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NUMBER 6

14: Reinforced and Laminated Plastic Sheets, Tubes, Rods; Copper-Clad and Unclad; Plain and Composite

New Developments

A thermosetting epoxy bonded glass paper laminate is said to provide designers with a glass fiber reinforcing material that fills the gap between cellulose paper/epoxy and glass fabric/epoxy laminates. Advantages include excellent mechanical strength and machineability in combination with the outstanding electrical properties of glass laminates. In addition to lower initial cost, the material also offers economies in fabrication. Specific gravity is low because of high resin content, making it attractive to airborne insulation applications. The material uses a reinforcement of oriented glass fibers produced on a modified paper making machine and is bonded with a flame-retardant epoxy resin. It is produced in sheets from 1/32 to 1" thick with copper cladding on one or both sides.

Properties include flexural strength of 35,000 psi LW and 30,000 CW; Izod impact edgewise in ft lbs per inch notch of 8.0 LW and 4.0 CW; Rockwell Hardness of 105 M scale; short time dielectric strength, perpendicular, condition A, of 600 vpm; dissipation factor at 1 Mc of 0.020; dielectric constant at 1 Mc of 4.2; insulation resistance, Cond. C-96/35/90, of 500,000 megohms; arc resistance of 60 seconds; and water absorption, 1/16" thick, 24 hrs immersion, of 0.2%.

The material is designated as grade FR-16 by the producer Synthane Corp.

◀ A new process to produce extremely thick-wall, small diameter reinforced phenolic tubing has been developed by Reinhold Aerospace Div., a subsidiary of Haveg Industries. The process consists of tube rolling the resin impregnated material (cotton, paper, asbestos, glass, or silica) in a machine that develops a very high densification. The wrapped mandrel is then subjected to very high cure pressures using a proprietary process.

◀ A family of vinyl ester thermosetting resins which are particularly well suited for matched metal preform and mat molding use are low viscosity, low molecular weight resins dissolved in styrene monomers. They can be stored, formulated, and handled employing technology similar to that commonly used with polyester resins. Compared to conventional polyesters, they reportedly offer high filler acceptance, faster curing capabilities, greatly reduced stress cracking in filled systems, improved stiffness, and improved surfaces. The resins also show promise for filament winding, spray-up, and hand lay-up.

Dow Chemical Co. is the supplier.

◀ Grade X-831 is a paper base phenolic laminate formulated and controlled to meet very stringent requirements of the electrolytic capacitor industry. Each run is tested for corrosion characteristics—capacitor closure materials must not contaminate the electrolyte. In addition, the stock must be especially strong to withstand the flexural load when the aluminum can is spun over it. The laminate has good punching characteristics and can be die stamped for identification. Spaulding Fibre Co., Inc. is the supplier.

◀ MX6500 flexible epoxy "CuClad" is reported to be a truly flexible, copper-clad fiber reinforced epoxy dielectric system capable of withstanding class 130 temperatures. It can be plated, etched, soldered, and otherwise processed in accordance with standard printed circuit techniques. The producer is 3 M Co., Electrical Products Div.

Author Credits:

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INTRODUCTION

The terms, "reinforced plastics" and "laminated plastics," generally refer to thermosetting plastic materials made from fabric, paper, or mat reinforcements combined with synthetic resins. Suitable fillers may or may not be added to the resins.

Through common usage, the terms have evolved to designate different types of products. *Reinforced plastics* (also referred to as *FRP* and *GRP*) is most frequently used to describe molded shapes manufactured from

oped for this grade in this form. *Molded Tubes*—Made from fine-weave cotton fabric weighing 4 ounces or less per square yard. The minimum thread count in any ply is 72 threads per inch in the filler direction and a total of 140 threads per inch in both the warp and filler directions. Has high density and good moisture resistance. Primarily suitable for mechanical applications where finer machined appearance is required than is secured with grade CE molded tubes or where tougher material than grade LE molded tubes is required. This grade does not have controlled electrical properties and its use for electrical applications is not recommended. *Rods*—Made from a cotton fabric with the same weight and thread-count limits as molded tubes of this grade. In general, characteristics are similar to those for molded tubes except as limited by inherent difference in construction and shape. *Application*—Fine tooth gears, aircraft fair leads and radio parts. Meets MIL-P-15035 C-FBI.

Grade LE—Class 105

Sheets—Made from a cotton fabric having the same weight and thread count limits as grade L. Suitable for electrical applications requiring greater toughness than provided by grade XX. Better in machining properties and appearance than grade CE, and available in thinner sizes. Good in moisture resistance. This grade is not recommended for primary insulation for electrical applications involving commercial power frequencies at voltages in excess of 600 volts. *Rolled Tubes*—Made from a cotton fabric having the same weight and thread-count limits as grade L molded tubes. Suitable for use where the seams of a molded tube may be objectionable and where the application requires good machining qualities, together with fair electrical and good mechanical properties. This grade is not recommended for primary insulation for electrical applications involving commercial power frequencies at voltages in excess of 600 volts. *Molded Tubes*—Made from a cotton fabric having the same weight and thread-count limits as grade L molded tubes. Has excellent machining and moisture-resisting characteristics. For use in restricted electrical applications where a tougher material than grade XX tube is required at some sacrifice of electrical properties. Dielectric strength may be low at molded seams, especially in thin walls. Better electrically than grade CE molded, but not quite as tough. This grade is not recommended for primary insulation for electrical applications involving commercial power frequencies at voltages in excess of 600 volts. *Rods*—Made from a cotton fabric with the same weight and thread-count limits as for molded tubes of this grade. In general, characteristics are similar to those for molded tubes except as limited by inherent differences in construction and shape. *Application*—Marine relay bases, terminal boards, radio parts, ball bearing retainer rings, gas tubing systems and circuit breaker grid tubes. Meets MIL-P-15035-C-FBE.

ASBESTOS-BASE GRADES

Grade A—Asbestos Paper—Class 130

Sheets—More resistant to flame and slightly more resistant to heat than cellulosic laminated grades because of high inorganic content. Not recommended for primary insulation for electrical applications involving commercial power frequencies at voltages in excess of 250 volts. Small dimensional changes when exposed to moisture. *Rolled and Molded Tubes*—Characteristics are similar to those for sheets except as limited by inherent differences in construction and shape. *Rods*—Not recommended in this form. *Application*—Applications for class 130 insulation; products requiring a heat resistant material. Transformer coil spacers, armature slot wedges, furnace parts, etc.

Grade AA—Asbestos Fabric Base—Class 130

Sheets—More resistant to heat and stronger and tougher than grade A. Not recommended for primary insulation for electrical applications at any voltage. Small dimensional changes when exposed to moisture. *Rolled and Molded Tubes*—Characteristics are similar to those for sheets except as limited by inherent differences in construction and shape. *Rods*—Not recommended in this form. *Application*—Applications requiring good machining and mechanical properties also heat resistance. Armature wedges in railway, mill motors and turbine generators.

GLASS-BASE GRADES

Grade G-2—Staple-Fibre-Type Glass Cloth, Electrical and Heat Resisting Grade—Class 130

Sheets—Good electrical properties under high humidity conditions. Mechanically it is the weakest of the glass-base grades. Lower in dielectric losses than other glass-base grades excepting silicone. Good dimensional stability. *Tubes and Rods*—Not recommended in these forms.

Grade G-3—Continuous-Filament-Type Glass Cloth, General Purpose Grade—Class 130

Sheets—High impact and flexural strength. Bonding strength is the poorest of the glass-base grades. Good electrical properties under dry conditions. Dielectric strength perpendicular to laminations is good. Good dimensional stability. *Rolled Tubes*—Characteristics are similar to those for sheets except as limited by inherent differences in construction and shape. *Molded Tubes*—Not recommended in this form. *Rods*—Characteristics are similar to those for sheets except as limited by inherent differences in construction and shape. Mold seams are weak points mechanically and electrically. *Application*—Applications requiring a class 130 material with good electrical properties but where mechanical properties are not important.

Grade G-5—Continuous-Filament-Type Glass Fabric With Melamine Resin Binder—Class 130

Sheets—Highest mechanical strength and hardest laminated grade. Good flame resistance; second only to silicone laminates in heat and arc resistance. Excellent electrical properties under dry conditions. Low insulation resistance under high humidities. Good dimensional stability. *Rolled Tubes*—Characteristics are similar to those for sheets except as limited

Silicone Asbestos Paper Laminate

A laminate composed of silicone resin and a totally inorganic high silk asbestos paper is a class 180 material with electrical and thermal stability reportedly beyond 220°C. It is said to retain its properties under severe conditions of heat, humidity, and water immersion and to have greater heat stability, less tool wear, longer life, and lower cost than silicone glass fiber laminates.

Acrylic Laminates

Thermosetting acrylic resins for reinforced plastics using glass fiber materials for reinforcement are stated to exhibit high physical strength in combination with excellent heat resistance and chemical resistance. Electrical properties of cast specimens of the resin appear to compare favorably with the polyesters. A glass mat grade retains 97.8% of flexural strength after heat aging at 220°C and meets MIL-M-15617A. Typical properties are shown in the table.

Typical Properties, Glass Mat/ Thermosetting Acrylic Laminate, ⅛"

Tensile Strength, room temp, psi	12,880
Flexural Strength, room temp, psi	35,060
Flex. Str., room temp, Cond. E 168/220°C, psi	34,220
Mod. of Elasticity in Flexure, room temp, psi	1.53×10^6
Compr. Strength, Edge, rm temp, psi	35,000
Compr. Strength, Flat, rm temp, psi	56,680
Impact Str., Izod, Edge, rm temp	9.82
Specific Gravity, room temp	1.78
Shear Strength, room temp	16,400
Water Absorp, ⅛", room temp, %	0.34
Arc Resist., rm temp, seconds	187
Diel. Constant, room temp, 60 cps	4.97
1 kc	4.15
300 kc	3.96
Dissip. Factor, room temp, 60 cps	0.0350
1 kc	0.0204
300 kc	0.0205
Diel. Str., parallel, in oil, rm temp	65 kv
Diel. Str., perpen., in oil, rm temp	472 vpm
Insul. Resistance, rm temp, ohms, Condition C 96/35/90	2.5×10^{13}

Glass Filament Wound Tubing and Structures

Spirally wound glass filament tubing and structures offer extremely high burst strength, corrosion resistance, high strength to weight ratio, low water absorption, heat resistance, and shock absorbing characteristics in combination with desirable electrical properties. Although a variety of bonding resins can be used, the epoxies and polyesters appear to be the most popular. In addition to standard circular sizes, these products can be furnished in special shapes and also in combination with fibre, or with metal inserts or other conductive layers. Applications include switchgear, high voltage fuse tubes, circuit breaker arc interruption chambers, cases for seawater activated batteries, lightning arresters, grid tubes, bushings, spacers, antenna masts, coil bobbins, printed circuits, towers, conduit, etc. Some of the filament wound tubings are reportedly available at about half the cost of comparable NEMA grades of tubing. They may be made flame retardant. Typical properties (which can be varied widely) are shown in the table.

Typical Properties, Glass Filament Wound Tubing

Property	Polyester	Epoxy
Diel. Str., short-time, vpm	240	500
Power Factor, 1 Mc	0.007	0.010
Diel. Constant, 1 Mc	2.9	3.5
Tensile Str., psi	11,000	40,000
Axial Compr. Str., psi	11,000	35,000
Specific Gravity	1.8	2.0
Water Absorp., %	0.25	0.30

Others

Other laminates available include asbestos cloth, mat, and paper base with melamine resin; asbestos mat or cotton mat with phenolic resin; cotton cloth with diallyl phthalate resin; glass flakes with epoxy resin; parallel glass filaments with epoxy resin; glass reinforced/asbestos paper combinations with phenolic or silicone resins; silica cloth with phenolic resin; spirally wrapped paper tubes with phenolic or polyester resin; and glass filament reinforced epoxy, polyester, or silicone resin rods and shapes.

In addition to copper clad materials, a number of other composites are available—cladding materials include aluminum, Kovar, nickel, and other metals; as well as polyester, polyvinyl fluoride, and fluorinated ethylene films; rubber; vulcanized fibre; and asbestos paper. Laminated plastic faced chemically reconstituted lignocellulose board can also be supplied.

Impregnated Spiral Tubing (Paper) Properties*

Water absorp., %, ASTM D-348, 24 hrs at 23°C	15-25
Axial compr. strength, psi, ASTM D-348	5000-8000
Diel. str., short time, vpm, ASTM D-149, 1/16" wall	130-175
Arc resist., sec., ASTM D-495, min.	5
Dissip. factor, ASTM D-150, avg., 10^6 cps	.026
Diel. constant, ASTM D-150, avg., 10^6 cps	3.1

*Values are typical or average and should not be used for specifications.

ADVANTAGES OF THERMOSETTING PLASTICS

Saves Weight—Thermosetting plastics weigh approximately one half as much as aluminum (except for asbestos and glass base grades which have a density of .065 to .070 lbs/in³). Paper and cloth base grades have an average density of .050 lbs/in³.

Resist Compression — Thermosetting plastics have their greatest strength in compression where, pound for pound, they exceed structural steel. Flexural strength is also extremely high.

Resist Impact—The combination of toughness and resiliency gives thermosetting plastics the ability to absorb impact and withstand severe shocks in service.

Withstand Vibration — The resilience of thermoset plastics enables them to absorb severe vibrations and cushion repeated shocks without deterioration in structure or appearance.

Excellent Insulators — Thermosetting plastics are one of the best insulating materials known. They were originally developed for electrical use.

Excellent Chemical Resistance—Thermosetting plastics are not materially affected by acids and alkalis up to 10% concentration. Conditions of continued exposure to smog, oils, gasoline, or mildly corrosive fumes will not impair their usefulness.

Cold and Heat Resistance—Ther-

moset plastics may be applied within a temperature range of —80°C (—112°F) to 200°C (392°F) depending on the resin and base material used. Below zero temperature actually increases tensile and compressive strengths. Higher temperatures increase impact strength considerably.

Repel Moisture—The moisture resistance of thermoset plastics is such that the material is not subject to excessive swelling or warping. When used in bearings, the best lubricant is water.

Wear—In many applications, thermoset plastics wear more slowly than metals. Their uniformity of structure assures smooth, even wear.

Reduced Noise—Thermoset plastics squelch vibrations and deaden noise because of the resilient structure.

MACHINING CHARACTERISTICS

One of the biggest advantages of thermosetting plastics is their ability to be easily machined.

General Machining Information

Paper, Fabric, and Asbestos Base Grades

As a rule they are machined more readily than metals on standard machine tools such as those used for wood or metal fabrication.

For most machining operations, ordinary high-speed steel tools are satisfactory. However, where production quantity, production speed, or finish are important factors, carbide-tipped tools often prove more economical. Cutting tools must be kept extremely sharp to achieve accuracy and fine finish.

Thermosetting plastics are ordinarily machined dry. Cooling by air is preferable to the use of liquid coolants which are difficult to remove from finished parts. Machine operators should be cautioned to keep the temperature of the work below 150°C since temperatures above 150°C may distort the material. Cuttings are readily removed by suction.

Glass Base Grades

In many cases, the same machining operations employed in the fabrication of metals and wood may also be adapted to glass base grades. However, certain slight changes in tools and the use of proper speeds are necessary.

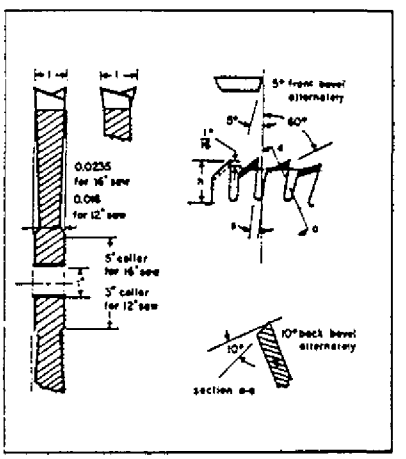
Diamond or tungsten-carbide tools will give more satisfactory work with longer, more economical life than high-speed steel tools.

Circular Sawing

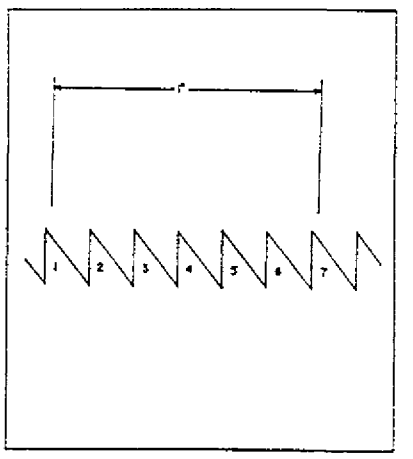
Paper, Fabric, and Asbestos Base Grades

Circular saws may be used for straight or angular sawing. When smooth edges are required or close tolerances are important, a hollow-ground circular saw without set should be used. For rough cutting, saws with set are satisfactory. Best results are obtained when the saw blade projects a minimum distance above the saw table.

A design for circular saws used on thermoset plastics is shown.



Circular saw data. Westinghouse Electric Corp.



Band saw design. Westinghouse Electric Corp.

Twelve-inch saws should be [illegible] for material up to 1" thick and [illegible] saws should be used for thicknesses [illegible] to 2½". It is important that all [illegible] be square, of the same height, [illegible] free from burrs. The cutting [illegible] should run either directly toward [illegible] just back of the center hole. In both circular sawing and band sawing, the work should be fed as rapidly as possible without forcing.

Glass Base Grades

A diamond impregnated wheel with copper body 1/16" thick and [illegible] diameter run at 3000-3600 rpm will give good results cutting dry with good exhaust system. The material fed by hand into the saw as fast as will cut without forcing the [illegible]. Idling creates friction and heat, which cause excessive dulling and burning. A flood of water on the work and wheel can be used when necessary to prevent overheating. Abrasive wheel cutting under water is also recommended.

Circular Saw Design

Circular Saw Data

Application	rpm	no. teeth	dia.	N	T	
rough cut*	2150	100	16"	3/8	1/4	1
smooth cut	2150	200	16"	9/32	5/32	1
all purpose*	2860	100	12"	3/8	3/16	1
tubing cuts	2860	100	12"	1/4	.095	1

* These saws have .019" set. Other saws are hol[illegible] ground to prevent binding.

Band Sawing

Paper, Fabric, and Asbestos Base Grades

The standard band saw is satisfactory where close tolerances or smooth edges are not important. It is most effective in sawing blanks from plate stock.

A design for band saws is shown. Saw blades should have between 4 and 7 teeth per inch with some set, the number of teeth depending on the thickness of the material being sawed. For heavy material, 3" thick and over, a blade with three teeth per inch is recommended. Operating speed should be approximately 3000 feet per minute and blades should be tempered to permit frequent sharpening.

Width of the blade will vary depending on the radius to be cut. For circular cuts the width should be narrow, but for straight cuts the blade may be up to 1" in width.

Glass Base Grades

For good results, steel blades [illegible]

ardened teeth and a soft back should e used. Work should be fed lightly nd the blade should be kept sharp. iamond coated band saw blades are ow available and are superior to teel. Sawing can be done dry with a ood exhaust system which is very mportant for safety.

unching

aper, Fabric, and Asbestos Base rades

Thermoset laminates are suitable or either hot or cold punching. Dies ust be kept sharp to obtain best esults.

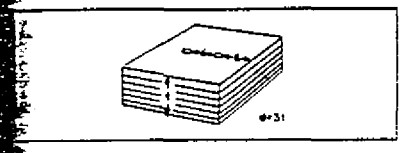
The minimum clearance between ndividual punchings and between unchings and the edge of plate hould be two to three times the thick- ess of the plate.

Dies for punching may be designed s those used for punching metal ex- ept smaller clearances should be llowed between punch and die. Strip- ers should be close fitting and backed y strong springs.

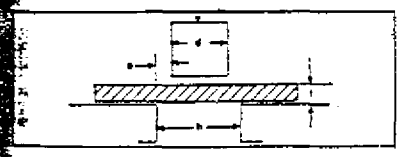
Since the diameter of punched holes hrinks when the punch is removed, he size of the punch should be .001" arger than the desired diameter of the hole for every .020" thickness of material punched cold, and .001" larger for every .015" thickness punched hot.

ll . . .

T = thickness of plastic
A = 1/40T (cold) or 1/60T (hot)
hd = hole diameter
D = diameter of punch



Plastic block.



Punch.

H = diameter of die
then . . . diameter of punch
(D) = hd + (T/.020).001 (cold)
or = hd + (T/.015).001 (hot)
diameter of die (H) = D + 2A
diameter of hole
(hd) = D − (T/.020).001 (cold)
or = D − (T/.015).001 (hot)

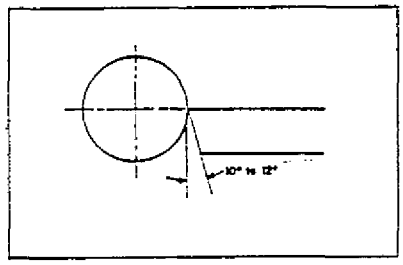
Example:

To obtain a 1.000" diameter hole in 3/32" (.094") thick grade X by hot punching, use a punch diameter (D) equal to hole diameter (1.000") + $\frac{(.094 \times .001)}{.015}$ or 1.006" and a die diameter (H) equal to punch diameter (D) + 2A, or 1.006" + (2 × 1/60 × .094"), or 1.009". If the piece is punched cold, the punch diameter (D) should be 1.005" and the die diameter (H) 1.009".

Laminates to be hot punched are preheated in a steam or electrical oven designed to give uniform heat throughout the heating chamber. Pieces should be well separated. The material should be left in the oven only long enough to become uniformly heated to oven temperatures. Further heating will cause brittleness. Temperatures of 100°C to 120°C are recommended. Consult manufacturer for recommended heating time for thickness concerned.

Glass Base Grades

Punching practices for glass base materials are the same as those used for laminated plastics generally, although die life is shorter. The use of carboloy and special die steels will help to increase die life. Sheets up to 3/32" in thickness can be punched with good results.



Turning tool.

Shearing

Paper, Fabric, and Asbestos Base Grades

Standard shears suitable for sheet metal are recommended. The knife blade should be kept sharp and the material held rigid with a hold-down bar. Most paper laminates up to 1/16" thickness and canvas laminates up to 1/8" thickness may be sheared at room temperature (70°F min.). Thicker stock may be sheared by heating the laminate to 200° to 250°F.

Glass Base Grades

Thicknesses up to 3/32" can be sheared. The same standard practices are used as for other laminated plastics.

Turning

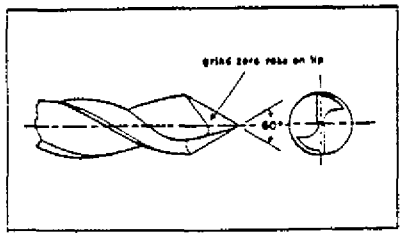
Paper, Fabric, and Asbestos Base Grades

Ordinary high-speed tool steel can be used in finishing operations for all grades. However, carbide-tipped tools may prove more economical and will hold sizes more accurately from piece to piece. About .010" stock should be left for finishing. Laminated plastics can be turned at 400 surface feet per minute with high-speed steel tools, and about twice that fast with carbides. Tools should be kept sharp, ground with an included angle of 80° to 100°, and with a 10° to 16° side clearance. Cutting should be done dry.

Glass Base Grades

Conventional machining, such as turning, boring, and facing, can be done on automatic screw machines, standard and production lathes, and hand turret lathes.

Carbide-tipped tools and cutters should be used with surface speeds below those used for paper base laminates. Tools should be ground with a zero rake and machining can be done dry with an exhaust system to remove



Drill diagram.

Diagrams courtesy Westinghouse Electric Corp., Micarta Div.

dust. A coolant can be used, but is not necessary.

Milling

Paper, Fabric, and Asbestos Base Grades

Standard tools may be used at speeds and feed similar to those for bronze and soft steel. It may be more economical in spite of higher material cost to use carbide tools. The cutting angle of the mill will give better results if ground with a slight rake.

Glass Base Grades

Glass base laminates can be milled very satisfactorily on any conventional metal-working milling machine. Carbide tipped tools should be used. Only climb or down milling should be practiced, as up milling will tend to delaminate the material.

Drilling and Tapping

Paper, Fabric, and Asbestos Base Grades

A standard high-speed drill with lips backed off to provide plenty of clearance is satisfactory for all grades. However, for long production runs and deep holes, carbide-tipped drills give the best performance. The drill design shown has been used most effectively by fabricators.

Drills should be lifted from the work frequently to prevent binding and excessive heating. The feed should be light and uniform and the speed of the drill should be considerably in excess of that used for soft steel. With tungsten-carbide tips, speeds may be as high as 16,000 rpm. Where possible, the material being drilled should be backed up with scrap or other soft material to prevent chipping out.

In drilling laminates parallel to laminations, extra care must be taken to prevent splitting. The material should be clamped in a vise or between plates and the drill should be lifted more frequently to remove chips.

Holes ¾" and over may be drilled in the conventional manner using radial drill presses or the counterbore method in which a pilot hole is drilled first.

Drill Size—Because of the nature of plastic material, the diameters of holes drilled in laminates are usually .002" under the drill size. Therefore, the drill selected should be at least .002" larger than the specified diameter of the hole. If the drill is being used dull, the hole size may be an additional .002" undersize, or a total of .004" less than the diameter of the drill.

The recommendations for drilling also apply to tapping. Taps used for metal are also suitable for laminates. Tapping heads or tapping machines may be used, and for production work, collapsible taps are available in sizes over 1¼".

Tap Size—In tapping, high-speed taps .002" oversize should be used. The tap drill size should also be changed to .002" oversize to counteract the tendency of the drill to cut undersize. If the thread is to be used frequently, metal inserts should be used.

For threaded holes over ½", it is often more desirable to chase the thread on a lathe using a motor-driven cutter mounted on the tool post.

Glass Base Grades

When drilling glass base grades. a carbide drill should be used. The materials can be drilled dry with a good exhaust system to remove dust. A flood of water on the work and drill can be used when necessary to prevent overheating and dulling of drills. High speed drills, mitrate treated, can be used, but must be sharpened more often. Care should be taken when sharpening that the drill is cut back far enough to original body diameter of drill. Spindle speed for these grades is 4800 rpm for ¼" diameter drills.

The methods for tapping these materials are much the same as for tapping paper base laminated plastics. The abrasiveness may cause taps to cut very close to size, resulting in a tendency toward binding when backing out. Standard high speed steel taps can be used on short runs. For any sizeable quantity carbide taps should be used. Taps should be purchased oversize. Coolant can be used, but is not necessary if a good exhaust system is available.

Threading

Paper, Fabric, and Asbestos Base Grades

For threaded holes over ½", it is often more desirable to chase the thread on a lathe, using a motor-driven cutter mounted on the tool post. When cutting a 60° thread, it is always advisable to swing the compound reset on the lathe to a 30° angle. The tool is ground to cut on one side only. For all other threads, standard methods are used with satisfactory results; the speeds and feeds are similar to those used in threading soft steel.

Glass Base Grades

External threads and internal threads can be cut on a lathe with a carbide-tipped tool, dry. Fine cuts should be taken to give best results. A coolant can be used, but is not necessary.

Buffing

Paper, Fabric, and Asbestos and Glass Base Grades

Standard polishing rouge on a rag wheel gives satisfactory results for laminates requiring a polished surface. Grinding and sanding may be done by belt, disc, or centerless methods. No lubrication is necessary.

Stamping and Engraving

Paper, Fabric, Asbestos, and Glass Base Grades

Laminated surfaces to be stamped should be smooth. Sanding may be necessary, in some cases, to obtain satisfactory results. Compression presses employing heated dies give best results.

Engraving can be done with any standard engraving machine. Tools should be sharp to produce clean-cut edges.

Conclusion

We are living in the age of plastics and thermosetting laminates continue to play a major role in electrical insulation.

It is said that the greatest limitation an electrical equipment manufacturer faces is the quality of insulation available for his product.

The plastics industry is continually improving and developing thermosetting laminates to keep step with the tremendous growth of the electrical industry.

NEMA Standards

Standards Publication on Industrial Laminated Thermosetting Products

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SUPPLIER DIRECTORY LISTING

IMPORTANT: For fabricated or converted laminates and reinforced plastic products, see other sections such as sections 3-17 and 3-22.

NOTE: Numbers in parentheses following each product covered in this section correspond with the numbers shown in front of each supplier of products listed here (thus indicating which firms supply the product concerned). Only company names are listed here—see Part 4, section 4-1, for addresses of suppliers. Bold face type indicates advertisers—see advertisers' listing at back of book for page numbers of advertisements.

Products Covered in this Section

Asbestos Cloth Base

Diphenyl oxide resin, sheets, tubes (66)
Melamine resin, sheets, rods, tubes (14, 23, 31, 34, 42, 48, 56, 61, 66)
Phenolic resin, sheets, rods, tubes (3, 14, 15, 18, 23, 31, 34, 42, 48, 52, 56, 57, 61, 63, 64, 66, 70)

Asbestos Mat Base

Melamine resin, sheets (23, 31, 34, 48, 56, 61, 70)
Phenolic resin, sheets (3, 15, 23, 31, 34, 28, 56, 61, 63, 64, 70)

Asbestos Paper Base

Melamine resin, sheets (23, 34, 48, 56, 61, 66, 70)
Phenolic resin, sheets, rods, tubes (3, 15, 18, 23, 31, 34, 42, 48, 50, 53, 56, 57, 61, 63, 64, 66, 70)

Perfted Asbestos Paper Base

Polyester resin, sheets (24, 68)
Silicone resin, sheets (24)

Cotton Cloth Base

Diallyl phthalate resin, sheets (15, 56, 61, 70)
Melamine resin, sheets, rods, tubes (3, 15, 23, 31, 34, 48, 53, 56, 61, 66, 70)
Phenolic resin, sheets, rods, tubes (3, 15, 18, 23, 31, 34, 48, 53, 56, 61, 63, 64, 66, 67, 70)
Polyester resin, sheets (56, 66, 68)

Cotton Mat Base

Phenolic resin, sheets (3, 14, 23, 31, 34, 42, 56, 61, 70)

Glass Cloth Base

Acrylic resin, sheets (16, 44, 65)
Diphenyl oxide resin, sheets, tubes (66, 67)
Epoxy resin, sheets, rods, tubes (3, 15, 17, 18, 23, 27, 31, 32, 34, 40, 42, 48, 54, 56, 58, 60, 61, 63, 64, 66, 67, 70)
Melamine resin, sheets, rods, tubes (3, 14, 15, 18, 23, 31, 34, 48, 53, 56, 58, 61, 63, 64, 66, 70)
Phenolic resin, sheets, rods, tubes (3, 14, 15, 16, 23, 31, 34, 48, 53, 56, 58, 61, 63, 64, 66, 70)
Polyester resin, sheets, rods, tubes (3, 6, 8, 14, 16, 17, 21, 30, 40, 44, 52, 60, 66, 67, 68, 70)
Polytetrafluoroethylene resin, sheets (3, 5, 11, 50, 55, 65, 70)
Silicone resin, sheets, rods, tubes (3, 15, 18, 31, 42, 44, 53, 56, 58, 61, 64, 66, 67, 70)

Glass Cloth/Asbestos Paper Combination Base

Polyester resin, sheets (68)

Glass Mat or Paper Base

Acrylic resin, sheets (2, 21, 40)
Epoxy resin, sheets (4, 17, 18, 23, 34, 40, 56, 60, 61, 63, 66, 70)
Melamine resin, sheets (31)
Phenolic resin, sheets (4, 14, 18, 23, 34, 56, 61, 63, 66)
Polyester resin, sheets, tubes (4, 7, 9, 14, 17, 20, 21, 23, 30, 40, 42, 43, 52, 56, 57, 60, 62, 66, 68)

Glass Mat/Asbestos Paper Reinforcement

Polyester resin, sheets (21, 25, 48, 49, 62, 68)

Glass Filament Reinforced

Epoxy resin, rods, tubes, and shapes (31, 33, 37, 38, 40, 44, 52, 56, 66)
Polyester resin, rods, tubes, and shapes (20, 25, 33, 38, 40, 44, 51, 52, 56, 62, 66)
Silicone resin, rods (44, 66)

Glass Filament Reinforcement, Parallel, Uni- or Multi-Directional

Epoxy resin, sheeting (4, 29, 40, 49)
Polyester resin, sheeting (4, 23, 40, 49)

Glass Reinforced/Asbestos Paper Combination Base

Phenolic resin (4)
Silicone resin (4)

Nylon Cloth Base

Phenolic resin, sheets, rods, tubes (3, 15, 18, 31, 34, 56, 61, 64, 66, 70)

Paper Base

Epoxy resin, sheets (2, 3, 15, 18, 31, 34, 48, 56, 61, 63, 66, 70)
Melamine resin, sheets (2, 23, 34, 45, 48, 61)
Phenolic resin, sheets, rods, tubes (2, 3, 15, 18, 23, 31, 34, 36, 42, 48, 53, 56, 58, 61, 63, 64, 66, 70)
Polyester resin, sheets (2, 56, 68)
Spirally wrapped paper, phenolic or polyester resin, tubing (3, 9, 28, 36, 42, 59, 69)

Silica Cloth Base

Phenolic resin, sheets, rods, tubes (22)

Wood Veneer Base

Phenolic resin, sheets (37, 45, 67)

Copper Clad Laminates

Cotton cloth base, phenolic resin, sheets (15, 34, 41, 48, 49, 61, 70)
Glass cloth base, epoxy resin, sheets (3, 15, 18, 27, 31, 32, 34, 35, 41, 48, 49, 50, 56, 61, 63, 64, 66, 67, 70)
Glass cloth base, melamine resin, sheets (15, 34, 41, 48, 49, 61, 70)
Glass cloth base, phenolic resin, sheets (15, 34, 41, 48, 49, 61, 70)
Glass cloth base, polyester resin, sheets (8, 41, 49, 67)
Glass cloth base, polytetrafluoroethylene resin, sheets (1, 3, 11, 19, 29, 41, 49, 50, 55, 70)
Glass cloth, base, silicone resin sheets (41, 49, 70)
Glass mat reinforcement, polyester resin, sheets (8, 41, 49)
Nylon cloth base, phenolic resin, sheets (15, 34, 41, 49, 61, 70)
Paper base, epoxy resin, sheets (3, 15, 18, 31, 34, 41, 48, 49, 56, 61, 66, 70)
Paper base, phenolic resin, sheets (3, 15, 18, 31, 34, 41, 45, 48, 49, 61, 66, 70)
Polyester mat, epoxy resin (29)

Composite Laminates

Aluminum, kover, nickel, or steel clad laminates (3, 4, 15, 27, 32, 34, 45, 46, 47, 48, 49, 56, 61, 64)
Asbestos paper clad laminates (4, 34, 49)
Laminated plastic faced hardboard (26, 45)
Plastic film clad laminates (4, 12, 13, 31, 34, 39, 49, 54, 61, 63)
Rubber clad laminates (3, 4, 10, 23, 31, 39, 48, 49, 56, 63, 64, 66)
Vulcanized fibre clad laminates (2, 23, 31, 34, 49, 56, 61, 63, 64, 66, 70)

Suppliers of Preceding Products

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3—**THE BUDD CO., POLYCHEM DIV.**
4—Chase & Sons, Inc.
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21—**HAYSITE CORP.**
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33—New Plastic Corp., Nuple Mfg. Co. Div.
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35—Paltflex Products Corp.
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39—Plymouth Rubber Co., Inc.
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61—Synthane Corp.
62—**TRW ELECTRO INSULATION, TRW INC.**
63—Taylor Corp.
64—Thiokol Chemical Corp., Panelyte Industrial Div.
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