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Glass textolite is a glass fabric material which is impregnated with furil, epoxy, polyester, silicone-organic or other resins. The polymers in the fabric act as the bonding and chemically stable components, while the glass fabric acts as a reinforcing element which takes the basic load under operational conditions.

Glass filler. As a result of the glass thread-like base, the glass textolite has improved heat-flash, and water-resistance, chemical stability, hydrophobic nature, and a low modulus of elasticity. It does not creep even as a result of prolonged loads.

The qualities of glass textolite may vary widely, depending on the thickness of the glass fiber, the structure of the glass thread, the previous processing of the glass filler, the type of bonding agents, and the method of producing the laminated plastic.

According to their chemical composition, glass fibers are divided into the following categories: nonalkali, alkali, silver, copper, boron, lead, phosphorous, etc.

A glass fiber which is obtained from nonalkaline or low-alkaline aluminium boro-silicate glass possesses greater strength (almost 20% more), lower hygroscopicit, greater chemical stability and improved dielectric properties in comparison with an alkaline glass fiber. In the production of glass plastics, a thin textile glass fiber of 3-12 micron diameter is used most frequently.

For the production of glass textolite which has a tensile strength of 4000-5000 kg/cm^2, a glass fabric of satin interweaving is used. It is distinguished by the fact that the warp threads pass over every 8th thread of the woof. Satin glass fabrics of various strengths and thickness have the following characteristics:

Nominal thickness in mm	0.22	0.33	0.46	0.69
Weight in g/m^2	300	414	567	880
Tensile strength in kg/mm^2				
warp	61	79	117	171
woof	59	72	112	144

Knitted glass fiber made of continuous fibers is used for making parts with a complex configuration and a smooth surface. Its characteristics are:

Nominal thickness (ordinary) in mm	0.53
g/m^2	328
Tensile strength in kg/mm^2	13.4
Elongation at rupture in %	31

By using the so-called glass mat (glass flet) as a base, one can obtain a laminated material with physical and mechanical characteristics which do not differ from the characteristics of conventional textolite based on cotton fabric. These are inexpensive materials with high uniform strength and low dielectric losses.

Table 21 shows a comparison of the strength indices of glass fiber anisotropic materials (SVAM) and other laminated construction materials /11, 33/.

Table 21.

Qualities of SVAM and other laminated plastics

Indices	Textolite	Glass textolite	SVAM (1:1)*	SVAM (10:1)*
Specific weight in g/cm^2	1.35	1.65	1.90	1.90
Strength in kg/mm^2				
In compression	16	---	42	----
In tension	17-18	25-30	48-50	90-95
Specific impact strength in $kg.cm/mm^2$	40-80	110-140	245-270	-----
Stiffness in kg/mm	1000	2200	3500	5800

*The numbers in parenthesis indicate the ratio of longitudinal and transverse layers of the glass sheet

The quality of the glass textolite depends to a large extent on the degree of wetting the glass fiber by the bonding agent and on the adhesion of the resin to the glass fiber after hardening. For that reason, it is necessary to remove from the glass fabric the lubricant which was used during the textile processing. This lubricant decreases the wettability of the fiber and the adhesion qualities of the bonding agent. Usually the lubricants contain lubricating substances (mineral oil, fatty acids), binders (polyvinol alcohol, dextrin, paraffin) and surface-active agents (aminoy-alcohols, acetyl trimethy ammonium bromide, and others).

Bonding agents. Polyester resins could be used as binders in the production of glass plastics. They lend themselves to molding various articles at low pressure and temperatures which simplifies considerably the technology of making large scale articles. Glass plastics with polyester binders are used for structural materials.

Polyesters based on methacrylic acid are used in the USSR as a component in the production of the plastic textolite materials such as: TGM-3 - dimethacrylic-triethylene glycol, MGF-9, dimethacrylate bistriethy glycol phthalate and TMGF-11 tetramethacrylate bisglycerine phthalate.

Table 22.

Properties of Polyethacrylate Resins

Properties	MGF-9	TGM-3	TMGF-11
External appearance	Transparent liquid from yellow to dark brown color		Viscous, homogeneous liquid from light brown to dark brown color
Specific weight at 20°	1.13-1.22	1.05-1.13	1.14-1.20
Visocity at 20° C in centipoise	100-325	5-40	---------
Acidity number in mg KON per 1 g polyester, not more than	5.0	5.0	15.0
Polyester content in percentage, not less than	96	96	----
Saponification No., mg KON per 1 g polyester, not less than	380	376	515
Speed of polymerization to a hard state at 100° C with 1% of benzol peroxide in minutes	1-3	1-3	1-3
Content of mineral ions:			
SO_4	Not more than 0.04%	traces	0.8
Cl	traces	traces	0.2
Fe^{+2} and Fe^{+4}	The presence of very small fibers or granules are allowed in the filter		

Besides that, two basic types of polyesters, which are based on malaic anhydride, are used. These are PN-1 - polydiethylene glycol malenate phthalate and PN-2 - polyethyene malenate phthalate.

Glass plastics which are based on the polyester PN-1 possess considerable internal elasticity. The polyester PN-2 serves as a binder for rigid plastics.

Tables 23 shows the qualities of the polyester resins PN-1 and PN-2.

These resins, on a glass fiber base, are used in the making of large sized articles by the so-called contact molding methods.

Glass textolite, which are based on a modified eopxy resin have good strength characteristics. Thus, pipes which are made of glass textolites with binders from modified phenol formaldehyde epoxy resins withstand elevated pressures at temperatures up to 200°C.

Table 23

Qualities of the polyester resins PN-1 and PN-2

Qualities	Resins PN-1	Resins PN-2
external appearance	Yellow color liquid, weak cloudiness is permissible	
specific weight in G/cm^3	1.12-1.18	1.12-1.18
acidity number in mG KON/G of resin	35-45	35-45
time for jelling in the presence of 6% industrial hydroperoxide of isopropyl-benzol and 8% accelerant at 20° C/min	60-90	80-120
brinell hardness of the hardened resin in thee days after hardening	not less than 10	not less than 15
longevity at temperature not more than 20°C in months	not less than 2	not less than 3

The specific qualities of silicon-organic resins make it possible to use them for the manufacture of articles which could be used both at very low temperatures (-60° C), and at high temperatures. The glass plastics which are based on silicone-organic resins could withstand a prolonged heating at a temperature of 260°C and heating for a short time up to temperatures near 540°C. The ultimate rupture strength of these glass textolites at 260° C is preserved equal to 2100 kG/cm^2 (in the initial material - 2450 kG/cm^2. The rupture strength of glass textolite based on polyester resins attains a magnitude of 4200 kG/cm^2 at a specific weight of 1.7.

Anisotropic materials which have different qualities in the various directions of the glass fiber are of some interest for the development of extra strong plastics (the method was developed in the laboratories for anisotropic structures of the Academy of Sciences of the USSR). By using an oriented glass sheet, which is made according to this method, it is possible to obtain glass plastic with rupture strength higher than that of steel (50-60 kG/mm^2), and which is used for pipes which can withstand hydraulic pressure up to 300 atmospheres and for many other extra strong articles.

Production experience has already been acquired in the use at chemical plants of glass plastics based on furil resins and phenol formaldehyde, mainly for the making of structures which are used in the transfer of corrosive liquids; for bubbling pipes, which are subject to the action of hydrochloric acid, chlorine, the chlorine derivatives of benzol, etc. (See bibliography 2,33,40).

Table 24 shows the physical and mechanical qualities of the various types of glass textolites.

TABLE 24

Glass textolite	GOST or TU	Rupture Strength in kG/cm^2 1^n Tension	Comp.	Bending	Specific impact strength $kg\ cm/cm^2$	Brinel hardness	Elongation at rupture	Modulus of elasticity in kG/cm^2	Special Qualities	Area of Utilization
STK-1	TU 416-56	1000	-	-	-	-	-	-	Increased dielectric strength	Electrical insulation material in machinery which has an operating temperature
SVFZ-2	VTU SPP 503053-54	1300	-	-	-	-	-	-	The same	Electrical insulation material
Glass textolite KST	VTU 649-21244-52	1000	-	1200	60	30	-	-	Excellent mechanical qualities & heat resistance, increased water resistance Strength to weight ratio surpasses that of metals	Electrical insulation structural material with considerable heat resistance. Short time over heating of up to 200^0C is possible
Glass textolite impregnated with BF 2 glue	TU MKhP P73-56	o2600 y1505	1000 2700	- -	o400 y300	-	-	-	High mechanical strength & heat insulating qualities	Articles of various com figuration, which require high mechanical strengh & heat insulating qualities as well as light weights
KAST-1	TU MKhP-682-56	o2700-2800 y1500-1700	-	-	o125 y55	-	-	-	Excellent mechanical qualities, good heat resistance & increased water resistance. Surpasses metals in respect to specific weight durability	Sheet material. Used as building material in the aircraft, machine buildin radio, & shipbuilding industries

KAST-V	TU MKhP 2182-54	o2200-2700 y1400-1550	3500 100	-	o60-115 y45-	35-40	-	o220 000 y120 000	The same	The same
KAST-R	VTU MKhP 2769-54	o2800 y1600 1700	3000-3200 300-1200	2200-2800	o65-70 y55	24-35	0.5 1.0	16 000-200 000	-	-
KAST-15	VTU MKhP M-285-54	o1000-2600 y1600	2500 2700 600-1000-	-	o400 y300	-	-	-	Excellent physical & mechanical characteristics	Sheet material. Used as building material in the aircraft, machine,radio, & shipbuilding industry
SKM-1	TU MKhP 503-060-56	o1600	-	-	-	-	-	-	Excellent heat resistance strength & electric insulation qualities	Articles which could be used at a temperature up to 200°C, such as bushin washers,casings,etc.
STU	TU MKhP 503-070-56	o900 y700	-	1000	35	-	-	-	Increased dielectric strength	Electric insulation materials, which are used in a temperature range from -60 to +130°C
KAST	VTU MKhP 503-070	o925 y725	-	-	53	32	-	-	The same	Structural electrically insulating material
KAST	TU MKhP M682-56	o1100-2700 y800-1500	3000-3200 800-1200	o2200-2800	o60 y45	24-/35	0.5-/1.0	160000-200 000	Excellent mechanical qualities, high heat resistance & increased water resistance. In strength to weight ratio it is better than metals	Structural materials in aircraft, machine buildin shipbuilding, & Electric-radio industries.

The furil, polyesters and epoxy resins which are used in the glass plastics are resistant to the following media:

benzoic, limonic, hydrobromic, hydrochloric, lactic, oleic, phosphoric, and phthalic acids (only furilic is stable), aliphatic hydrocarbons, aluminium sulphate, nitrate of ammonia, benzine sulphonic acid, butyl and ethyl alcohol, calcium chloride, copper chloride, copper sulphate, iron chloride, hydrogen sulphide, nickel chloride and sulphate, potasium chloride, sodium sulphate, toluol, water, xylol, zinc chloride.

Besides that, the furil resins are resistance to acidic acid, butyric, chromic, formic, malic, oxilic, sulphuric (up to 70%) acids, acetone, aluminium flouride, ammonium hydroxide, anilin, benzol, calcium bisulphite, chlorobenzol, chloroform, chlorine, ether, ethylacatate, dichloroethane, formaldehyde, kerosene, lime, methyl acetate, methyl-ethyl ketone, nitrobenzol, phenol, potassium hydroxide, pyridin, sodium bichromate, sodium carbonate and trichlorethylene.

The polyester resins are resistant to butyric, chromic, nitric (cold diluted solutions), oxilic, sulphuric (up to 50%), acids, chlorine, formaldehyde, and kerosene.

Epoxy resins are resistant to chloroform, sulphuric (up to 50%) acids, lime, potassium hydroxide, and sodium carbonate.

Manufacturing of apparatus from glass textolites. Glass textolites which are based on polyester resins, epoxy resins, and other bonding materials can be used for the manufacturing of large size articles by molding in a vacuum unit or under low pressure (up to 5 kG/cm^2) with the use of rubber bags.

For the manufacturing of sheet glass textolite, the glass fibers are treated with resin, dried, assembled into packages and subjected to hot pressing in multistage hydraulic presses at pressures between 25 and 150 kG/cm^2. There are many different methods of manufacturing articles made of plastic textolites.

The pressing of articles is done in press molds at various pressures depending on the nature of the bonding material, the configuration of the article, its size, etc.

The most widely used method for manufacturing apparatus of large size is the contact method. In this case, the article is manufactured by means of applying the glass fabric previously treated with resin, onto wooden or plaster of paris molds. During the forming process it is possible to put in it various insertions, make reinforcing ribs, etc. The use of a special device, which simultaneously cuts the continous threads of glass fiber at lengths of up to five centimeters and brings them together with the bonding material at the surface of the model is of special interest when the contact method is used.

The method of vacuum molding is also used for the manufacturing of articles during which the air which is trapped between the molding and a rubber sheet is sucked out. The rubber sheet, under the action of the atmospheric pressure, is tightly pressed against the laid layers of the glass filler and packs them. During this method, the pressure on the materials reaches from 0.85 to 0.9 kG/cm^2. In other methods which involve the pressing of the rubber sheet to the article by means of compressed air, the pressure can be increased up to 4-5 kG/cm^2. An increase of the pressure to 25 kG/cm^2 is reached upon placing the article in an autoclave; this method is called the autoclave method.

The manufacturing of large size apparatus made of glass plastics for operation under pressure requires that the air-tightness of the container be assured as well as the high strength of the material itself. The air-tightness is achieved by way of the use of layer packing made of elastic materials. The apparatus is made in that case by spiral winding of glass packing material, impregnated with resin, with the packing of rubber or other elastic materials between the layers.

Containers which have a different type of bottoms pose greater difficulty. The most successful securing of the bottom with the shell is when they are joined with a slanted joint and reinforced in addtion by glass threads at the joint.

Pipes can be manufactured by way of winding the fabric on special winding machines which have two rollers, one of which is heated; they are the mandrel on which the winding takes place and the pressing roller, which presses the glass fabric layer along the mandrel where it is formed.

Figures 10-12 show a housing, the body of a drum filter, and a tank (container) made of glass plastics.

In the last several years a process has also been developed which involves the spray coating of resin and glass fiber on the surface of an article or the corresponding mold. Spray coating with the various components of the glass plastics is done with a special instrument - UNS-1.

The instrument UNS-1 consists of three basic units: carriage with a telescopic rotating support, two pressure tanks and an RSP type instrument for spraying, which has an original design. The RSP instrument has three units: a body, cutting mechanism, and two identical automatic sprayers for resin and initiator. The body of the instrument is similar to bicycle handle bars with two flat sides. There are two buttons at the handles; one of the buttons is for the turning on of the air in the drive for the cutting mechanism and diffuser and the second is for the supplying of air to the heads of the sprayers for resin and initiator. This arrangement permits, when needed, the successive feeding of glass fiber and the hardening compositions to the surface of the mold. In case both buttons are turned on, the glass fiber and the resin are fed simultaneously. This design permits the individual feeding of all components and the cutup glass fiber on the sprayed surface. The quick hardening components mix in the air and on the mold itself. The instrument can spray glass plastic onto any surface: covers of any machinery, housings, covers, boats, coatings of casting patterns, coating the slabs of wall partitions, columns, shelters, sanitary and technical fixtures (such as tubs, sinks, etc.) When the air is turned on, the feeding of resin and initiator begins automatically; the sprayers can be adjusted to feed resin and initiator in various quantities and under various air pressures. The capacity of the instrument is 27 m^2/hr with a thickness of glass plastic of 1.5mm.

Captions: Figure 10: Housing made of glass textolite

Figure 11: Body of a drum made of glass plastic

Figure 12: Tank made of glass textolite.