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ASBESTOS

FROM ROCK TO FABRIC

THE TEXTILE INSTITUTE
10 Blackfriars Street · Manchester 3
1956

ASBESTOSIS—Asbestos Dust

RECENT LITERATURE OF INTEREST

Asbestosis. A. J. Vorwald, T. M. Durkin and P. C. Pratt. *Arch. Ind. Hyg. Occ. Med.*, 1951, 3, No. 1; *Brit. Chem. Abstr.*, A.III 1951, 1106, 1. Inhalation or injection of asbestos fibres caused peribronchiolar fibrosis similar to human asbestosis in guinea-pigs, rats, rabbits, and cats, but not in dogs or mice. The mode of action of asbestos in production of this reaction is mechanical rather than chemical: fibres of 20—50μ in length produced the reaction, shorter fibres were inert: ignition of chrysotile fibres which changed their structure made them inert. Injection of brucite produced a similar fibrosis, glass-wool was inert.

$Al(OH)_3$ did not retard or prevent development of fibrosis. Air containing less than 1 million fibres longer than 10μ per cubic foot was capable of producing typical asbestosis when inhaled. The duration of exposure necessary to produce asbestosis was inversely proportional to the concentration of long fibres. Established asbestosis ceased to progress after discontinuance of dust exposure, possibly due to formation of asbestosis bodies which are not able to produce fibrosis. The outcome of experimental pulmonary tuberculosis was unaffected by inhalation of asbestos.

Effects of asbestos on tissue cultures: Comparative studies with quartz and coal dust. T. H. Belt, I. Friedman and E. J. King. *J. Path. Bact.*, 1947, 59, 159—164. Compared with quartz and coal dust, asbestos was slowly phagocytosed: no toxic effects were observed on the phagocytes, though their motility was decreased.

Symposium of industrial medicine. Pneumoconioses. L. U. Gardner. *Med. Clinics. N. Amer.*, 1942, 26th July. Attention is given to Roentgen findings, the part played by tuberculosis in asbestosis and its relation to infection, chemical course, complications and diagnosis.

Chemical studies in asbestosis. M. J. Stone. *Amer. Rev. Tuberc.*, 1940, 41, Jan. This report is based upon examination of 180 persons formerly employed in the opening, carding, spinning and weaving departments of an asbestos brake lining plant.

Carcinoma and asbestosis of the lung. Report of a case. T. K. Owen. *Brit. J. Cancer*, 5, 382—3. Asbestosis of the lung was found 20 years after the patient had worked in an asbestos factory for one year.

Asbestosis. R. R. Sayers and W. C. Dreesen. *Amer. J. Publ. Health*, 1939, 29, 3, 205; *Ceramic Abstr.*, 1939, p. 168. In a study of the North Carolina textile mills using asbestos fibre, a hydrated magnesium silicate containing no quartz, pulmonary asbestosis was the principal defect found. Exposures ranged from 0·10 to 76 million particles/cu.ft. Persons exposed from 5 to 10 years to dust concentrations exceeding 5 million particles/cu.ft. showed definite evidence of asbestosis. Data so far obtained indicate that 5 million particles/cu.ft. is the maximum safe concentration.

Prevention of pneumoconiosis. Anon. *Chem. Age* (London), 1944, 51, 180—181.

Medical Problems of the asbestos-cement industry. Hindley-Smith. *Brit. J. Phys. Med.*, 1947, 10, 2, 50: *Brit. Rubber Research*, 1948, 26, 316. The author, who was a part-time medical officer at an asbestos-cement factory for five years, did not find a single case of incipient asbestosis in this period, though he came across a few long-standing chronic ones. Dermatitis was the biggest problem, the cases occurring amongst men handling cement or a mixture of cement and asbestos. Asbestos itself did not appear to cause dermatitis.

Asbestosis. G. Luton and J. Champfit. *Arch. maladies profess. med. trav. sec. sociale*, 1946, 365: *Brit. J. Ind. Med.*, 1948, 5, 44: *Chem. Abstr.*, 1948, May, Aug. In a factory processing waste asbestos, the atmospheric dust concentration was 6-74 mg./cu.m., and the dust contained 2-14·6 per cent free silica; most of the particles were large. When raw Canadian asbestos was substituted for the waste asbestos, the atmospheric dust concentration fell to 6-11 mg./cu.m., there was no free silica, and 90 per cent of the particles were not larger than 1μ. Asbestosis bodies appeared in the sputum within 3 months after exposure and persisted for as long as 15 years after exposure had ceased. Although these bodies were found in all exposed to the dust, their presence in numerous amounts and massed arrangements in the sputum provided partial diagnostic evidence of pulmonary asbestosis.

Lung carcinoma caused by asbestos inhalation. Fr. Boemke. *Med. Monatsschr*, 1953, 7, 77—81; *Chem. Abstr.*, 1953, April, July. The relation between fibrotic changes caused by asbestos deposits in the lung and carcinoma is discussed. The lower lobe is the site of predilection. Characteristic are the multi-centred developments of flat epithelium carcinoma.

The pathology of diseases due to the inhalation of dust. Fr. Boemke. *Med. Monatsschr.*, 1947, 1, 2—6; *Chem. Abstr.*, 1948, 42, 9002. Thomas-slug pneumonia, pulmonary disorders due to Aluminium dust, and asbestosis are discussed. Attention is called to the association of asbestosis with pulmonary carcinoma, the latter almost always taking the form of carcinoma of the pavement epithelium.

Mineralogical aspects of pneumoconiosis research. G. Nagelschmidt. *Research* (London), 1949, 2, 170—5; *Chem. Abstr.*, 1950, 44, 8020. Three different fibrotic mineralogical groups are distinguished:—(1) quartz and other forms of uncombined SiO_2, (2) other silicate minerals, (3) fibrous silicates especially asbestos.

The effect of asbestos and asbestos and aluminium on the lungs of rabbits. E. J. King, J. W. Clegg and V. M. Rae. *Thorax*, 1946, 1, 118.

Toxicology. T. Lawrence. *Ann. Res. Med.*, 1952, 3. A review with particular reference to asbestos, silicones, halogenated methanes and insecticides.

Mortality from lung cancer in asbestos workers. R. Doll. *Brit. J. Ind. Med.* 1955, 12, 81—6; *Chem. Abstr.*, 1955, 49, 9195. Among 105 persons who had been employed at one asbestos works, and for whom the cause of death was determined at autopsy, 18 showed lung cancer. Of these 18, 15 also showed asbestosis; these 15 had worked at least 9 years before dust-control regulations had become effective. Among 113 men who had worked at least 20 years in places where they were liable to be exposed to dust, there were 11 deaths from lung cancer, 22 deaths from other respiratory and cardiovascular diseases, and 39 deaths in all as compared with expected numbers of 0·8, 7·6 and 15·4 respectively; all cases of lung cancer were associated with asbestosis. Conclusions: Lung cancer was a specific industrial hazard of certain workers. The risk has become less as the duration of employment under old dusty conditions has decreased.

Destruction of mineral particles and fibres in the lung after exposure to asbestos dust. J. F. Knox and J. Beattie. *Arch. Ind. Hyg. Occ. Med.*, 1954, 10, 30—6; *Chem. Abstr.*, 1944, 48, 14045. Examination of lungs from 27 cases where asbestos exposure showed that the greatest proportion of particles were in the 5 to 25µ range, and that in early exposure an appreciable portion was found above 25µ in length, with this fraction decreasing after the 8th year following the last exposure.

Asbestos dusting apparatus. L. C. Pharo. U.S.P. 2,420,495. Dust is removed from asbestos continuously without injury to the material by introducing it into the top of vertical and cylindrical screens containing a shaft which is rotated at 300—720 r.p.m. and to which are attached agitating arms to disperse the fibres. Finely divided material is dislodged and the dust removed through the screen by suction.

The problem of dust in asbestos preparation. M. C. Benham. 1954. Office of Chief Gov. Mining Engineer, Salisbury, Rhodesia. This comprehensive report deals with various problems of dust suppression during the extraction of asbestos from rock.

Air handling and dust control at the Jeffrey Mine of Canadian Johns-Manville Company. H. Rozowsky. *Canad. Mining J.*, 1953, Sept.

The separation of air-borne dusts and particles. C. H. Davies. *Proc. Instn. Mech. Engrs.* (London), 1952, IB, 185—98; Communications 199—213.

Filter efficiency and standardisation of test dust. H. Heywood. *Proc. Instn. Mech. Engrs.* (London), 1952, IB, 169—74; Discussion 175—9; Communications 180—4. The basic theory is developed for determining the efficiency of air cleaners and filters. Characteristics of natural air-borne dusts, methods of examination of dusts, and methods of preparing standard dusts for testing air filters are described.

Occupational Diseases of the Lungs. Institute of Industrial Medicine *A.M.A. Arch. Industr. Health* 1955, 11, No. 3, 183—211. Papers presented at a symposium on the above subject are as follows:—

Pathology of Asbestosis. K. M. Lynch, 185—188;

Recent Trends in Industrial Health. A. J. Lanza, 183—184.

Functional Abnormalities of Industrial Pulmonary Fibrosis. G. W. Wright, 196—203.

Some Clinical Observations of Asbestosis in Mine and Mill Workers. P. Cartier, 204—207.

Asbestosis as Differentiated from Other Pneumoconioses. O. A. Sander, 208—211.

CHAPTER 3

Section V

MICROSCOPY

THE ASBESTOS mineral, although in the form of hard rock, can be easily separated into slender fibres. The individual fibres of asbestos are so fine as to be below the limits that normal microscopes can resolve.

Table 15 gives comparisons of approximate diameters of various fibres with asbestos:—

Table 15

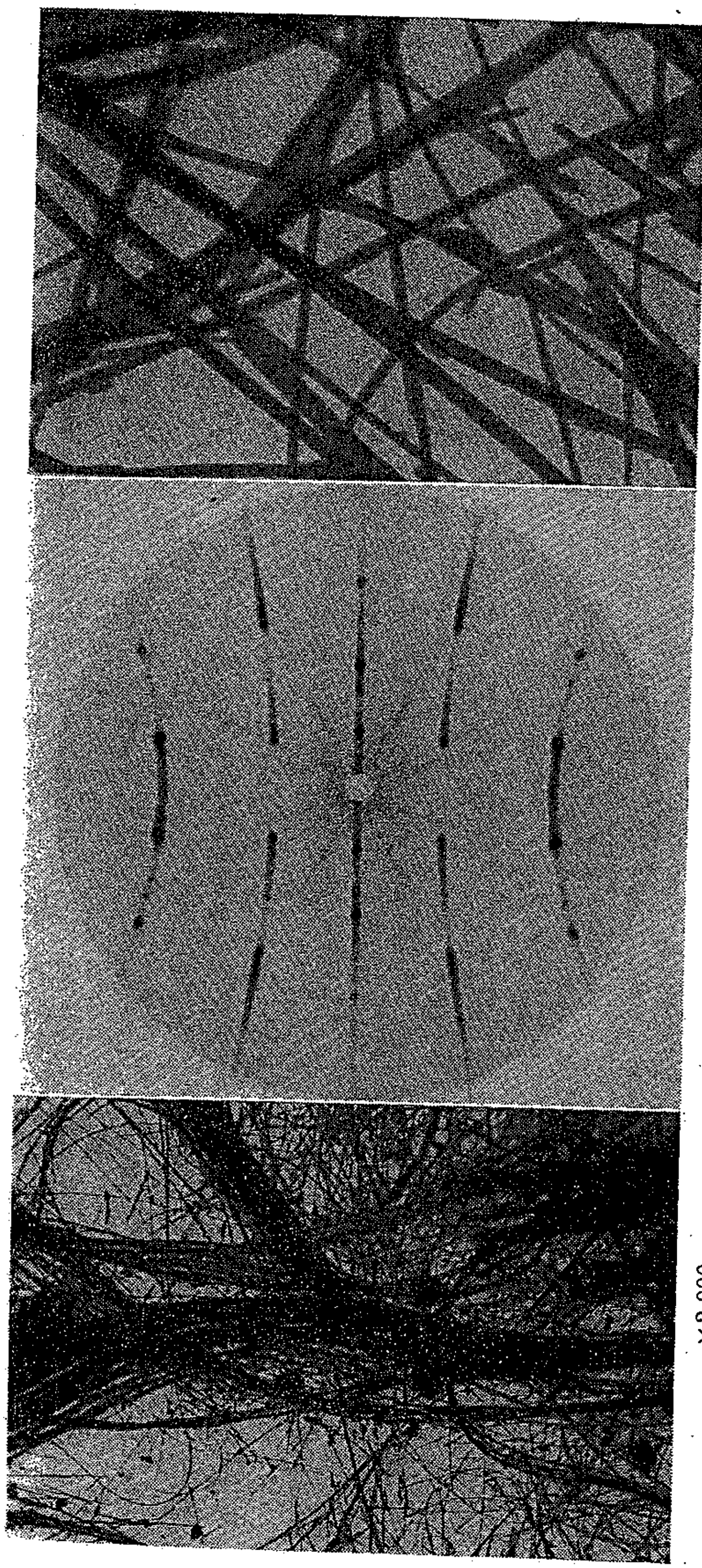
Type of Fibre	Fibre diameter in inches	Fibres in one linear inch
Human Hair	0·00158	630
Ramie	0·000985	1,015
Wool	0·0008 to 0·0011	910 to 1,250
Cotton	0·0004	2,500
Rayon	0·0003	3,300
Nylon	0·0003	3,300
Glass	0·00026	3,840
Rock Wool	0·000142 to 0·000284	3,520 to 7,040
Asbestos (Chrysotile) ...	0·000000706 to 0·00000118	850,000 to 1,400,000

Canad. min. metall. Bull., 1951, April.

Owing to the unlimited splitting of the fibre, it is difficult to determine its proper form. The original theory for many years was that asbestos fibres were solid. A new theory has recently been advanced that asbestos fibres in the final stages of dissection are tubular. Tubular crystals are believed to be known in other minerals, specifically endellite. Thus it is postulated that chrysotile, the fibrous form of serpentine, bears the same relation to antigorite, the plate-like form of serpentine, as the tubular endellite does to the plate-like kaolinite[1].

The tubular structure of chrysotile asbestos has been reported by several investigators[2,3,4].

It has also been stated[5,6] that chrysotile asbestos has an internal capillary structure, and that the capillaries within the individual fibres appear to be blocked in some manner with strongly sorbed water plugs, which are permeable to water vapour and ammonia but not to less polar gases. These water plugs can be removed by activation at 425°C. at 10—5 mm. pressure and re-formed in samples activated at less than 425°C. by saturation with water vapour.



×30,000

×2,000

Fig. 16
Canadian Chrysotile Asbestos

Fig. 93
Asbestos Filled Rope Lagging

ASBESTOS PACKING

Asbestos yarn is used in the manufacture of various forms of asbestos packing for valves, steam engines, pipe lines, air pumps and gasoline pumps.

The yarn is worked up into twisted or braided forms that are compressed info rings or into cloth which is subsequently coated with rubber compound and folded or wound into various forms of packing for high pressure steam work, and also transformed into gaskets for boiler tubes, handholes and manholes of boilers and for pipe flanges.

In fact asbestos packing is suitable for almost every purpose where packing is required.

Fig. 94 shows general constructions of steam packings.

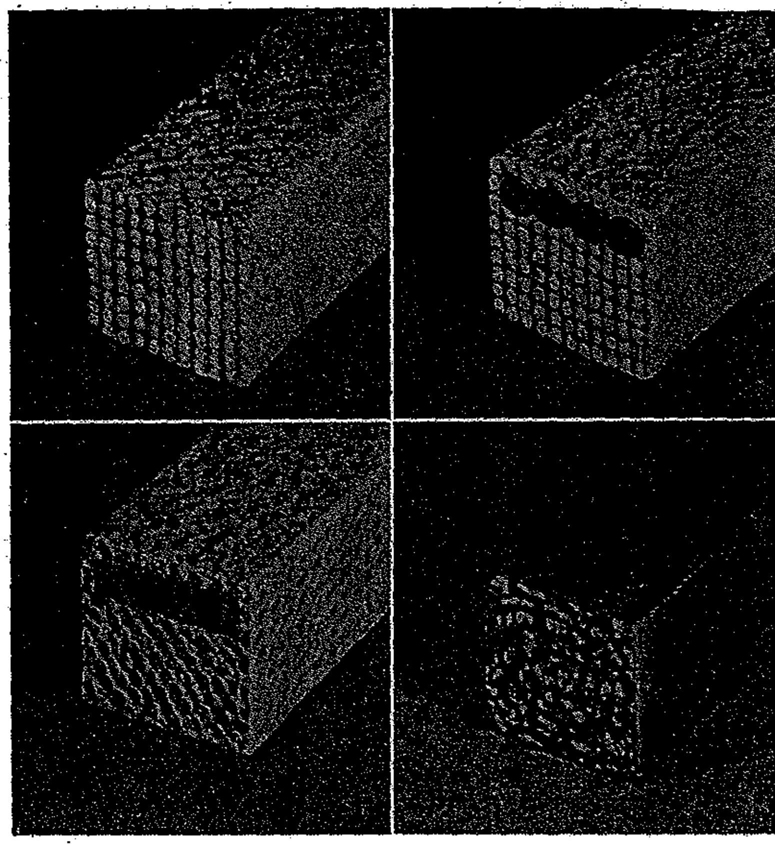


Fig. 94

Asbestos Rolled Cloth Packing — Asbestos Block Packing

Asbestos Multicore Packing — Asbestos and Lead Wire Packing

SQUARE PLAITED ASBESTOS PACKING

This material is used as self-lubricating packing for general steam purposes, and is made from good quality asbestos yarn of which each strand is individually impregnated with a high-grade lubricant, and the graphited square section is built up on solid plait construction.

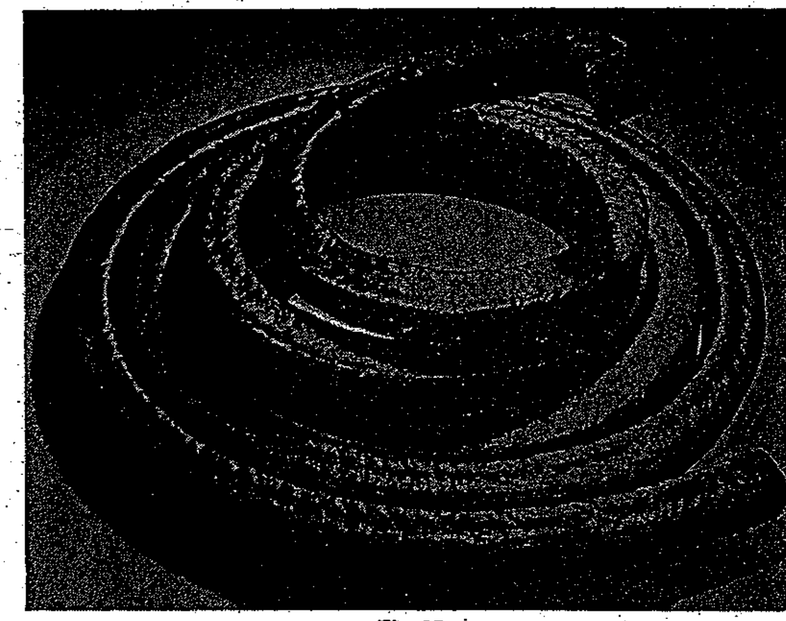


Fig. 95
Plaited Asbestos Packing

STEAM PACKING

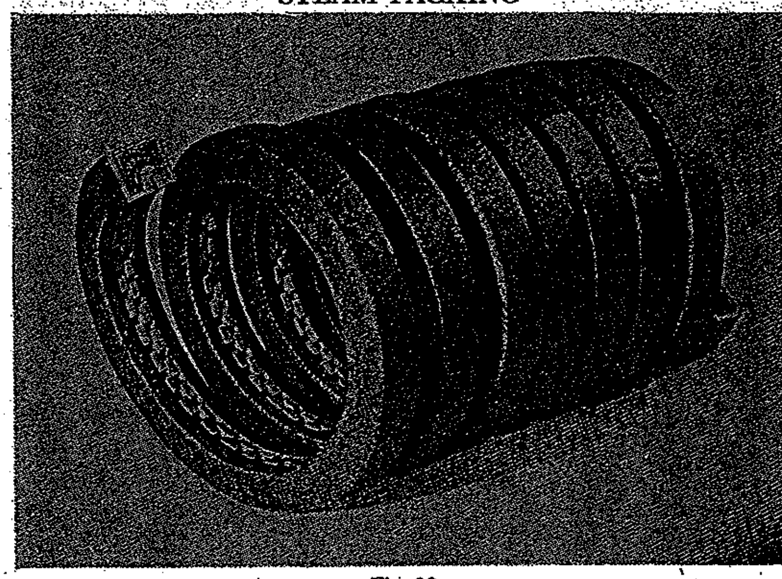


Fig. 96
Steam Packing

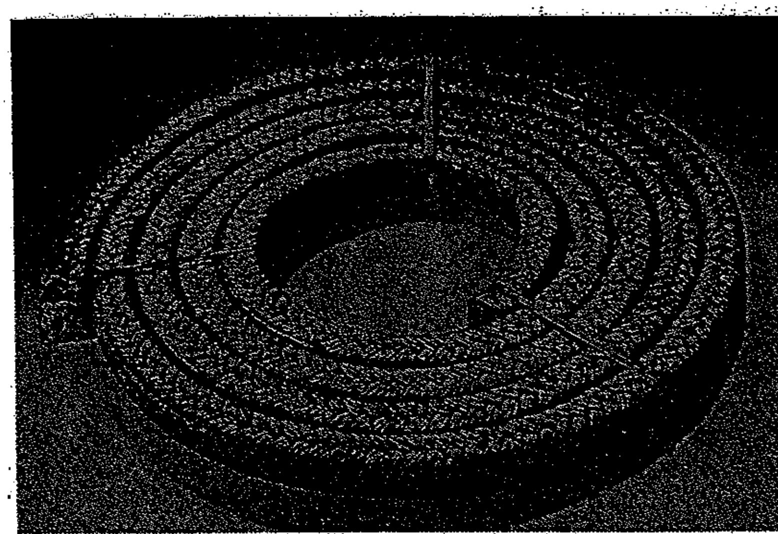


Fig. 97
High Temperature Packing

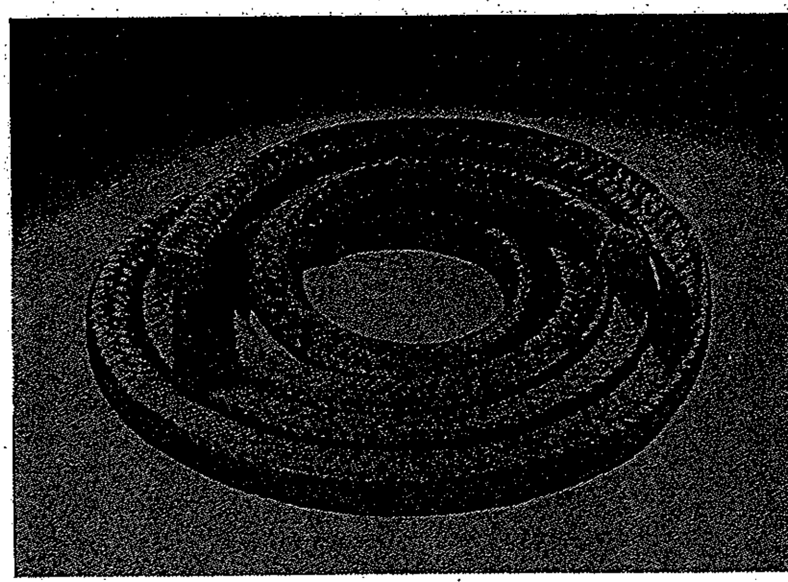


Fig. 98
Acid-Resisting Packing

Another type of steam packing is shown in Fig. 96.

This material is made of several bands of anti-friction white metal embedded in rubber-proofed asbestos cloth. Such composition forms a series of metal rings which give any piston rod a glass-like surface, doing away with any possibility of scoring, and is particularly recommended for marine and all high-pressure steam engines.

HIGH TEMPERATURE PACKING

Exposure to high temperatures necessitate the use of chemically pure asbestos yarns. The packing shown in Fig. 97 is braided from pure asbestos yarn reinforced with phosphor-bronze wire. Such packing is used against superheated steam and hot oil at temperatures up to 1,000°F.

ACID-RESISTING PACKING

Crocidolite asbestos is the most resistant type to acids and the packing shown in Fig. 98 is made from pure blue asbestos yarn, braided cover-upon-cover, and impregnated with a special acid-resisting lubricant. One of the chief applications of this packing is in acid pumps.

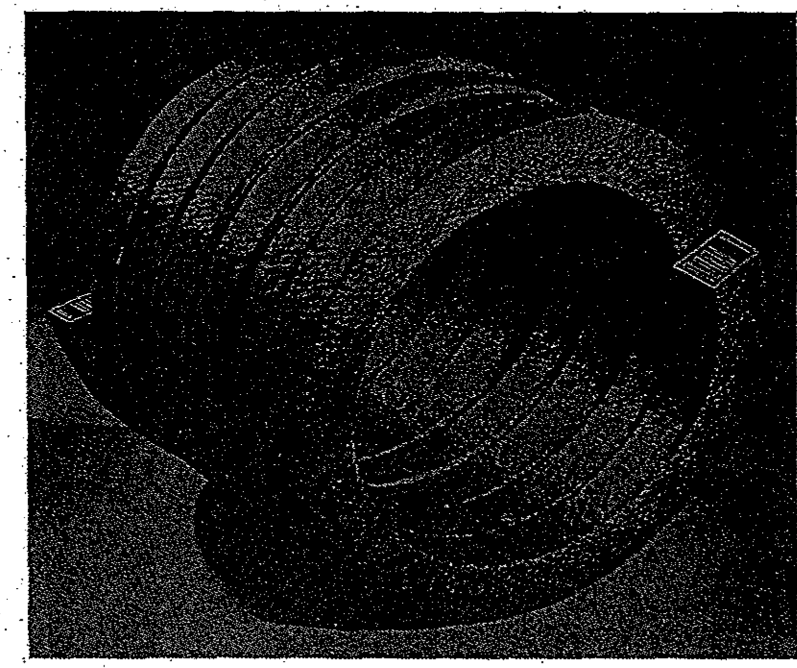


Fig. 99
High Pressure Packing

CHAPTER 14

Other Industrial Uses of Asbestos

GASKETS

A GASKET is a packing designed for inclusion between rigid parts of a fluid container in essentially stationary relationship*. The problems of making a pressure tight joint between flanges of pipes or providing a gas tight seal for engine cylinder heads, exhaust flanges, or manifolds require careful consideration of several factors in order to choose the right type of material[1-4]. The most important are (*a*) temperature and pressure, (*b*) fluid—whether it is liquid, gas or steam, and whether it is corrosive, and (*c*) nature of the flange surface.

Asbestos has been used for many years as a gasketing material either in the form of compressed fibre sheets or woven cloth. Compressed fibre jointing was invented in 1886 by Richard Klinger. Since that time asbestos jointing has been increasingly used for many gasketing services and today every engineer is familiar with the use of this material.

The best grades of jointing are made of long chrysotile fibres, which, after cleaning and opening, are compounded with binding agents and vulcanised under pressure into a homogeneous structure. Compressed sheets consist usually of 65—80 per cent of fibres; the remainder is a binder or compounding agent.

Natural rubber, Neoprene, Buna S and other synthetic binders are used, compounded with plasticisers, anti-oxidants, etc.

The first step in manufacturing this material is the cleaning and opening of the dry fibres. Particular attention should be paid at this stage to the elimination of hard fibre bundles and various mineral impurities, and at the same time care must be taken to avoid excessive fibre breakage. The degree of opening or fiberisation depends on the use of the final product and the softness and density required. Well opened and cleaned fibres are mixed with the correct proportion of rubber and other mineral ingredients to a dough-like consistency and rolled out in calenders, where heat

*A.S.T.M. definition.

ives off the solvent and the action of the rollers compounds the nstituents into a compressed homogeneous sheet.

The finished sheet acquires a "grain" and possesses a greater nsile strength in the circumferential direction of the calender llers. In order to improve the low tensile strength against the ain, two sheets are laid at right angles to each other and cemented gether. Such "cross-laminated" material has a similar tensile ength in all directions.

Besides chrysotile, "blue" asbestos is also used as a jointing aterial in chemical and industrial plants where resistance to acids of primary importance. In general, the three types of jointing at are made are (*a*) plain, (*b*) coated with graphite on one or th sides, and (*c*) reinforced with brass, copper and steel mesh. Depending on the compounding, they are used for superheated ams, air, acids and alkalis, gas, water, oil, and in fact for most er liquids. A quality of material intended for high duty (Grade G) ould have a tensile strength exceeding 5,500 lb. per sq.in. with ain, and 2,000 lb. per sq.in. across grain, as frequently the ength of the material limits its applications*[5].

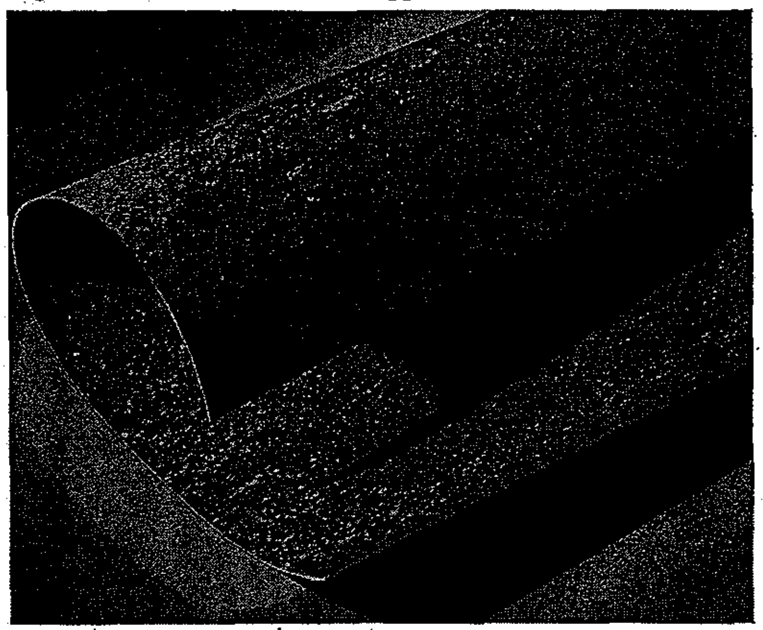


Fig. 122
Asbestos jointing

Low duty purposes 3,000 and 1,200 lb. per sq.in., respectively.

(Test sample 1 in. wide, 4—8 in. long, $\frac{1}{16}$ in. thick, rate of traverse 9 in./min.).

Tearing strength may also be specified by various users of this material to suit their own requirements.

The ignition loss in weight of the material on exposure to 850°C. serves also as a further check of quality: if it is greater than 30 per cent, it may indicate that the strength was increased by the excess of the rubber compound.

The specific gravity test indicates whether the material is insufficiently compressed or, if the figure is high, whether too high a proportion of fillers was used in compounding. A specific gravity within a range of 1·65 to 2·0 is considered normal. It must be realised however, that all these tests give a general idea only and do not preclude the serviceability of the material in certain applications, even when the test results are outside the specified limits already mentioned. The performance of the material in actual conditions of use is the best criterion of its value.

WOVEN CLOTH

Woven cloth as gasketing material is preferred in such cases where softness and pliability are most desirable. It is normally woven from asbestos yarns reinforced with fine brass wire and usually contains from 10 to 20 per cent of organic fibres, added to aid the carding and spinning processes. Such addition of organic fibre decreases the heat-resistance properties of the woven cloth and their amount should be kept as low as possible. Because the woven fabrics are porous they are impregnated with either rubber or plastic compounds.

For boiler handholes and manholes, plain or metallic asbestos cloth, treated with heat-resistant rubber compounds is used. It is folded, formed and pressed to the required size and shape. Besides chrysotile fibres, "blue" asbestos is also used and the cloth made from it is treated with neoprene cement and serves against strong mineral acids, oil and organic solvents.

TADPOLE TAPE

This is made of asbestos cloth wrapped over a core of asbestos wick, rope, rubber tubing, etc., depending on the size and softness required and on the service conditions. Tadpole firewall seals are made with cores of inconel mesh or with synthetic rubber for hot places. Tests show that they resist penetration by a 2000°F. flame and continuous temperatures up to 500°F.

RUBBER GASKETS

Natural rubber is mostly used for hot and cold water where its elasticity and ability to adapt to any surface imperfections are generally appreciated. Several synthetic rubbers like Buna S, Buna N, Neoprene, Butyl, Thiokol, are used for sealing against oil. Recently developed silicone rubbers possess outstanding heat-resistance properties and find application, alone or with asbestos reinforcement, as a gasketing material among other uses. (See also "Silicone Rubber" in Chapter 13).

Several plastic materials are used in the manufacture of envelope-type and moulded-shield gaskets. Teflon (tetrafluoroethylene polymer) and Kel-F (chlorotrifluoroethylene polymer) are most prominent, due to their resistance to heat and complete chemical inertness (see also Chapter 13).

METALLIC GASKETS

The most important factors that influence gasket selection are the temperatures and corrosive effects to be encountered. Non-metallic gaskets are generally limited to temperatures below 400°F. Semi-metallic gaskets made of asbestos and partially or completely clad with metal may be used up to 850°F. Above 850°F., only all-metal gaskets are satisfactory. A wide variety of metals are used including lead, tin, aluminium, copper, brass, monel, nickel steel and even silver.

In addition to metals, organic fibres in the form of treated paper and leather either alone or impregnated with rubber, are also used for gasketings.

New products or improvements are constantly being made and one of the latest worth mentioning is the combination of asbestos-metal-resin. This new product, made by Lancork Ltd., is manufactured for the specific purpose of providing a gas tight seal for internal-combustion engine cylinder heads, exhaust flanges and manifolds[6]. One particular feature of this material is that when the engine heat causes the resin to flow and the gasket is compressed, the asbestos moulds itself to the two surfaces and becomes impregnated throughout with resin and rock-hard, thereby giving the asbestos a greater strength than would be possible if the heating and compressing occurred prior to fitting the gaskets. Further strength is obtained by interleaving the asbestos with copper or aluminium for every $\frac{1}{32}$ in. of asbestos.

Recently a new type of cylinder head gasket was developed. This is made from a thick sheet of aluminium washer with an aluminium foil lamination on each side. It is claimed that these gaskets are superior to the conventional copper and asbestos types because of their better thermal conductivity[7,8].

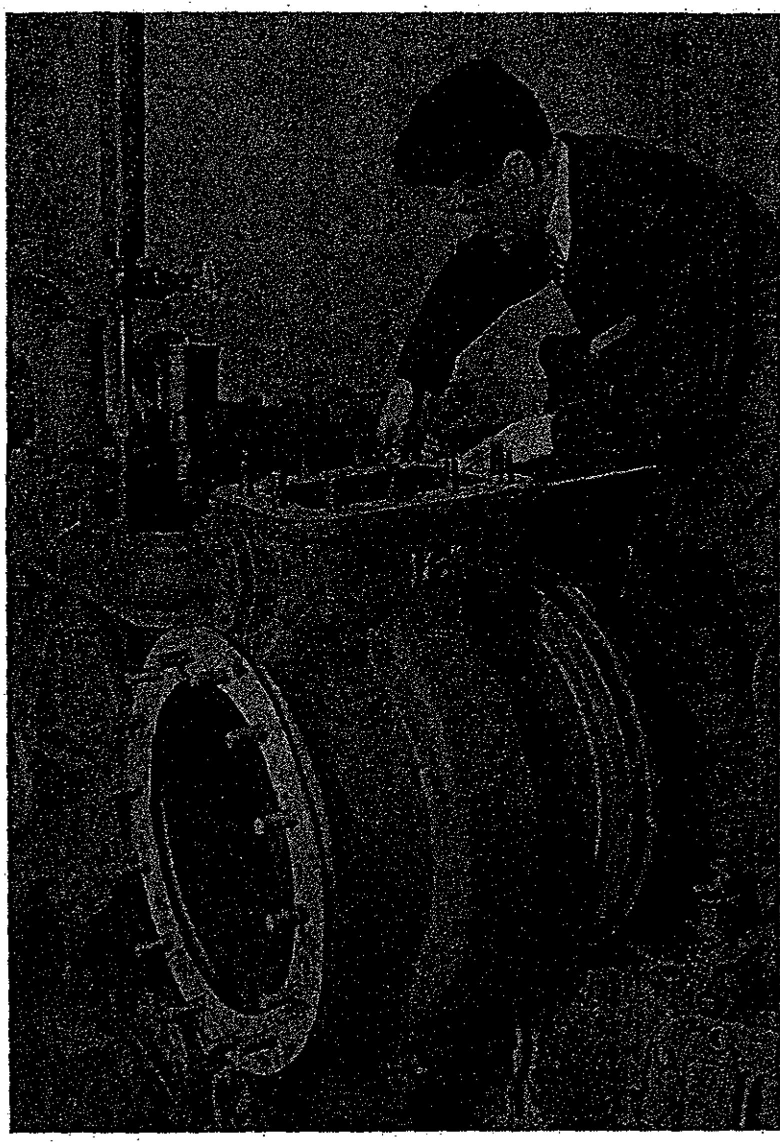


Fig. 123
Fitting of Asbestos Gaskets

BIBLIOGRAPHY

1. Good Gasket Practice. W. F. Schaphorst. *Asbestos*, 1951, 33, No. 3, 8.
2. Gaskets and Their Selections. W. F. Schaphorst. *Asbestos*, 1950, 32, No. 1, 18—20.
3. Asbestos, Its Preparation and Application. A. E. Williams, Mechanical World Monographs 47: 1948.
4. Gaskets. S. Elonka. *Power*, 1954, 98, No. 3, 105—124.
5. Compressed Asbestos Jointing for the Petroleum Industry. British Standard No. 1832: 1952.
6. Langcork Company Ltd., 8, Ajax Crescent, Cambridge, East London, S. Africa. (private communications).
7. De-rating Gaskets. Anon. *Automobile Engr.* 1953, 43, No. 564, 112.
8. B.P. 721,475. Improvements relating to the Production of Metallised Laminated Jointing Materials. Turner Brothers Asbestos Co. Limited.

CHAPTER 17

Asbestos Trade

ASBESTOS TEXTILE INSTITUTE

THE ASBESTOS TEXTILE INSTITUTE with office and laboratory at the Philadelphia Textile Institute, Philadelphia, U.S.A., serves the affiliated members of the industry through its many specific committee activities and those projects pursued in the general interest of the industry.

The organisation of the Asbestos Textile Institute is directed by the Board of Governors consisting of the following officers and members:—F. J. Wakem, Johns-Manville Corporation, President; J. A. Bettes, Raybestos-Manhattan, Inc., Vice President; J. G. Schoepf, Asten-Hill Manufacturing Company, Treasurer; R. S. Hulse, Southern Asbestos Company; G. W. Marshall, Jr., Raybestos-Manhattan Inc.; A. J. Scanlan, American Asbestos Textile Corp.; and D. W. Widmayer, Keasbey & Mattison Company. Dr. M. C. Shaw serves the Institute as Executive Secretary and Director of Research.

The membership of the Asbestos Textile Institute consists of six asbestos textile manufacturers located in the United States, four asbestos fibre mining companies located in Canada, three asbestos textile manufacturers located in England, two asbestos textile manufacturers located in France and one asbestos fibre mining company located in Africa with offices in England and the United States.

There are four functioning groups or committees within the Institute, each concerned with different aspects of the industry and each carrying on studies designed to improve or develop that segment of the industry in which it is particularly interested.

The Air Hygiene section is engaged in important investigations relating to dust control and elimination in the manufacturing operations involved in this industry and in studies designed to determine the hygienic and physiological effects resulting from exposure to various dust conditions.

The Sales Promotion Committee is continually engaged in efforts to promote the use of asbestos textiles and in investigating and initiating new applications for the materials produced by the industry. Industry-wide improvements in quality and serviceability are the aims of this section of the Institute, and consumers are becoming increasingly aware of the fruits of the efforts of the group. The section works closely with the Technical Committee and the Research Fellow in seeking the solution to many of the problems with which it is confronted.

The Technical Committee is continually investigating the many problems involved in improving the quality of available materials, development of new materials and in devising new and improved methods for testing and evaluating results.

The Fellowship laboratory under the direction of Dr. M. C. Shaw serves all of the committees in their many investigations and provides technical assistance whenever necessary. In addition, there is conducted by the Fellow an extensive research programme as established by a special committee of the Institute.

The activities of the Asbestos Textile Institute are continually expanding and the efforts exerted through the participation of the membership in the programme encompassed by the several specialized sections of the organisation serve to provide the industry with an ever-increasing fund of knowledge regarding the products of the industry. With this increased understanding it is felt that the industry will be in a position to continue to expand and to meet the demand for the new and improved materials which will be required by the engineers of the future.