

The Role of Asbestos in Plastics

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(Annual General Meeting, Quebec City, April, 1956)

(Transactions, Volume LIX, 1956, pp. 283-288)

INTRODUCTION

DURING the past twenty years the use of asbestos fibre in molding compounds has increased considerably, and hence the plastics field has served as an outlet for large quantities of asbestos fibres from Canada. It is estimated that approximately 14,000 tons of asbestos fibres varying from Group 4 to floats are used by the plastics industry.

The utility of fillers in molding compositions has long been known. Their original purpose was to help make molding practical and to reduce the product cost. In the early days, these fillers consisted of sawdust, cotton waste, powdered asbestos, silica, diatomaceous earth, sand, clay, powdered glass, cork, marble dust, slate flour, or other materials. Each filler had certain good characteristics as well as certain objectionable ones.

In this presentation it is proposed to discuss only asbestos as a filler in molding plastics.

TYPES OF PLASTICS

In general, molding plastics can be divided into the following categories: (1) cold-molded plastics, and (2) hot-molded plastics.

Cold-Molded Plastics

Asbestos fillers have the following advantages in the cold-molding field:

- (1) Lower molding cost
- (2) Make cold-molding possible by controlling the flow of material under pressure while it is in the cold mold
- (3) Improve mechanical properties
- (4) Increase hardness
- (5) Decrease molded shrinkage.

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(6) Increase heat and fire resistance

(7) Allow ejection of the cold moldings from the mold, and improve handling and movement of the uncured moldings without danger of deformation or warpage.

Unfilled moldings would be impractical in the cold-molding field of bitumens and phenolics. Because the filler must produce sufficient handling strength, asbestos, with its fibrous character, is a desirable binder. Binders normally used are asphalt, pitches, gilsonite, polymerizable oils, resins, and similar compounds.

Cold-molded products of the fibrous type are sometimes loaded with as much as 50 per cent of asbestos. Such a product possesses good heat resistance and better good electrical insulating properties, and is less in cost. Its strength is not equal to that of hot-molded products, however, it is sufficient for the type of moldings made with cold-molding powders.

Cold-Molded Phenolics

Various grades of a suitable asbestos may be used as binders in cold-molded phenolics. The advantages of this higher priced type of cold-molding compound are: better surface finish, lighter colours, more dimensional uniformity, and better mechanical and electrical properties.

Manufacturing Method

Cold-molded compounds are in general made by loading the fillers into a heated internal mixer, after which the binders and other ingredients are added in liquid form or in solution. This mass becomes somewhat tacky and, after discharge, it is allowed to 'season'. Later on it is screened to separate lumps, whiskers, and other extraneous material to provide a fairly uniform granular compound for molding.

The grades of asbestos used in the cold-molding field are normally described as floats and shorts. The quality and physical characteristics of the asbestos are important and should be controlled. The most important and troublesome variables within this field are:

(1) Texture and quality of fibre should be as constant as possible so that the molder can set up his working formula and not be forced to make repeated changes.

(2) Bulkiness property of fibre should be kept constant. For example, if the fibre is increased in bulkiness properties, more binder is required and this increases product cost. On the other hand, if the fibre is too heavy or less bulky, the molding material becomes tacky because it does not absorb the proper quantity of binder. This condition also causes screening and molding difficulties, sticking to the molds, increased baking time, and softer moldings. Often, the mechanical strength of the product is lowered.

(3) Excess moisture in the asbestos also can cause trouble, such as sticking and blistering. Normally, asbestos as received by the molder contains from one to two per cent of moisture. Under some storage conditions in customers' plants, the fibre may pick up additional moisture; this is why some plant operators pre-dry their fibre as a protection against any moisture increase due to storage conditions.

(4) Non-uniform fibres should be at an absolute minimum. They may be described as those that have 'whiskers' or long fibrils in excess of the average fibre length for that particular grade. These 'whiskers' twist and tangle and interfere with the efficiency of the screening process. They also cause sticking to the molds, produce surface blisters, and in most cases affect the finish and the appearance of molded products.

After the molding powders are properly sized by screening, they are ready to be placed in the mold. At this point, the bulk factor is extremely important because pre-forming and final molding are one and the same operation. Moreover, positive molds are used, and most molded parts are each fitted with from one to several metal inserts. The molds are loaded by means of a small hand rake or mechanical rake. Good pourability and proper bulk of the molding compounds are indispensable at this step for good and efficient cold-molding. If the molding compound charge is insufficient, then the molded part is off-size; and if the charge is excessive, the product is heavy and in some extreme cases may even damage the mold.

The cold-molding operator has his own responsibilities. He must develop a well-balanced compound in which the ratio of binder to filler is adjusted in relation to the bulk value of the filler. If he does this, sticking and off-size products, as well as other troubles, will be minimized or eliminated.

In most cases, the compounds are dusted with a powdered lubricant before they are loaded into the mold, to prevent any sticking tendency. If the formulation is made correctly, the cold-molded compound will flow properly and produce good material. The main factors the operator must constantly watch are: (1) bulk of the asbestos filler; (2) ratio of binder or filler; (3) proper size of particles of the molding compound; and (4) molding pressure as well as baking temperatures and cycles.

In general, it may be stated that cold-molded products are not suitable for power factor applications of any importance; but they are used extensively as heater plug parts and as housings for the shielding of electrical units. High loading of asbestos as a filler imparts the heat and flame resistance required.

Thermoplastics

In the thermoplastics field the fillers generally used are zinc oxide, titanium oxide, blanc fixe (barium sulphate), talc, diatomaceous earth, and asbestos.

The common names of the most familiar thermoplastics are: cellulose nitrate, cellulose acetate, cellulose acetate butyrate, ethyl cellulose, vinyls, polystyrenes, vinylidene chlorides, and esters of acrylic acid.

The disadvantages of fillers in thermoplastics may be summarized as follows:

(1) Mineral fibres increase the specific gravity and molding weight of both thermoplastics and thermosetting molding compounds.

(2) Fillers preclude production of transparent or translucent plastics (molded, cast, or fabricated). Translucency can be obtained only to a limited extent when the refractive index of the plastic and the filler are approximately the same; in these cases, however, the moldings lack quality.

(3) Fillers decrease water and moisture resistance.

(4) Fillers also reduce electrical and mechanical properties. The exceptions are resistance to arcing and compressive strength.

(5) Fillers in most cases damage the delicate molding and fabricating equipment.

(6) Fillers frequently introduce new and sometimes complicated problems in the difficult art of colouring, mottling, and configuration of thermoplastics.

(7) Fillers in thermoplastics impose the need for special types of processing, molds, and methods of molding.

(8) Fillers increase the quantity of waste and re-work.

(9) Fillers make injection and extrusion molding methods troublesome and wasteful. Consequently, work along these lines is chiefly experimental at present.

Asbestos improves the heat resistance and compressive strength of the thermoplastic moldings. It also reduces the cost and the tendency to cold-flow, with resultant deformation and warpage. Although hardness is improved, the increase is only moderate. Resistance to flammability and arcing is also improved by asbestos; however, this is true of all mineral fillers.

Incorporation of fillers in thermoplastics is usually handled by one of three different methods, briefly described as follows:

(1) Preliminary mixing of the plastic binder in powdered or flake form with the plasticizers, fillers, and other ingredients in ball mills or in internal mixers.

(2) Blending of the ingredients, including binders, plasticizers, and fillers, with or without solvents, in

heated kneaders. Hot-rolling is followed by calendering, stamping, or by molding.

(3) Incorporation of the fillers and plasticizers on the hot rolls after the plastic binder has been consolidated into a plastic sheet. This procedure is used for blanking and/or fabricating and/or molding.

To obtain a good product requires considerable good judgment on the part of the operator. This is influenced by: (1) method of incorporation; (2) time of mixing; (3) temperature of mix; (4) percentage of filler; (5) type of filler; (6) mixing technique; and (7) type and condition of the plastic binder.

Because of the conditions under which hot-rolling is practical in the thermoplastics industry, and because the binders are plasticized, the operation is a safe and efficient one for the operator. Binders remain fusible indefinitely, and this permits perfect blending by pulling the filled compound in fairly thin sheets over and over as required. Filler loadings are usually on the low side.

In most cases, a well-formulated compound can be processed and molded without sticking to hot steel; however, in some special cases lubricants are used to minimize possible difficulty.

Most of the thermoplastics used for regular molding can be produced in a large variety of molding flows, because the plastic base and the plasticizer content, or their ratios, can be changed within wide limits.

In thermoplastics, the molder must give close attention to: (1) nature, grade and flow of the base; (2) nature of the plasticizer, whether it is a solid or liquid; (3) percentage of plasticizer; (4) nature and percentage of fibre; (5) pre-heating; (6) molding temperature; and (7) molding pressure.

Special techniques have been developed by the trade for the drilling and machining of each particular type of thermoplastic, filled or unfilled.

Asbestos, especially light-coloured fibres, can be used in moderate percentages in the manufacture of thermoplastic molding or calendering materials based on ethyl cellulose, vinylchloride acetate, and vinylchloride (polyethylene has been tried experimentally). The asbestos filler improves the hardness, heat resistance, burning rate, compressive strength, and arcing resistance of the product but it affects

adversely such characteristics as specific gravity, translucency, appearance, depth of colour, other colour possibilities, flexibility, shock and flexural strength, water resistance, and electrical properties.

In the thermoplastic field, the use of fillers is very limited. Vinyl chloride acetate and vinylchloride-base floor tiles, however, constitute a very important and growing field. Work is also being done on floor coverings.

Asbestos is used in some types of shellac-base compounds also, but not to the extent it was in the past.

One manufacturer in the United States has been producing injection moldings in very large quantities with a compound made with mineral fillers, asphalts of high purity, pitches, plasticizers, and hardening or strengthening agents such as asbestos or other fibres of short or medium length. We understand that the cost of these moldings ranges from \$20 to \$200 per ton.

Thermosetting Plastics

The thermosetting field of plastics is large, and use of fillers has many advantages. Filled moldings are cheaper, and the fillers control the flow of the molding compound. In addition, they improve the mechanical strength and dimensional uniformity, they make the moldings more dependable and durable, and they decrease the shrinkage and warping tendencies of moldings after their ejection from the hot mold. Filtres shorten the curing time and increase hardness; they improve heat, fire, and arcing resistance.

Some of the disadvantages in the use of commercial fillers in these plastics are: increase in specific gravity and molded weight; decrease in water and moisture resistance; lowering of electrical properties; increase in wear and tear on equipment and molds. Moreover, asbestos introduces grit, rock, and magnetite. These impurities increase deterioration of equipment; they make drilling and machining operations difficult.

In the production of thermosetting plastics it is generally accepted that, if the compound has a tendency to stick to the hot-mixing rolls, it will also stick to the molds and cause rejections, expensive delays, and cleaning jobs. Moreover, the mirror polish of the cavities may be damaged, and internal lubrication of the molding compounds is indispensable.

If the compound flows poorly, production is decreased. Also, moldings are mechanically weak, untrue, and defective dimensionally, and electrical and other properties are erratic.

On the other hand, if the compound flows immoderately and too rapidly, it causes excessive case hardening, excessive and wasteful flash, lack of dimensional accuracy, decreased mechanical and electrical strength, and upsetting of pins, removable parts, inserts, and the like. It also interferes with the efficiency of the ejecting devices.

Chrysotile asbestos as a filler has a number of advantages, some of which are common with other fillers. Advantages of chrysotile are: (1) it is mineral in nature; (2) it is available in large quantities; (3) it is low or moderate in cost; (4) it is fibrous in structure; (5) it is possible to adjust percentages used in relation to fibre length; (6) it is easy to process and mold in compounded form; (7) it retains the binders; (8) it is inert to reactions involving rolling, molding, and curing of the compounds; (9) it permits the manufacturer to use high percentages of filler, e.g., 65 to 70 per cent; (10) it allows the molder to vary the percentage and fibre length to achieve desired mechanical strengths; (11) it imparts toughness; (12) it provides better surface finish than soft wood flours, barytes, or mica; (13) it retards the burning rate; (14) it supplies heat and fire resistance; (15) it increases hardness; (16) it reduces the natural shrinkage of the resins and plastic binders; (17) it allows blending with mineral and organic fillers; and (18) it increases the moisture resistance of moldings partly filled with cellulose fillers.

Compared with other mineral fillers, chrysotile has the following advantages: (1) it is fibrous and available in lengths desired; (2) it has excellent binder retention; (3) it is easy to process and mold; (4) it may be loaded at higher levels than other mineral fillers; and (5) it produces the hardest and toughest moldings at loadings impossible with other fillers.

Asbestos-filled thermosetting moldings excel all others in heat resistance, up to temperatures of 450°F., because asbestos loadings can be made at higher percentages than is possible with other mineral fillers. The impact strength can be varied within wide limits by varying the quantity and length of asbestos.

Chrysotile asbestos has some disadvantages however. Chief of these are:

(1) *Combined Water*

Combined water is present as a part of the chrysotile structure. If temperatures of molded products reach 450°F. or higher and some of the combined water in the asbestos is liberated, the molding will blister and crack. This difficulty is particularly significant when heater plugs and other electrical and heating appliances are involved.

(2) *Fibre Length*

Fibre lengths of asbestos used in plastics vary, depending upon the grade. The molder must understand the type of fibre and something about its properties, especially the specific gravity, bulk, molded weight, mechanical and electrical properties, water and moisture resistance. In addition, he must understand mixing techniques, colouring, surface finish, molded shrinkage, and percentage of fibre available in the asbestos grade used.

(3) *Dust or Fines*

The so-called 'dust' or 'fines' in asbestos may be granular, fibrous, or talcy. Variations in the ratio of dust to fibre, and its degree of fineness, will affect all those properties mentioned under the heading of fibre length. For example, surface quality of the molding will improve as the percentage of dust increases; however, all other conditions being equal, the surface quality of the molding will be lowered as the fibrous structure of the dust, or as the particle size of the dust, increases. In other words, a fine granular dust will impart the best surface finish.

(4) *Talcy Dust*

Talcy dust adheres to the surfaces of the fibres, producing what is called the 'talcoase' effect. It retards, and in extreme cases prevents, adhesion of the resin binder to the asbestos filler and adhesion of the blending charge to the hotter of the mixing rolls. This often results in increased rolling time, sticking, fouling, irregularities, poor detail, inferior surface finish, and increased rejections or waste.

(5) *Rock*

The so-called 'rock fraction' in asbestos, which is mostly ground serpentine, is usually present in dif-

fering percentages. This fraction has a tendency to segregate when the ingredients forming the molding compound are given the preliminary dry- and cold-mixing. Accumulation of rock on the bottom of the mixer or ball mill unbalances the disposition of the ingredients. Presence of this rock in a molding compound will tend to scratch the delicate mirror polish of the mold, which is costly to repolish.

(6) Pencils of Fibre

'Pencils' are defined as fibre bundles not well opened, and thin in cross-section. These pencils cause the charge to stick to the hot rolls and molds as a result of the pencils being crushed between the friction rolls or under the molding pressure. When this happens, the newly exposed fibre surfaces remain partly coated and do not ride with the charge on the rolls or within the mold. When the pencils remain uncrushed they are enclosed by the binder, and, when opened by the grinding operation, they appear as poorly bound units, or as uncoated fibres or specks that show on the exposed surface of the moldings and throughout their mass. These pencils may also be blamed to a certain extent for blistering of material within the mold or in service.

(7) Lumps of Fibre

If the fibre is lumpy before the molding powder is made it will cause about the same trouble as pencils. Lumps must be removed to ensure good disposition. The fibre product as produced from the mine should be void of lumps; if not, it should be screened or lightly fluffed before use.

(8) Whiskers

Small percentages of long fibres in an extremely short fibre product are called 'whiskers'. Although these whiskers may be only a fraction of an inch longer than the main makeup of the fibre grade, they cause sticking and affect surface quality and appearance.

(9) Grit

Grit is usually smaller in particle size than the rock discussed earlier; it is harmful, however, and can damage the molds.

(10) Magnetite

Magnetite, an iron oxide having magnetic properties, is usually present in most grades of chrysotile as-

bestos. Its removal is difficult. The effect of magnetite on electrical properties has been the subject of much discussion, particularly when it is coated by a resin. Its black colour is objectionable in moldings of light colour or shade. Electrical properties of the molding may or may not be affected by the presence of magnetite.

(11) Alkalinity

Chrysotile asbestos has a high alkalinity because of the nature of the molecular grouping of its elements, which, in the presence of water, combine to form a small percentage of $Mg(OH)_2$. The *pH* is usually around 9.3 to 9.7. In many molding powders this alkalinity is not objectionable; in others, such as urea formaldehyde, alkalinity is troublesome. However, asbestos is not used to fill resins of this type.

(12) Capacity for Moisture Absorption

Asbestos, unfortunately, has a high capacity for absorbing moisture. This effect can be counteracted, however, by oven-drying before the molding powders are made.

(13) Surface Finish Imparted by Asbestos

Floats of good grade impart good finish as well as the desired toughness and mechanical strength. As the result of considerable experimentation, floats of excellent quality are now available.

(14) Phenolic Molding Compounds

Phenolic resins include the condensation products resulting from the controlled reaction of phenol with formaldehyde or with furfuraldehyde. The ratio of the reactants can be varied. The variations as well as the type of condensing agents, modifiers and/or additives used determine the characteristics of the resultant resin. One- and two-step resins and variations are made; they are used within the field discussed, the type selected being based on the properties desired in the end product. Phenolic molding compounds are made by blending short-fibred asbestos and/or floats and subjecting the mixed ingredients (including fibre) to some type of mechanical or heat treatment while the mass is in motion. Chief among these treatments are: (1) preliminary dry-mixing in ball mills or in internal mixers followed by hot-blending in friction rolls, and finally grinding of the mass to pow-

ders of the desired fineness; (2) preliminary dry-mixing in ball mills or in internal mixers followed by hot-friction blending in Banbury mixers, and grinding to powders of the desired fineness. By this method of treatment, fibre length is sometimes reduced, and consequently the toughness and mechanical strengths of the moldings are decreased. However, good blends are made and the curing cycles are reduced.

The purpose of the hot-rolling or hot-blending in Banburys is twofold, (1) to ensure thorough blending of the resin, fillers, dyes, and lubricants, and (2) to facilitate the advance of the resin in order to decrease molding time. Moreover, reduction in the amount of condensation produced in the mold favours production of perfect, blisterless moldings and tends to reduce molding flash. Thermoset flash is practically useless. On the other hand, the thermoplastics type can be reworked and mixed with virgin compound, with or without the addition of plasticizers to compensate for volatilization in molding.

Preforming.—Phenolic molding compounds are usually preformed in suitable equipment. Preforms produced with the original powders are made in various forms and sizes or pellets, or in shapes approximating the final molding. This method accelerates production, assures uniformity of the molding charge, and reduces waste and flash to a minimum.

Preheating.—Molding preforms are usually preheated in special ovens to bring them to the proper degree of plasticity. Preheating reduces molding time.

When long or very long asbestos fibres are used in phenolic molding compounds they are mixed with the finely powdered resins and other ingredients in internal mixers, or by spraying liquid resins, or in solutions. The resultant mixture, although not very uniform, is used for molding. Mechanical mixing does not affect fibre length, but it does create a problem of loading the mold because of the high-bulk factor. Toughness and mechanical strengths are improved, but flow within the mold is retarded. Consequently the molding cycles are longer, more internal lubricant is usually needed, surface quality is poor, and the molded mass is not so uniform as that resulting from short asbestos grades.

The furan resins include the products resulting from the reaction of furfuryl alcohol and furfural;

HEAT-PLASTIC-MOLDING COMPOSITION (1)

Thermosetting Types

	PHENOLICS		FURANS	MELAMINE-FORMALDEHYDES	COLD MOLDED	
	Molded	Cure	Molded	Molded	Organic	Inorganic
Specific gravity	1.25-2.00	1.75	1.75	1.70-2.00	1.37-2.15	1.80-2.3
Specific volume, cu. in./lb.	12.5-12.8	18.2	18.30	12.5-12.8	14.3-12.8	17.5-12.7
Mold shrinkage, in. per 100 in.	0.0008-0.008	—	—	0.005-0.007	0.015-0.017	0.000-0.018
Tensile strength, p.s.i.	4,000-6,500	3,500-4,000	3,000-4,500	3,500-7,500	1,480-3,000	2,200
Compressive strength, p.s.i.	15,000-25,000	15,000-12,500	15,000-18,000	20,000	6,000-15,000	15,000
Flexural strength, p.s.i.	7,000-15,000	5,000-3,500	4,000-9,000	9,000-11,000	5,700-10,000	2,400-7,500
Impact strength, ft. lb. 1/2 in. notch-Izod test	0.27-3.5	—	—	0.23-0.40	0.40	0.45
Hardness, Rockwell	M85-M115	R110	R110	M110	M85-M80	M75-M85
Thermal conductivity, 10 ⁻⁴ cal/sec./sq. cm. per 1°C./cm.	3-15	8.4	—	18-17	—	—
Resistance to heat (continuous), °F.	350-400	300	285-320	250-400	500	900-1300
Heat distortion temp., °F.	250-350	—	—	255	>400	>400
Dielectric strength, 1/2 in. thickness, short time, volts per mil.	100-350	—	—	350-400	85-115	45
Dielectric strength, 1/2 in. thickness; step by step, volts per mil.	75-325	—	—	320	50-75	50-80
Dielectric constant, 10 ⁶ cycles	5-7	—	—	4.1-5.7	4.0	—
Dissipation (power) factor, 10 ⁶ cycles	0.10-0.50	—	—	0.041-0.550	0.07	—
Arc resistance, seconds	Traces	—	—	120-140	75-200	100-500
Water absorption, 24 hr., 1/2 in. thick, %	0.10-0.50	—	0.01-0.3	0.08-0.14	5.5-2.0	0.5-15
Burning rate	Nil	Almost nil	Slow	Nil	Nil	Nil
Effect of weak acids	None to slight	Same as molded	Same as phenolics	None to slight	Slight	Slight
Effect of strong acids	Decomp. by oxidizing acids; others nil	Depends on alkalinity; al. or marked	None	Very light attack	Decomposes	Decomposes
Effect of weak alkalis	—	—	None	Slight attack	None	None
Effect of strong alkalis	—	—	None to slight	Decomposes	Decomposes	None
Effect of organic solvents	None on bleed-proof materials	—	Completely resistant	None on bleed-proof colours	Attacked by some	None
Machining qualities	Poor	—	Fair to good	Fair	Poor to fair	Poor
Molded qualities	Fair to good	—	Good	Good	Fair to good	Fair to good
Cure	In mold	In mold	In mold or oven	In mold	In oven	In oven

(1) Data taken from *Modern Plastics Encyclopedia*, 1955 edition.

furfuryl alcohol with formaldehyde; furfuryl alcohol and ketones, and finally the product resulting from the polymerisation of furfuryl alcohol.

Resins made by reacting phenol and furfural also belong to the furan group, but their properties place them with the phenolics.

(15) Melamine-Formaldehyde Molding Compounds

Calcium cyanamide, a fertilizer prepared by heating calcium carbide with nitrogen under pressure, is the starting point in the synthetic preparation of melamine. This water-soluble material reacts with formaldehyde adjusted to a pH of 7.5 to 9.0 by means of caustic soda. The primary advantages of melamine formaldehyde resins compared with cheaper urea formaldehyde types are increased resistance to heat and hot water, and greater resistance to alkalis and fruit juices. Moreover, the melamine formaldehyde resins permit use of alkaline fillers, such as asbestos. Such fillers cannot be used with the urea resins because they would inhibit setting.

Molding powders are prepared by mixing the liquid resin with the desired percentage of filler. Double-arm open mixers provided with ducts to remove the formaldehyde fumes are used. The damp mass is dumped onto a screener provided with a device to break up the damp resin-filler mixture. From this

screener, the compound is conveyed to the oven drier. The galvanised iron shell of the driers must be acidproof. The continuous conveying belt should be chromium plated. The compound, spread in thin layers, is dried under very closely controlled temperature and humidity conditions. During the drying cycle the water content drops from 50 to 1 per cent and chemical condensation of the resin proceeds.

Cutting and grinding are the next steps. Grinding is done in ball mills where pigments, lubricants, and catalysts are added. The catalysts develop acidity when the compounds are heated to molding temperatures. These curing agents reduce the curing time and make the molding operation faster and more economical. The compound taken from the ball mill is ground to a fine powder to provide a more uniform molding powder.

If a molding compound of higher density is desired, the material is heated from 120° to 320°F. in Banbury mixers. The partial fusion thus obtained reduces the volume of the molding compound.

Powders must be kept in cold storage under controlled conditions.

(16) Color of Thermosetting Moldings

For most phenolic molding compounds used for industrial and many other applications, the colour is not important. Colours other than black

and brown are available today, however, and the filler has to be selected accordingly.

(17) Textures

Asbestos of the chrysotile variety, whether in the form of shorts or floats, should be of soft texture. Semi-harsh and harsh chrysotile fibres have a tendency to pulverise during the processing cycles and are more difficult to coat with resins than are the soft chrysotile fibres. Likewise, the molder will have less trouble in formulation if he knows that the physical properties of his fibres are not altered during his processing.

In the paper, *Heat Treatment of Chrysotile Asbestos Fibres* (1), it was stated that this kind of fibre in the form of floats is very good for use in plastics because of its improved physical properties.

Considerable research is being done in the fields of polyester and epoxy resins with asbestos in various forms. These fields may be very important in the not-too-distant future.

(18) Physical Properties of Fibre-Containing Moldings

The accompanying Table, taken from the *Modern Plastics Encyclopedia*

(1) BADOLLET, M. S., and STREIB, W. C., *Heat Treatment of Chrysotile Fibres*; C.I.M., Trans., Vol. LVIII, 1955, pp. 33-37.

pedia for 1955, shows the various properties of the asbestos-filled molded compositions of the thermosetting type.

CONCLUSIONS

The role of asbestos in plastics has been reviewed from the viewpoint of its usage in the mold-molding, thermoplastic and thermosetting fields. The advantages and disad-

vantages of chrysotile asbestos in these fields have been discussed, as well as general methods of compounding the fillers with the resins.

The use of asbestos in plastics is important to both the plastics manufacturer and the asbestos industry, and it will continue so for a long time.

Today, in the competitive market, it is necessary for the asbestos fibre salesman to understand the us-

age of asbestos in plastics and to be able to help the manufacturer wherever possible. His contacts furnish the leads for future development by the mines of the proper grades of asbestos for the plastics industry. The closest possible co-operation between the mines and the plastics manufacturer is essential to assure the success of the product by keeping variations in quality within the narrowest limits.

Asbestos Floats

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(Ottawa General Meeting, January, 1952)

(Transactions, Volume LV, 1952, pp. 185-189)

INTRODUCTION

ASBESTOS FLOATS may be defined briefly as blends of airborne particles of fibrous asbestos and dust produced during the milling stages and collected by Cottrell precipitators, dust sheds, or baghouses.

The various grades of asbestos floats on the market contain fibrous asbestos particles ranging in length from microscopic to approximately $\frac{1}{4}$ -inch. The fines or dusts present in the floats are from 40 microns to 2 microns or less in cross-section.

Airborne asbestos particles are of diverse length because they are collected at numerous places in the mill. There are: (1) dusts removed from dry rock storage bins, (2) dusts removed from rock and fibre screens, (3) particles from the tops of collectors, and (4) fines removed by suction from the processing equipment.

Sometimes the airborne particles are kept segregated, so that there is a partial separation by gravity. This is accomplished by a series of dust chambers enclosed in a long, rectangular building. The longest and heaviest particles fall nearest to the air flow entrance, the small-

est at a point farthest away and nearest the exit. Sometimes the air from the dust chamber building is passed through a series of baghouses or electric precipitators to collect the extremely fine particles which normally escape to the atmosphere.

In other instances, the airborne particles by-pass the dust chambers and are passed through rows of bag collectors.

Regardless of the method of collecting the particles, the milling department must select proper fibre sizes for blending, producing uniform floats to meet the requirements of the trade.

Sometimes one grade of float can be used successfully in many commercial products; in other cases, great care must be taken to produce a float for use in a specific product.

The present total production of all grades of Canadian floats approximates 40,000 tons per year and it is possible that this quantity may be greatly increased by the proposed expansion programmes now going into effect in Canada.

Since floats are valued at \$40 per ton at the Canadian mines, a tonnage of 40,000 has a potential sales value of \$1,600,000. This division of the asbestos industry is a good business, and it is well worth the concentrated effort of research and development engineers to find

new uses, and so expand the market, for all available floats.

PHYSICAL PROPERTIES OF FLOATS

According to the Quebec Screen classification, there are two general classes of floats, known as 7RF and 7TF.

Samples of various commercial floats were obtained on the market and a series of tests were devised to determine the differences in their physical properties. Some of these tests were similar to those made by many manufacturers who use floats in their products. The results of some of these tests are given in Table I. They do not, however, include the official Quebec Screen test. Manufacturers using floats usually set up their own specifications, based upon requirements for their particular products.

Loose Density

The loose density of floats can be measured by slowly sifting the powder into a can or container of definite dimensions so that the weight per cubic foot can be calculated.

Although in some products the loose density of the floats is not particularly important, in others it is critical, so each float must be considered as an individual case.

In the present investigation eleven 7RF floats were tested and their loose densities were found to range

TABLE I

IDENTIFICATION	LOOSE DENSITY lb./cu.ft.	MATERIAL +100 M %	FINES -200 M %	GRIT +48M %	WHISKERS +48 M %	GRIT -48 M +80 M %	WHISKERS -48 M +80 M %	OIL ADSORPTION c.c./g. fiber
(1) 7RF	19	3	96	0.04	1.90	0.02	0.64	0.66
(2) 7RF	20	4	93	0.14	2.50	0.14	0.66	0.74
(3) 7RF	21	4	93	0.24	2.26	0.12	1.18	0.75
(4) 7RF	22	4	93	0.16	1.30	0.20	0.94	0.68
(5) 7RF	22	3	95	0.12	0.80	0.10	0.46	0.65
(6) 7RF	24	5	90	Tr.	1.16	0.04	0.96	0.68
(7) 7RF	24	5	89	0.06	1.28	0.10	1.12	0.71
(8) 7RF	20	6	91	0.12	4.12	0.56	1.10	0.66
(9) 7RF	25	7	84	0.24	0.70	0.46	1.30	0.65
(10) 7RF	23	7	88	0.46	2.38	0.54	0.92	0.65
(11) 7RF	14	1	96	0.04	0.50	0.02	0.84	1.05
(12) 7TF	23	2	96	Tr.	0.30	Tr.	0.50	0.75
(13) 7TF	23	2	95	0.06	0.60	0.06	0.70	0.65
(14) 7TF	26	3	91	0.00	0.10	Tr.	0.16	0.68

from 14 to 25 pounds per cu. ft. The heaviest is No. 9 and the lightest No. 11. Nos. 1 to 5, inclusive, and No. 8, all with loose densities between 19 and 25 pounds per cubic foot, may be considered as falling within the same range; as also may Nos. 6, 7, 9, and 10, which are slightly heavier (23 to 25). Float No. 11 is in a class by itself and is light in weight as well as bulky (loose density 14). If density were the only physical property that had to be considered, this record would enable the manufacturer to select the proper one for his purpose.

The three *TF* floats included in the Table differ from the *RF* floats in degree of particle fineness. Nos. 12 and 13 have identical loose density (23) while No. 14 is heavier (26).

CLASSIFICATION BY WET WASHING

Fibre and Grit +100 Mesh

A classification of the particles can be obtained by a wet-washing method which determines the amounts of fibre and grit plus-100-mesh and of fines minus-200-mesh. This information is particularly useful if the floats are to be used in molding, extrusion, or spraying.

The *RF* float No. 11 contains only 1 per cent of material larger than 100 mesh. In the other *RF* floats, the content ranges from 8 to 7 per cent, indicating the presence of material that is sometimes referred to as 'whiskers'. In the plastics industry, particles plus 100 mesh may be helpful in producing impact strength in the product.

The three *TF* floats contain almost identical amounts of plus-100-mesh material. In two of them the percentage is lower than in the first ten *RF* floats.

Fines -200 Mesh

The fines minus-200-mesh in the *RF* floats range from 84 to 96 per cent, and in the *TF* floats from 91 to 96 per cent.

The material between plus 100 mesh (fibre and grit) and minus 200 mesh (fines) would be collected on the 200 mesh screen. Its amount can be obtained by adding the plus 100 mesh and minus 200 mesh values shown in the Table and subtracting the sum from 100.

This test, although useful, does not distinguish between, or give the relative amounts of, 'whiskers' (asbestos fibres) and particles of grit that might be present in the floats.

Grit +48 Mesh

In many cases, the grit particles in the floats are of very diverse size. Usually, they are small pieces of serpentine rock and magnetite, or small bundles of asbestos fibre. Complete classification, therefore, requires a further breakdown to determine the quantities of these objectionable particles present in the floats.

This test is made by water elutriation and by careful separation of the grit from 'whiskers' of fibre bundles.

The amount of grit plus-48-mesh in the eleven *RF* floats ranges from a 'trace' to 0.46 per cent. The percentage is lowest in samples Nos. 1, 6, and 11 and highest in No. 10. Although these quantities of grit seem small, they could cause considerable trouble in a manufacturing process by plugging extrusion apparatus or scoring the walls of expensive molds.

The three *TF* floats are almost free from grit plus-48-mesh.

'Whiskers' +48 Mesh

'Whiskers' are short asbestos fibres that may be valuable or objectionable, depending upon the use for which the product is required.

The quantity of whiskers in the eleven *RF* floats ranges from 0.50 per cent (in No. 11) to 4.12 per cent (in No. 8). In the *TF* floats, the range is from 0.10 per cent (No. 14) to 0.60 per cent (No. 13).

Grit -48 Mesh +80 Mesh

In some special products, the presence of grit smaller than 48 mesh, and even smaller than plus 80 mesh, is considered objectionable. Therefore, a further separation is made to determine the quantities of this grit that may be present in these floats.

As shown in Table I, the range for the eleven *RF* floats tested is from 0.03 per cent (Nos. 1 and 11) to 0.56 per cent (No. 8).

Two of the *TF* floats are free from this size of grit and the third (No. 13) contains only 0.06 per cent.

'Whiskers' -48 Mesh +80 Mesh

The presence of whiskers in the sizes of minus 48 mesh and plus 80 mesh is also objectionable because they affect the surface of certain products.

The eleven *RF* floats tested contain whiskers of this size ranging from 0.46 per cent (No. 5 to 1.30

per cent (No. 9). Corresponding figures for the *TF* floats are a low of 0.16 per cent (No. 14) and a high of 0.70 per cent (No. 13).

In the manufacture of plastics, the presence of whiskers results in non-uniform pourability of the molding powders. This necessitates a re-screening operation so that uniformly coated powders will properly fill the molds. In many cases, the whiskers and crudy fibre bundles are not thoroughly covered by the organic plastic material and this increases the water absorption properties of the plastic material, which may result in the formation of blisters.

OIL-ADSORPTIVE CAPACITY

The capacity of a float to adsorb oil is important because it gives an indication of ability to hold an organic liquid when manufacturing a plastic or caulking compound.

This test, made by manufacturers, consists of titrating a given weight of float with oil until its adsorptive capacity is reached. In practice, the adsorptive capacity is considered to have been reached when oil can be released from a ball of the thoroughly mixed float and oil by applying a small amount of pressure against it. The results of this test are expressed in terms of cubic centimeters of oil per gram of float.

For the eleven *RF* floats tested, the oil adsorptive capacity ranges from 0.65 to 1.05 cubic centimeters per gram. The value for No. 11 (1.05 c.c./gm.) is much higher than that for any of the others, which all fall between 0.65 and 0.68 c.c./gm. except Nos. 2, 3, and 7 (0.71 to 0.75 c.c./gm.).

Two of the *TF* floats, Nos. 12 and 14, have closely similar adsorptive capacity, 0.65 and 0.68 c.c./gm., respectively. No. 12 gave a higher value (0.73 c.c./gm.).

MISCELLANEOUS PHYSICAL TESTS

Numerous other tests, of importance to the manufacturer of certain asbestos products, are made on floats. Data for these are given in Table II and are summarized in the following paragraphs.

Surface Area

Study of the surface area of each float was made to obtain data on its covering power as a filler. In this test, the surface area is measured by the air permeability method by means of the Bowen apparatus, fol-

TABLE II

IDENTIFICATION	SURFACE AREA cm ² /gm.	DENSITY lb./cu. ft.		COMPRESSIBILITY* % THICKNESS AT 200 COMPRESS.		SPRINGBACK, % THICKNESS AT MAX. COMPRESS.		SUFF. COND. OF PRESSED SPECIMEN	IONIZABLE SLATS, MICRO- mhos/ cm. 10 volts	DRY BULF. VOL. OF 100 g. cc.	WATER-SOLUBLE		MAGNETIC RATING ²
		2,000 p.s.i.	3,000 p.s.i.	2,000 p.s.i.	3,000 p.s.i.	2,000 p.s.i.	3,000 p.s.i.				Solids %	CHLORINE as Cl %	
(1) TRF	14,800	89.9	94.7	29	32	2.5	2.8	Sm'l whiskers & bundles	219	350	0.16	0.017	4.7
(2) TRF	11,300	93.6	97.0	28	32	3.1	3.7	"	218	335	0.17	0.024	6.3
(3) TRF	13,000	93.5	99.2	28	32	3.2	3.3	"	222	340	0.18	0.029	6.1
(4) TRF	11,800	95.5	99.1	29	32	3.3	3.4	Grit & few whis. & bund.	204	305	0.16	0.025	6.0
(5) TRF	13,000	95.0	98.2	28	31	2.6	3.4	Sm'l amt. of grit & whis.	212	300	0.17	0.022	5.7
(6) TRF	14,000	100.0	105.4	28	32	3.8	4.0	Good smooth	379	320	0.36	0.15	4.1
(7) TRF	13,900	100.8	105.2	28	32	3.4	4.0	"	393	295	0.38	0.16	5.1
(8) TRF	12,500	102.7	107.7	28	32	3.6	4.2	Grit mostly	421	360	0.26	0.15	5.1
(9) TRF	7,500	99.6	105.8	27	31	3.4	3.9	"	190	255	0.12	0.0049	5.9
(10) TRF	8,650	101.2	105.8	28	31	3.0	3.4	"	243	285	0.14	0.0038	9.6
(11) TRF	20,800	93.6	99.2	35	39	5.8	6.7	Good Surface	260	475	0.15	0.0015	3.4
(12) TTF	15,400	95.0	100.0	27	31	3.3	3.7	Good surface	221	295	0.15	0.022	5.0
(13) TTF	11,300	94.8	99.4	27	30	3.5	3.3	Large grit	176	290	0.14	0.0034	4.0
(14) TTF	15,600	96.0	99.5	27	29	3.3	3.3	Good surface	396	275	0.36	0.16	3.9

*Measurements start at 200 p.s.i. as zero point.

lowing the Lea and Nurse technique (1).

The eleven *RF* floats tested show a wide range of surface area, from 7,500 cm²/gm. (No. 9) to 20,800 cm²/gm. (No. 11). In other words, float No. 9 has the lowest, and float No. 11 has the greatest, covering power as a filler. In plastics, the surface area of the float governs the amount of filler that can be used successfully prior to pressing in a given mold.

Two of the three *TF* floats (Nos. 12 and 14) have the same surface area, approximately 15,500 cm²/gm. For No. 13 the value is 11,300 cm²/gm. The high value of 15,500 for Nos. 12 and 14 indicates the presence in these floats of a large percentage of fines.

Density at 2,000 and 3,000 p.s.i.

Ten-gram samples of each float were subjected to pressures of (1) 2,000 p.s.i. and (2) 3,000 p.s.i. and their densities calculated in pounds per cubic foot. These pressures were selected because they correspond to the range of pressures used in the plastic-molding industry, and the data obtained are helpful in selecting the proper asbestos filler for molding powders.

At 2,000 p.s.i. the densities range from 89.9 lb./cu. ft. (No. 1) to 102.7 lb./cu. ft. (No. 8). Several of the samples have substantially identical density, but for the group as a whole the differences in density are such as would influence the selection of the filler to be used for certain products.

At 3,000 p.s.i., the densities range from 94.7 lb./cu. ft. (No. 1) to 107.7 lb./cu. ft. (No. 8). The increase in density for the additional

1,000 p.s.i. pressure ranges from 3.2 to 6.2 lb./cu. ft.

Compressibility of Floats at 2,000 and 3,000 p.s.i.

In this test, a 10-gram sample of the float is compressed at 200 p.s.i. and its thickness measured. It is then compressed at (1) 2,000 p.s.i. and (2) 3,000 p.s.i. and its thickness again measured. The reduction in thickness, expressed as a percentage, gives a measure of the compressibility for each float. Thirteen of the fourteen floats tested show about the same percentage of compressibility (27 to 29). For No. 11, the value (35) is appreciably higher.

This is an important property and must be taken into consideration when pressing a molding powder to a definite size after the molding cavity has been properly filled. Uniform compressibility is important as a bulky fibre will also exhibit poor dimensions after pressing.

Springback After Release of Pressures

The amount of 'springback' of a molding powder is another important property considered by plastics manufacturers. If the springback is too great, it will be difficult to obtain the proper dimensions for a molded product. Too much emphasis cannot be placed upon this property.

All fourteen floats were tested for springback at pressures of both 2,000 and 3,000 p.s.i. As will be noted from the data in Table II, the springback factor is uniformly low for all of them except No. 11 which, also, is the sample with the highest percentage of compressibility.

To use float No. 11, with a springback of 5.8 and 6.7 per cent, allowance must be made for its compressibility or the plastics manufacturer cannot control the dimensions of his product.

Surface Condition of Pressed Blocks

The surface characteristics of pressed blocks of the floats are noted in Table II. The surfaces usually show long 'whiskers', short stubby fibre bundles, and grit, which generally are considered poor properties from the viewpoints of appearance and water adsorption.

A smooth surface is desirable, provided the molded product meets all other specifications of the manufacturer. Five of the floats give good smooth surfaces and probably will be satisfactory for use in molding powders, provided other properties are acceptable.

Ionization Salts

For the manufacture of some special types of molding powders, it is essential that the asbestos fibre have low electrical conductivity. In this case, some plastics companies make a test on water-soluble material leached from floats. Apparently, all floats contain a certain quantity of water-soluble material. Its conductivity is determined, and the result of the test is expressed in terms of micromhos per centimeter per 10 volts. For the eleven *RF* floats tested, this factor ranges from 190 (No. 9) to 421 (No. 8). For the *TF* floats, Nos. 12, 13, and 14, the values are, respectively, 221, 176, and 396.

It is not known at present which values are objectionable, but it appears that a conductance of 300 micromhos or higher per centimeter

(1) For references see end of paper.

per 10 volts may cause trouble, with the molded plastic product having a low dielectric strength.

Dry Bulk

The bulking values of floats are sometimes considered important factors in plastics as well as in dry-wall joint fillers.

By some manufacturers, the bulking value is expressed as the volume, in cubic centimeters, of a given weight, say 100 grams, of the float. Some fillers should have high dry-bulk value while others should not; this depends entirely upon the intended application.

The eleven *RF* floats have dry-bulk values ranging from a low of 255 (No. 9) to a high of 475 (No. 11). For the three *TF* floats, Nos. 12, 13, and 14, the values are, respectively, 295, 290, and 275—differences that may lie within experimental error.

Water-Soluble Material

All floats were analyzed for water soluble materials by allowing a sample of each to stand in distilled water for 63 hours and filtering off the clear water. Aliquots of the filtrates were dried and weighed to determine total solids, and these were then analyzed for chlorides.

The amount of water-soluble material in the eleven *RF* floats ranges from 0.12 per cent (No. 9) to 0.38 per cent (No. 7). In the *TF* floats the range is about the same, with a maximum of 0.36 per cent for No. 14.

No good correlation exists between the ionizable salt values and the quantity of water-soluble material.

The percentage of chlorine in the residues also was determined. For the eleven *RF* floats it ranges from 0.0015 to 0.16 per cent, and for the three *TF* floats from 0.0084 to 0.16 per cent.

Magnetic Rating

Since many floats are used as fillers in products employed by the electrical industry, it may be important to learn something about their magnetic ratings. The test, an adaptation of the Mapes (2) test, measures the amount of magnetic present.

Ratings of the eleven *RF* floats range from 3.4 (No. 11) to 9.6 (No. 10). The other nine *RF* floats have ratings between 4.1 to 5.9 with an average of 5.4. The three *TF* floats range from 3.9 to 5.0, averaging 4.3.

The maximum magnetic rating value for a successful float is not known precisely, but it is believed that the manufacturer would prefer the lowest rating available. It is known that the smallest trace of magnetite can be easily detected in a magnetic field and it may result in the rejection of the plastic material.

Use of Asbestos Floats

Asbestos floats have a definite use in such industrial products as automobile body coatings, adhesives, caulking compounds, dry-wall joint filler, lubricating greases, asphalt and cold-water paints, plastics, molding powders, welding rods, insecticides, radiator scaling compound, acoustical plasters, cements, and many others.

Asbestos floats offer to manufacturers the advantages of being a low-cost inorganic filler, which will improve impact strength and provide good workability, good binding qualities, heat resistance, fair acid and alkali resistance, large surface area, and availability in commercial quantities.

A recommendation for the best grade of asbestos floats for a particular product should be made carefully, since each product has its own requirements and specifications.

Automobile Body Undercoating

A float for automobile body coating to be applied by spray gun may require the absence of 'whiskers' and large particles of grit. If the coating is to be applied by brush, however, the presence of whiskers and grit would not be objectionable. Therefore, the selection of a float for this job depends upon the method of application and such other factors as bulk and fluidity when incorporated in a binder.

Adhesives

The use of floats in adhesives depends upon the type and application of the adhesive product. The proper recommendation can be made only after knowing the desired properties of the adhesives and the method of application. The amount of floats in adhesives (3) varies between 9 and 40 per cent of the mix, depending upon the product.

Caulking Compounds

Caulking compounds may be sensitive to changes in grade of floats. For example, a gun grade of caulking compound may require a float

relatively free from whiskers and grit, while, for a caulking compound applied by knife, a float containing whiskers and some grit could be used. In general, the use of floats in caulking compounds (3) may range from 4 to 15 per cent by weight of compound.

Wall Joints

The manufacturer of dry-wall joint filler is very careful in his selection of floats. His specifications for asbestos fibre are rigid and he insists upon good bulking value, freedom from grit, good coverage, and no whiskers. Very few natural floats on the market today fulfill these requirements and, therefore, a special float must be made for this job. The amount of floats (3) required for this use may vary between 5 and 20 per cent of the dry mix ready for the market.

Lubricating Greases

Various types of floats have been used in some grades of lubricating greases, but in most greases grit is objectionable. Whiskers may be permitted unless the customer's specification indicates otherwise. The amount of float used in greases varies between 10 and 25 per cent of the product (3).

Paints

Paints, with either asphalt or cold-water base, may require a grit-free and whisker-free float if smooth surface is demanded. Otherwise, some grit and whiskers are allowable. Paints may contain from 5 to 11 per cent of floats.

Plastics and Molding Powders

Floats, with specifications varying from customer to customer, are used extensively for plastics and molding powders.

The general opinion of the plastics manufacturer is that fibrous float structure increases impact strength, allows a wide range for adjusting quantity of floats as filler, furnishes good binder retention and workability, imparts hardness and toughness to the moldings, increases heat and fire resistance, reduces natural shrinkage of resins and binders, reduces warpage and deformation, makes cold-molding possible by controlling the flow under pressure in the molds, allows blending of mineral and organic fillers, imparts good finish, improves the

electrical properties and reduces the cost of moldings.

Molded plastics are carefully checked for specific gravity, flexural strength, tensile strength, compressive strength, impact strength, water absorption, dielectric strength, power factor, shrinkage, heat resistance, visual observations of molding qualities, and ejection from the mold. It is important, therefore, that the plastics manufacturer select asbestos floats with care so that molding powder and molded product have the desired properties. The asbestos floats used as a filler in these materials generally form from 60 to 80 per cent of the mix (3).

Welding Rods

The welding rod manufacturer desires a float which will produce good coating as a filler, and which lacks whiskers and grit that might clog extrusion equipment. Floats also should be free from any sulphide mineral, or at least should contain less than the 0.01 per cent of sulphur that would produce obnoxious gas during welding. The amount of floats used for coating rods varies between 8 and 10 per cent*.

Insecticides

Floats sometimes are used as filler for insecticides to be dusted or sprayed onto flowers, weeds, and other plants. In this case, the float should be a fine dust so that it will impart large coverage. Floats for

*British Patent 535,355; Canadian Patent 365,792.

this purpose must compete with such other powders as talc and diatomaceous earth. The amount of float in a ready-to-use insecticide is approximately 4 to 5 per cent.

Radiator Sealing Compound

Various combinations of materials, including fine asbestos, are used in sealing compounds for automobile radiators. The asbestos forms from 1 to about 6 per cent by weight of the solids content of the mixture†.

Acoustical Plasters

Based upon the weight of the dry compound, some acoustical plasters contain from 6 to 15 per cent of asbestos floats. In this application, the floats function as a filler to provide bulk and fire resistance. Whiskers and grit are not objectionable unless a spray gun is used.

Cements

Cements and adhesives are considered similar by some authorities, and the amount of floats needed for adhesives would apply also to cements. Depending upon the type of cement and the application, the asbestos floats content ranges from 9 to 40 per cent (3). In many cases, whiskers and grit are permitted.

CONCLUSIONS

(1) Fourteen asbestos floats produced in Canada have been examined in tests similar to those made

†U. S. Patents 2,391,737, 2,315,321.

by customers in their own laboratories.

(2) Many of these floats have almost identical characteristics; however, one float, No. 11, differs considerably from all the others and has many unique properties.

(3) The type of float required for a particular product depends upon the use for which the product is manufactured, and each manufacturer has his own specifications and methods for testing the float.

(4) Float characteristics such as grit, whiskers, compressibility, springback, and magnetite rating are usually carefully checked by the plastics manufacturer, since these qualities affect his products.

(5) Bulk, surface area, and density values of floats are considered important factors in such products as wall joint fillers, caulking compounds, some pressed products, and acoustical plasters.

(6) The amount of ionizable salts, water-soluble solids, and chlorides in the floats is a matter of importance and frequently is checked by plastics manufacturers interested in improving the electrical properties of their products.

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