mills should be hooded and every precaution taken to keep down dust. Lead oxide is toxic, but there is no need to enlarge here on lead poisoning. Litharge can be safely handled if reasonable care is exercised in its use. The worker should be instructed as to its serious toxic properties, and pains should be taken to show him how to handle it safely.

51 *Sublimed white lead* is largely lead sulphate with about 15 per cent of active lead oxide present. It is the free lead oxide which is the active accelerating ingredient and also the real toxic substance. While much less toxic than the litharge, it should be handled with the same care as the latter substance.

52. *Basic white lead* is a white powder consisting of a basic carbonate of lead. It is not used now to any great extent for rubber compounding, but it is a very active and toxic substance and if used should be handled with as much care as litharge.

53 All persons using lead compounds to any extent should inform themselves on the symptoms of lead poisoning, its treatment and avoidance of trouble from poisoning. See also National Safety Council Safe Practices Pamphlet No. 3, "Lead

Lime

54. A fine dry white powder used extensively in rubber compounding as a secondary accelerator and drying ingredient. This compound is the so-called hydrated calcium oxide or slaked lime. It is slightly caustic and irritating to mucous membranes, and suitable protection against its caustic action is required. (See Industrial Data Sheet D-Chem. 19, "Lime," for details.)

Litharge

55. Lead oxide. (See lead compounds.)

Lithopone

56. A fine white powder consisting of barium sulphate and zinc sulphide of high coloring power. It is a widely used pigment for producing white rubber goods. Being rather inert, there is no hazard connected with its use other than the general dust hazard. The zinc present in the material might be dissolved if considerable quantities of dust were taken into the system, but zinc in such small quantities would not be considered as a toxic material.

Magnesium Carbonate

57. Also called magnesia carbonate and light carbonate. This is a fluffy white powder; next to carbon black it is one of the lightest powders used, and it therefore causes considerable dust. It is very soluble if taken internally, but it has no poisonous effects. It is an ingredient often used for baby and toilet powders and also used in many medical preparations as an anti-acid and mild laxative. There is no health hazard connected with its use other than that of dust.

Magnesium Oxide

58. Also called magnesia oxide and calcined magnesia. It is obtained by heating the magnesium carbonate. Two grades are used extensively in the rubber industry, one called heavy calcined magnesia and the other light calcined magnesia. The heavy product is more dense and slightly darker in color than the light calcined material. Both are used as auxiliary accelerators and to neutralize acid reactions. The percentage used is relatively small in most cases. The dust is slightly irritating to mucous membranes but non-toxic. Suitable respiratory protection is required in its use.

Magnesia Usta

59. Same as magnesium oxide.

Mica

60. A form of aluminum silicate which, when finely ground, is a soft glistening powder. The flat particles slide over each other, giving the slippery properties noted in graphite. The color runs from a cream white to gray. It is used for dusting raw rubber to keep the slabs from sticking together, also for dusting finished goods to give a smooth, glistening finish. Mica is also used in packings and mechanical goods as a filler where goods are to resist heat and acid. The material is non-toxic, and there is no hazard other than the dust hazard. Cheap grades, however, may contain traces of silica. Suitable respiratory protection is necessary. Mica in needle-like form is likely to be more irritating to the skin and nasal passages than mica in plate form.

Oxide of Magnesia

61. (See magnesium oxide.)

Oxide of Iron

62. (See red oxide.)

Paris White

63. (See whiting.)

Plaster of Paris

64. (See gypsum.)

Plumbago

65. (See graphite.)

Pumice

66. A grayish powder consisting of ground lava. It is a complex silicate of aluminum, potassium and sodium. It is used as a soft abrasive for producing a smooth polished surface on rubber goods such as mechanicals and rolls. Also it is used as a filler in acid and heat-resisting rubber goods. It is non-toxic, but care should be exercised in keeping down dust.

Prussian Blue

67. There are a number of so-called prussian blues with varying shades and solubilities, all belonging to the iron blues. They are ferro-ferri-cyanide compositions and are non-toxic. The blues used for rubber are the insoluble type and prepared to withstand the temperatures of vulcanization. They are used in comparatively small quantities, and there is no health hazard connected with their handling, aside from that of dust.

Red Oxide

68. A fine red pigment, very dense and heavy, and consisting of the red oxide of iron; also called iron red. It is one of the most widely used red pigments for coloring rubber. It is non-toxic, and no serious health danger is involved in its handling. However, it is advisable to keep dust down, as the oxide flies readily.

Red Ochre

69. A dull brownish-red powder used for coloring rubber goods. It consists of a ground natural impure form of iron oxide, more gritty as a rule than the regular red oxide. It is non-toxic, but it may contain silica, and so care should be exercised in keeping down dust.

Rotten Stone

70. (See tripoli.)

Sand

71. (See silicon dioxide.)

Selenium

72. Metallic selenium in the form of a fine heavy grayish-black powder is used to a limited extent in several branches of the rubber industry, notably in the insulated wire industry and where a very low percentage of sulphur must be used. Information concerning its toxic properties is rather meagre. It is claimed to be non-toxic, and we have no records to indicate that there are any health hazards in connection with its use in the rubber industry. It is advisable to protect workers against inhalation or swallowing of the dust.

Silica

73. (See silicon dioxide.)

Silicon Dioxide

74. Also called silica and quartz sand, etc. A hard abrasive powder, varying in particle size from a very fine powder to large sharp particles known as sand. The color may vary from almost pure white to yellow or

brown or gravish. This is the material which has been so widely discussed in cases of silicosis. It occurs as an impurity in many dusts and powders and is usually present in common road dust. In rubber compounding, its use is confined to such special rubber articles as erasers and abrasive wheels. A very fine grade is also used as a filler for certain rubber goods. Wherever it is used, the workers weighing and mixing should be protected by exhaust systems, or they should wear suitable respiratory protective equipment. There is an abundance of data available on silicosis which should be studied by anyone using or contemplating use of silicon dioxide. (See also National Safety Council Health Practices Pamphlet No. 20, "Silicosis.")

Slate Flour

75. A fine bluish-gray powder consisting of ground slate. In composition it is a sedimentary rock. It is used as a cheap filler and for certain heat-resisting and acid-resisting rubber goods. It is non-toxic, but it may contain silica, therefore precautions should be taken to prevent inhalation of the dust.

Soapstone

76. (See talc.)

Sulphur

77. A pure natural deposit ground to an exceedingly fine powder. It is light yellow in color and is the principal vulcanizing ingredient used in rubber manufacture. With few exceptions, all rubber goods are cured or vulcanized with sulphur or with sulphur compounds. Sulphur dust is irritating to the eyes, respiratory organs and skin. Gloves and shirts with sleeves may be necessary to protect the hands and arms. Goggles and respirators should be used if there is much sulphur dust. Adequate ventilation and exhaust equipment should be provided to keep the dust at a minimum. There are several varieties of sulphur, such as flowers of sulphur and precipitated sulphur, but chemically they are the same as the natural product.

Talc

78. A fine white-to-gray powder that feels extremely soft and peculiarly greasy or soapy. It is used throughout the rubber industry as a lubricant or dusting powder. It is a hydrous magnesium silicate, very inert. It is non-toxic, and there is no health danger in its handling other than that of dust.

Tellurium

79. Tellurium is used to a limited extent as a vulcanizing agent and especially where very low-sulphur stocks are desired. It is a grayish-black amorphous powder. Definite records as to its toxicity are lacking, but some workers appear to be very sensitive to the odor given off when they come into intimate contact with rubber stocks containing this chemical. Aside from the disagreeable odor, there appear to be no records of cases where it has presented a serious health hazard when used in rubber. It is advisable to protect workers from direct contact with the material as much as possible.

Titanium Dioxide

80. Titanium dioxide, either as the oxide or in combination with barium or calcium sulphate, is used as a white coloring pigment for compounding rubber. It is one of the whitest and most stable of the few white pigments suitable for rubber. These titanium whites are exceedingly fine white powders, and the usual precautions for pigment dusts should be observed. There appear to be no records of their having caused any toxic hazards as used for rubber compounding.

Tripoli

81. Also called rotten stone. It is a porous, siliceous rock resulting from the natural decomposition of sandstone. It is used as an inert filler and as a mild polishing compound for rubber. It is non-toxic, but care should be exercised to prevent excessive dust, and especially inhalation of dust, since it may contain a small amount of silica as an impurity.

Tripolite

82. (See diatomaceous earth.)

Ultramarine Blue

83. A powder used for coloring rubber goods. Its composition is variable but consists essentially of a double silicate of sodium and aluminum and sodium sulphide. It is a dark-blue powder, fast to heat and sulphur. It is non-toxic, but dust should be kept to a minimum.

Umber

84. An iron oxide with varying amounts of clay and silicon compounds. There are two common varieties. The raw umber is the natural deposit ground and made smooth, whereas the burnt umber is calcined at low heat. The former is a yellowish-buff to brown color, and the latter a reddish-brown color. They are low cost colors, used extensively in rubber floorings and mechanical goods. There is no health hazard in their handling other than that of the dust.

Venetian Red

85. (See red oxide.)

Vermilion

86. A fine brilliant scarlet-to-orange-colored powder consisting of mercuric sulphide. It is used in a limited way for coloring certain types of rubber but is too costly for general use. It is a very inert compound, and no health hazard is involved in its use except that of dust.

Whiting

87. A soft white or gray powder consisting of more than 98 per cent calcium carbonate. It is one of the most widely used filling compounds for rubber manufacture. The poorer grades may contain some traces of silica. It is non-toxic, and there is no health hazard connected with its use unless it contains free silica, which can be determined by laboratory analysis.

White Lead

88. (See lead compounds.)

Yellow Ochre

89. A mineral deposit which, when ground, produces a cheap pigment used in coloring rubber goods. Used principally for flooring and mechanical goods. It consists of hydrated ferric oxide mixed with clay and other siliceous materials in varying amounts. There is no health hazard in its use except that of dust.

Zinc Oxide

90. Next to sulphur, this is probably the most widely used rubber

ingredient. It is used both as an activator of acceleration in vulcanizing the rubber and as a white reinforcing ingredient. It is a fine white amorphous powder. Taken internally, it is slightly toxic, but with proper precautions for keeping down the dust there is no serious health hazard in its handling. However, many grades of zinc oxide contain lead salts which increase their toxicity.

Zinc Sulphide

91. A fine white powder with yellowish tinge used for coloring rubber. It has great coloring power but is not as good a reinforcing ingredient as zinc oxide. There is no especial hazard involved in its use. (See also zinc oxide.)

Gums, Oils, Resinous Materials and Waxes

92. The substances in this group are largely used as softeners and plasticizers.

93. This group contains materials which are either liquids or semi-solids, and therefore there is no dust hazard. Also, all members of this group are practically non-volatile at temperatures encountered in rubber processing. None of the substances mentioned is known to be toxic with the possible exception of some of the tars or pitches. They are not hazardous as used in the rubber industry because of the relatively small amounts used and because they are neither in fine particles nor sufficiently hot to give off fumes.

94. The oils are usually added directly to the rubber on the mills and worked in. The solid resins and waxes are either melted or ground to coarse flakes before they are added to the rubber; with reasonable care and cleanliness there is no health hazard in their use.

95. Oils and resins known as organic accelerators are not included with this group but are discussed in N. S. C. pamphlet No. RU-1.

Asphalt

96. Also called bitumen and mineral pitch. It is a natural deposit of bituminous mixture, either solid or semi-solid, readily softened by heat, and is used as a softener and cheap filler, especially for extruding and covering stocks. The color of the natural materials is brown or brownish black. Many treated or blown asphaltic compounds are also used in rubber compounding, and the latter may be obtained in almost any degree of hardness. They are usually black and have a bright fracture when broken. Asphalt handlers may be troubled with irritation of the skin because of the mineral oil in the asphalt. Therefore handling of asphalt with the bare hands should be avoided where possible.

Balsam

97. (See Canada balsam.)

Beeswax

98. A yellowish-to-white colored wax obtained from the honey comb of bees. It is tough and has a fairly high melting point. It is used to render rubber impervious, as well as a softener in extruding, and as a mild preservative against the action of light.

Bitumen

99. (See asphalt.)

Brown Substitute

100. (See factice, brown.)

Black Substitute

101. (See factice, black.)

Burgundy Pitch

102. An opaque yellowish to reddish-brown resin obtained from Norway spruce. Softens under heat and is used in conjunction with other oils, to give tack to rubber, especially unvulcanized frictions, tapes, etc. It is also used in tacky cements. Pitch is a skin irritant to many persons, especially when a high standard of personal hygiene is not maintained.

Canada Balsam

103. A resinous exudation from spruce, used to give tack in rubber frictions and cements. (See also burgundy pitch.)

Carnauba Wax

104. Used quite extensively in rubber compounding to produce a dense, impervious product for rubber coatings, flooring, etc. It is a very hard, yellowish-to-buff-colored wax of high melting point; it usually is melted before it is added to the rubber batch. Carnauba wax is obtained as an exudation from leaves of the Brazilian wax palm. Its use does not present any special hazards.

Castor Oil

105. A thick yellowish oil obtained from the castor bean. Used as a softener in rubber and in the production of certain rubber substitutes or factice.

Ceresin

106. A purified mineral earth wax having a melting point of approximately 74 degrees Centigrade. It comes in white cakes. Used in rubber to render it more impervious to water and air, as a softener, and for extruded articles and coverings, electrical insulations and for acid-resisting rubbers. No hazard is involved in its use.

Coal-Tar Pitch

107. A brown-to-black amorphous body consisting of the residue remaining after the coal-tar has been distilled. It varies from a soft sticky to a hard brittle mass according to the degree to which distillation has been carried out. Coal-tar pitch is used as a softener and tack producer, and for extruded goods. It may contain residues of coal-tar products which are toxic, but the high temperatures of distillation should remove most of these, and the small amounts used for most rubber work preclude any serious health hazard in its use provided a high standard of personal hygiene is maintained.

Colophony

108. Common pine resin which is obtained as a residue after the distillation of turpentine oil from crude turpentine. Varies in color from light-amber to dark reddish brown. It is used in rubber compounds for producing tack and in rubber cements. It usually comes in lumps and is readily pulverized or melts down when added to the rubber batch on the mill. There is no known hazard in its use.

Corn Oil

109. A pale yellow oil obtained from the germ of corn. It is used in rubber as a softener, in reclaiming old rubber, and in the manufacture of factice or rubber substitute.

Cottonseed Oil

110. A pale yellow- to reddish-brown oil obtained from seeds of the cotton plant. It is used in rubber as a softener, for reclaiming old rubber, and in conjunction with resins to produce tack.

Cumar

111. A synthetic resin consisting of polymers of coumarone, indene, and homologous compounds. It can be obtained in several states, varying from a liquid to hard, high-melting resins. The color varies from light-buff to brown. It is used quite extensively in various rubber compounds such as those for soles, flooring, friction tapes and cements. Cumar is also used in acid-resisting and alkali-resisting stocks. It is non-toxic.

Degras

112. Also known as sod oil and wool grease. It is a dark-brown grease obtained from the washings of sheep's wool. It is used as a softener and for aiding in the processing of raw rubber, such as in calendering and extruding. It is non-toxic.

Factice, Black

113. A black gummy cake resembling rubber but easily disintegrated by crushing. It is made by vulcanizing vegetable oils with sulphur and adding mineral rubber. Black factice is added directly to the rubber on the mill and is used as a soft filler. It has the property of absorbing other fillers and thus bulking up the rubber. It is also used for producing a smooth finish on calendered and extruded goods. There is no health hazard in the use of factice.

Factice, Brown

114. Also called brown substitute. It is a vulcanized oil usually made from corn or similar oil by heating [illegible] has processed to the proper stage. It is a dark-brown cake, easily crumbled [illegible] to the rubber on the mill. It is used as a soft filling material in moulded goods, druggists' sundries, proofing and tubing.

Factice, White

115. A white granular powder prepared by vulcanizing vegetable oils with sulphur chloride. Rapeseed in soya bean oils are often used for making white factice. The factice is added directly to the rubber batch on the mill. It is used in druggists' sundries, tubing, extruded articles, rolls, pads and moulded articles. It gives a smooth, velvety finish and facilitates calendering, tubing and other processing operations. There is no hazard aside from that of dust.

Gilsonite

116. A very pure natural bitumen found in the United States only. It is a black mass breaking with conchoidal fracture and showing bright lustre. It is used in floorings, mechanical goods, coatings, varnishes, insulation, gaskets and cements.

Glucose

117. A thick, viscous, syrupy liquid made from corn. It is used in a few rubber compounds and cements, and for latex compounding.

Glue and Gelatin

118. A nitrogenous colloidal substance of the protein class which is derived from animal connective tissues and bones obtained from slaughter house and tannery waste. It comes in sheets, chips or ground granules, usually of a light-amber color, and always contains some water. It is added directly to the rubber on the mill or dispersed in water. Glue is used in rubber as a reinforcing ingredient of low gravity. It gives strength, stiffness and good processing qualities. It is used in tubing, rollers, coatings and latex compounding.

Guayule

119. A resinous rubber native to Mexico and southern United States, having about twenty-five per cent of resin. It is used largely for soft rubbers such as friction stocks. Being of a soft resinous nature it does [illegible] as smoked sheet, and stearic amount are often added to the harder rubbers to speed up the breaking down time.

Gumkaraya

120. Gumkaraya is a bassora type of gum similar to gum tragacanth. It is used for thickening latex solutions and is non-toxic.

Gum Tragacanth

121. Dull white translucent flakes or yellowish powder. It is a vegetable gum used for cements and as a thickener for latex solutions. It is non-toxic.

Gutta Percha

122. The coagulated milk juice of various tropical trees. It comes in yellowish or grayish hard leathery sticks. It is used with rubber to impart certain leathery properties and in golf ball manufacture and cements. One large use has been in the coating and impregnation of fabric for driving belts, clutch linings and wire coverings. It is non-toxic.

Hardwood Pitch

123. A brown bituminous material consisting of the residue from the distillation of hard wood. It is used as an accelerator activator, and for giving tackiness to rubber stocks. It is added directly to the rubber on the mill. Only comparatively small percentages are used, and no health hazard is involved except that of possible skin irritations.

Hydrolene

124. A black bituminous mass resembling asphalt, obtained from the residue remaining after the destructive distillation of petroleum. Used as a filler and softener in much the same manner as asphalt. (See asphalt.)

Linseed Oil

125. An amber-colored drying oil obtained from the seeds of the flax plant. It is used in rollers and cements in preparing rubber substitutes in the form of factice by vulcanizing the oil with sulphur chloride. It is non-toxic.

Mineral Oils

126. Numerous grades of mineral oil, ranging from the light paraffin oil to petrolatum [illegible] these are the light paraffin oils. The oils are added directly on the mill and are rapidly absorbed by the rubber. There is no health hazard except possibly that of skin irritation.

Mineral Rubber

127. A term applied to [illegible] asphaltic deposits such as gilsonite

and also to blown asphalts. Blown asphalts may be obtained in varying degrees of hardness and are sold according to their respective melting points. They are often called "M. R." by rubber compounders. Mineral rubber is used in many lines of rubber manufacture both as a cheap bulking filler and to aid in processing raw rubber. It is used in frictions, spread goods, cements and many types of mechanical rubber goods. Mineral rubber comes as a solid mass in sheet metal drums or it may be obtained in a granular form. It is added directly to the rubber on the mill. There is no health hazard

[illegible] crushing, and the liberation of hydrogen sulphide which should be removed by adequate ventilation.

Montan Wax

128. A mineral wax extracted from lignites. In the crude state it is dark brown. When refined, it is a white semi-soft wax. The crude wax is used for soling, flooring, special stocks, insulating compounds and extruded stocks. This wax imparts excellent processing qualities without the softening effect resulting from the use of softer waxes such as paraffin. No hazard in its use.

Naphthalene

129. White crystalline flaky compound, used to a limited extent in certain rubber goods as an odorant and processing aid. The material has a camphor odor characteristic of moth balls. It may contain, as impurities, coal-tar products which are slightly toxic. However, such small quantities are used in rubber compounding that the health hazard is slight.

Oil Substitutes

130. (See factice.)

Ozokerite

131. A mineral fossil wax occurring native, and yellowish-brown-to-black or green in color. Used as a rubber filler and softener, especially in such goods as electrical insulations, frictions, extruded and mechanical stocks. Usually added directly to the rubber on the mill, either as broken lumps or in molten state. (See also ceresin which is prepared from ozokerite.) There is no health hazard.

Palm Oil

132. An orange-yellow fatty oil or grease of butter consistency. It is obtained from the fruit of a tropical palm. It consists chiefly of palmitic acid and the glycerides of palmitic, oleic and stearic acids. It is used in rubber to aid processing, especially for producing a smooth finish on calendered and extruded goods. Also used to reduce the tack in very sticky compounds. There is no health hazard in its use.

Paraffin Oils

[illegible]

Paraffin Wax

134. A white, translucent, waxy, tasteless and odorless solid obtained from petroleum. It consists of a mixture of hydrocarbons chiefly of the methane series. It varies in color from the light-yellow crude to a hard white refined wax. Wax is used in rubber as a softener, as an aid to processing, as an anti-scorch material, and as an anti-oxident and light resistor. It is also used for rendering rubber less permeable to water solutions.

Petrolatum

135. Also called vaseline and mineral fat. A light-yellow-to-amber colored, oily, semi-solid material consisting chiefly of hydrocarbons of the methane and olefine series. It is obtained by distillation of the still residues obtained in steam distillation of paraffin base petroleum. It is used in rubber as a softener, in reclaiming old rubber, as an antiscorch material for active accelerators, and to aid in smooth calendering and extruding operations. There is no health hazard.

Pine Tar

136. A very viscid, blackish-brown liquid with a characteristic odor and taste. It is obtained from the destructive distillation of pine wood. It is used in rubber goods as a softener, tack producer, dispersing agent, and accelerator for synthetic rubber. It finds a large use in tread stocks, frictions, tape, reclaiming of rubber and cements. It contains phenolic bodies, but as used in rubber it should not be hazardous. It is usually added directly to the rubber batch on the mill.

Pine Tar Oil

137. A reddish-brown oily substance obtained from the destructive distillation of pine wood. It is a lighter distillate than pine tar. It has a strong tarry odor and taste. The material is somewhat toxic and should be handled carefully. It is used for the same purposes as pine tar in rubber, but the lighter oil is preferable for certain compounds.

Rapeseed Oil

138. A dark-brown-to-pale-yellow [illegible] making factice or so-called rubber substitute. (See factice.)

Rosin

139. (See colophony.)

Rosin Oil

140. An amber-colored oily liquid, with a pleasant odor but a strong, peculiar taste. It is obtained by fractional distillation of rosin. It is used for producing tack in rubber adhesives, tapes, mechanicals, and in reclaiming rubber. There is no health hazard.

Shellac

141. A resinous exudation from the twigs of a species of East Indian tree, it is caused to exude by the bite of an insect. It is obtained as orange-to-light-buff brittle flakes or as a ground powder. It is used to a limited extent in rubber as a stiffener and in hard rubber to give firmness and finish. It is non-toxic.

Sod Oil

142. (See degras.)

Stearic Acid

143. A colorless, odorless wax-like material handled in block or flakes. It is obtained from high-grade beef tallows by saponification or distillation and pressure and also by hydrogenation of oleic acid. It is used in most types of rubber goods as a stabilizer of vulcanization, as an activator of certain accelerators, and as a dispersing agent and softener. It is used up to several per cent on the rubber and added directly on the

rubber, in which it readily disperses. It is non-toxic.

Liquids and Gases

144 In this group are included the usual liquid solvents and gases used in rubber manufacture with the exception of the liquid accelerators, which are listed under organic accelerators in N.S.C. pamphlet No. RU-1, and softening oils, which are listed above.

145 This group contains some of the most hazardous chemicals used in the industry and should be given careful study by the safety engineer to see that they are properly handled.

Liquids

Acetic Acid

146 Acetic acid is not used generally throughout the rubber industry only in special parts of it. It is, however, used in large quantities for certain purposes. It is used for coagulating rubber latex, in certain latex preparations, and in sponge rubber production. In coagulating and latex work, the temperatures are low or normal, comparatively small proportions on the batch are used, and handling is simple. When used for sponge rubber, the temperatures are higher, and disagreeable fumes are given off which should be conducted away by proper ventilation and exhaust equipment.

147 Acetic acid is a clear, colorless liquid at ordinary temperatures. It comes in a number of different strengths, varying from the pure concentrated acid, known as glacial acetic acid, down to dilutions as low as 25 per cent. It has a strong, pungent odor characteristic of vinegar and is very corrosive, especially in the higher concentrations. It is very irritating to hands and nasal passages. In small quantities it is not toxic, but care should be taken to keep it away from the bare skin, and any fumes should be conducted away from the workers.

Alcohol

148 Alcohol is usually used in the denatured state. Its use is not extensive in the rubber industry, being confined to certain types of cements as a means of introducing certain resinous compounds into rubber, and as a cleaning solution for raw and finished rubber where it is necessary to avoid solvent action on the rubber. The characteristics of alcohol are well known; it is not necessary to dwell here upon its relative toxicity. Various types of denatured alcohol are available, and all are toxic if taken internally; but as used for rubber work there should be no hazard if not actually taken internally. All grades of alcohol are flammable.

Ammonia

149. Ammonia is a colorless gas, but as usually used it is dissolved in water and known as ammonia water or ammonium hydroxide. It is sold on its ammonia content designated by degrees Baume. The usual grade used is 26 Baume, or a saturated solution. It is a clear, water-like liquid with a strong, irritating odor. In the concentrated form it is strongly caustic and should be kept away from the skin. Rubber gloves and non-ventilated goggles should be used in handling it. It gives off powerful, pungent fumes when exposed to the air, causing bronchial disorders if inhaled in considerable quantities. The fumes are toxic, but usually do not leave any serious lasting effects. Where used, a good ventilating or exhaust system should be installed. In the more dilute forms of ammonia liquid, the water retains the gas in solution, and only slight fumes are given off. Under certain conditions ammonia mixed with air is explosive.

150. Dilute ammonia is used very generally to preserve raw latex, in manufacturing latex compounds, and throughout the liquid latex industry. The concentrations here seldom run higher than a few per cent, and there is practically no hazard other than where the ammonia solutions are prepared. Ammonia is also used in the spread-goods industry as a neutralizer for acid released during the vulcanization operation where sulphur chloride cures are used. The hazard here is also small since most of the cold curing chambers are of necessity equipped with adequate venting systems. (See also N.S.C. pamphlet No. 25, "Acids and Caustics.")

Benzol

151. Benzol, or benzine, as it is chemically defined, is a clear, water-white liquid of characteristic odor, derived from the destructive distillation of coal. It is very volatile at room temperatures and should never be allowed to stand in open containers. The vapors are very flammable and very toxic. Benzol is used largely for making cements and adhesives for assembling rubber parts during process of manufacture. It was formerly used in large quantities as a wash for raw rubber, being applied by hand swabs. It was here that many of the most severe poisoning cases were experienced. The vapors spread rapidly and should be removed by exhaust systems to decrease both the fire hazard and the health hazard. The workers should not be allowed to breathe any considerable quantity of benzol vapors, nor should they be permitted to get the solvent on their clothing, hands, or other parts of their bodies. The solvent can be absorbed through the skin as well as through inhalation, producing lasting serious complications. (See N.S.C. pamphlet No. H.P. 14, "Benzol.")

Benzene

152. Same as benzol. Must not be confused with benzine, which is a petroleum product and not a coal-tar product.

Benzine

153 A distillation product from petroleum, being a clear solvent similar in properties to ordinary cleaner naphtha but very light and volatile. Also called petroleum ether. It is used as a cleaning solvent for swabbing raw rubber and is much safer to use than benzene, from the toxicity standpoint. However, it is very flammable. It should be used in safety dispensers to eliminate the fire hazard. Breathing benzine vapors will cause dizziness.

Carbon Bisulphide

154 A clear, colorless, very flammable liquid. When pure it is almost odorless, but the commercial grade usually used has a strong disagreeable odor. It is exceedingly volatile at room temperatures having a flash point at minus 25 degrees Centigrade. It may ignite from a spark or flame many feet away. It is very poisonous to breathe. (For further details as to its toxicity, see N.S.C. Industrial Data Sheet D-Chem 1, "Carbon Bisulphide.")

155. Carbon bisulphide is used for removing sulphur bloom on rubber goods, in rubber adhesives, and as a diluent for sulphur chloride in cold vulcanization and vapor cure. Departments using this solvent should be adequately equipped with fire extinguishers and exhaust systems. Keep solvent off the hands.

156. Within recent years the use of carbon bisulphide has been very limited as, in the majority of cases, less dangerous materials have been substituted. There are, however, a few places where it finds a use in rubber manufacture, and the safety engineer should study each situation and see that the material is handled in a safe manner.

Carbon Dioxide

157. Carbon dioxide is an inert gas used in the rubber industry for inflating air bags and tubes and for vulcanizing purposes. It is non-toxic, but is highly suffocating since it is devoid of active oxygen and does not support life. Its danger lies in the fact that it is a heavy gas and likely to collect in "dead pockets" where ventilation is poor. Considerable quantities may be liberated through leaks, or discharge from bags or vulcanizers at the conclusion of vulcanization operations. Adequate ventilation will remove any danger.

Carbon Tetrachloride

158. A light, colorless liquid with a peculiar characteristic odor. It has a low boiling point and is very volatile at room temperature, giving off heavy vapors. The vapors are not flammable but are toxic. They are heavy and sink to low parts of the room, often collecting in corners and poorly ventilated places, making a real hazard to workers unless removed by proper ventilation or exhaust equipment. This solvent finds an extensive use in rubber manufacturing on account of its freedom from fire hazard and its excellent solvent properties for rubber. It has replaced many other solvents. (See N.S.C. Industrial Data Sheet D-Chem 25, "Carbon Tetrachloride.")

Chloroform

159. A clear, colorless, highly volatile liquid with a peculiar characteristic odor. It is toxic, but it will not ignite readily. It is an excellent solvent for rubber and is used for cements and cleansing solvent. However, it has been almost entirely replaced by carbon tetrachloride which has properties very similar to chloroform where used in rubber manufacturing. It should be handled with the same care as carbon tetrachloride.

Coal-Tar Naphtha

160. Refined coal-tar naphtha is a clear, water-white liquid having a heavy, gassy odor. It is flammable and should be kept in approved dispensers. There is also a crude material which is straw colored, but this grade is not used to the same extent as the refined grade. Coal-tar naphtha consists of a mixture of benzene, toluene, xylene and other higher homologs. It is toxic, but less volatile than benzol. It is used to a considerable extent for rubber cements, rubber doughs, and as a cleaning solvent. The same precautions should be taken as for benzol.

Ethylene Dichloride

161. A colorless liquid having a strong chloroform-like odor. It is an excellent solvent for rubber and is used for rubber cements and doughs on account of its low fire hazard. It is toxic and in many respects acts like carbon tetrachloride. It should be handled in a similar manner to carbon tetrachloride. Its vapors are very heavy.

Gasoline

162. The name given to a series of solvent distillates derived from petroleum and having a range in gravity from 50 degrees to 90 degrees Baume. The range from 56 degrees to 70 degrees is the usual range of rubber solvents. They are clear, water-white, oily liquids of characteristic not unpleasant odor. The gasolines are the most universally used solvents in rubber manufacture, partly because of their low cost. They are all toxic and flammable and should be handled with care. Vapors should be removed. Gasoline dissolves the natural oils and fats of the skin causing dry and chapped skin. This can be prevented to a great extent by first coating the hands with a neutral glycerine soap preparation, which repels the gasoline.

163. Gasoline is used as a cleaning and swabbing solution in the manufacture of many rubber articles, in all types of rubber cements in preparing, coating and spreading doughs, and as a diluent for other solvents.

Glycerine

164. Also called glycerol. It is a clear, colorless or pale-yellow, heavy, syrupy and odorless liquid having a sweet taste. It is non-flammable and non toxic and presents no hazard from the health standpoint. It is used in rubber manufacturing as a preservative coating or dressing on finished rubber goods, to prevent rubber from sticking together while in the raw state and in liquid latex preparations. When used as a dressing, it is either swabbed, sprayed or painted on.

Kerosene

165. A clear, water-white to straw-colored, oily liquid. It is obtained as a distillate from petroleum and refined to remove low flash constituents. It is comparatively safe to use, although the skin of some workers is sensitive to kerosene oil. It is used to a limited extent in rubber manufacture, but very extensively as a wash for rubber machinery, rubber rolls, etc. In rubber manufacturing it is used for softening and blowing sponge goods. Kerosene presents a fire hazard, but it is not as hazardous as gasoline.

Naphtha

166. A name given to both petroleum and coal-tar solvents. The type of naphtha should be specified, otherwise it is very misleading. (For petroleum naphtha, see benzine, petroleum ether, and gasoline. For coal-tar naphtha see coal-tar naphtha.)

Petroleum Ether

167. (See benzine.)

Solvent Naphtha

168. (See coal-tar naphtha.)

Sulphur Chloride

169. The subchloride of sulphur. It is an amber-to-yellowish-red, very fuming liquid with very penetrating odor, used in vulcanizing rubber by the so-called cold process and vapor process. Its use as such is confined

...ngely to sheet, spread and dipped goods. It is also used in the manufacture of rubber substitutes and oil factice. When used for sheet and spread goods, the sulphur chloride may be applied in liquid form by distributor roll, or the goods may be hung in chambers where the sulphur chloride is vaporized by heat. The sulphur chloride is extremely active chemically and is usually diluted with some solvent such as carbon bisulphide or benzol. In vulcanizing dipped goods, the latter are usually immersed for a very short time in a diluted solution of the sulphur chloride.

170. Sulphur chloride is readily decomposed in a damp atmosphere and should be kept well bottled when not in use. It is extremely corrosive, due to liberation of hydrochloric acid in presence of moisture. It is extremely irritating to the eyes, lungs and mucous membranes. Workers should be protected from its fumes by adequate ventilation and warned to keep it away from their hands.

Sulphuric Acid

171. A strongly corrosive, dense, oily liquid, colorless to dark brown, depending upon its purity. Used for removing cotton fiber in reclaiming old rubber. In a diluted form it is used as a coagulant for latex mixture. It is also used in attaching rubber to metals and in producing sulphonated rubber resin products. It causes very severe burns and will char almost any organic matter. Workers using sulphuric acid should be protected from having the material fly into their eyes or onto their skin or even their clothing. The acid will rapidly eat its way through clothing to the flesh. (See N.S.C. pamphlet No. 25, "Acids and Caustics," for details.)

Toluol or Toluene

172. A colorless flammable liquid obtained by fractional distillation of coal tar oil. It resembles benzine in odor in many of its properties, although it is less volatile at room temperatures. It is an excellent rubber solvent, used for rubber cements, doughs and as a cleansing solution. It is toxic and should be treated in the same manner as benzol. Poisoning effects can be very serious. Workers should be protected from its vapors and should keep it from their hands. Its vapors are heavy and cling to the floor and in poorly ventilated corners. (See benzol for handling.)

Turpentine

173. Also called spirits of turpentine. A clear, flammable, colorless liquid with a characteristic rosin-like odor, obtained by distillation from turpentine rosin. Turpentine is a powerful solvent for rubber and was formerly used in making rubber cements. But its use in rubber work has become very limited, and it is no longer an important factor in rubber manufacturing. It is toxic and irritating to the skin, eyes and respiratory organs. (See N.S.C. Industrial Data Sheet D-Chem 12, "Turpentine" for details.)

Xylene or Xylol

174. Xylene is a clear, colorless, flammable liquid with a characteristic penetrating odor. It is one of the constituents of coal-tar naphtha and is obtained from the latter source by distillation. It is a good solvent for rubber and is used in rubber cements, doughs for the spreading trade, and as a swabbing solution in the manufacture of rubber goods. It is toxic, but not to so great an extent as benzol and toluene, probably because it is less volatile. It is a fire hazard, and the same precautions should be taken both for fire and toxicity as those noted for benzol.

Gases

175. Comparatively few gases are used in rubber manufacture, and in nearly every case they are used for vulcanization in some form. Gases are handled in closed chambers. Consequently, leakage or inadequate exhaust systems are the usual causes of trouble or discomfort to the workers.

Ammonia Gas

176. A colorless gas with a powerful, penetrating and irritating odor. It affects the eyes and respiratory organs. It is used for neutralizing any acid after sulphur chloride vapor cures. It is produced by heating concentrated liquid ammonia water in the curing chamber and finally is exhausted by suction or forced air. (For full details see N.S.C. pamphlets No. 25, "Acids and Caustics," and No. 95, "Safe Handling of Compressed Gases.")

Chlorine Gas

177. A heavy, greenish-yellow gas, highly irritating and toxic. It is used only in specialized industries, for instance, in producing chlorinated rubber. It must be rigidly confined in suitable chambers and kept away from workers. It is extremely corrosive, therefore hazardous, especially in the presence of moisture. (For further data on chlorine see N.S.C. pamphlet No. 71, "Safe Handling of Chlorine.")

Hydrogen Chloride

178. Also known as hydrochloric acid gas; is colorless and exceedingly pungent. It is highly irritating and toxic. It has a strong affinity for water and should be kept in closed systems. It is used only in specialized industries where rubber is converted into certain resinous products. It requires special handling.

Hydrogen Sulphide

179. A colorless, flammable gas with a very offensive odor and a sweetish taste. It is used only to a limited extent for specialized work in vulcanization of sheet or spread goods in conjunction with other reactive gases. It is highly toxic and flammable and must be handled with great care. The goods are exposed in closed chambers and the gas blown in and later expelled. (For details on its health hazards see N.S.C. Industrial Data Sheet No. 16 "Hydrogen Sulphide.")

Sulphur Chloride

180. (See sulphur chloride under liquids.) Where the gas is used it is merely the liquid sulphur chloride vaporized by heat in the hot curing chambers for vapor curing of sheet and spread goods. Usually the goods are festooned in large rooms or chambers, and a quantity of liquid sulphur chloride is evaporated on a hot plate, circulation being accomplished by fan if necessary. Concentrations are usually small and therefore serious hazard is avoided with adequate ventilation.

Sulphur Dioxide

181. A poisonous, colorless gas with a suffocating odor. It is ...

and in special industries for producing special types of vulcanized products. The vulcanization must be carried out in closed chambers, and workers should be adequately protected from the gas.

ACKNOWLEDGMENT

This pamphlet is based on a paper presented before the Rubber Section of the National Safety Council by L. J. D. Healy, consulting chemist, Milwaukee, Wisconsin. The National Safety Council is indebted to M. Healy and the Executive Committee of the Rubber Section, under whose direction the pamphlet was published.