CARBON AND HIGH PERFORMANCE FIBRES

DIRECTORY AND DATABOOK

EDITION 6

CHAPMAN & HALL

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PREFACE

PURPOSE

Since the publication of the previous, Fifth Edition of this volume in 1991, the 'advanced' sector of the world-wide composites industry in particular, has seen many company changes in reorganisation, realignment and ownership. These changes have affected the raw material suppliers as well as those moulding the finished product. Changes in the demands of the aerospace, defence and allied industries have largely been the cause.

That situation has been particularly true for those manufacturing and distributing reinforcement fibres and fabrics, necessitating this comprehensive Sixth Edition revision. However publication is also timely, because a major and important consequence is the better consideration now being given by the 'commercial' market sector, to the use - and advantages - of some of the carbon, aramid and other high-performance reinforcements, described within these pages.

Although supplying at a much lower finished component cost than applies for the aerospace and defence markets, the total tonnage output answering the typically lower-performance requirements of the 'commercial' sector, is higher by many factors. Overall therefore, the summation of output tonnage and price, will continue to favour the latter. Nevertheless this 'commercial' market sector must, albeit slowly, ultimately benefit to a marked degree from an increasing technology spin-off, promoted to an extent somewhat earlier than might otherwise have been expected, by the noted changes in market place demand.

The Sixth Edition aims to continue to be an invaluable source of accurate high-performance fibre and allied products data, answering the needs of those concerned in any way with 'advanced' and now (from earlier comment), also 'commercial' composites. Its contents enable an optimum choice of reinforcement and allied material to always be made. This combination of supplier directory and raw material databook will therefore be of interest to all manufacturers and suppliers, finished component production managers, designers and specifiers, workers in industrial laboratories, or graduates and researchers in academia.

LAYOUT

Careful selection of these high-performance reinforcements is, and must therefore very clearly remain, imperative. This demands a regularly up-dated systematic compilation of their availability, covering manufacturer, supplier and major properties. This two-part Directory and Databook answers that need. However it must be stressed that a large number of specialised reinforcement and allied materials, formulated for specific customer needs and requirements, have not and cannot be, listed.

Of concern are carbon fibre tow, yarn, fabric, braid, mat, paper and felt, whether employing a polyacrylonitrile (PAN), pitch or rayon precursor. Fibrous carbon and graphite, oxidised polyacrylonitrile materials as well as thermoset and thermoplastic preimpregnated tapes and fabrics (and their respective resin matrix detail), are all included together with aramid, other polymer and then specialised glass, quartz, ceramic (e.g. alumina and silicon carbide) materials. Metal (or metallized) fibres, plus as appropriate their respective fabric materials, have not been overlooked. Finally important hybrid yarn, fabric and reinforcement hybrids with co-mingled, cowoven and plied yarns etc. - which offer an alternative to thermoplastic prepregs - are along with thermoplastic moulding granules employing carbon or other high-performance fibre reinforcement, not excluded.

After several introductory pages including a short material review, a technical vocabulary, terminology and trade names summary, Part One - the Directory Section - opens with an alphabetical list of all the raw material manufacturers and suppliers who during the preparation and Sixth Edition revision work, kindly responded to a request for property and other information.

Employing ten main raw material-type classifications, this list indicates the respective materials supplied. In doing so, that tabulation and a further product group : manufacturer/supplier listing, provides a cross-reference of both tabulation and page numbers from Part Two - the Databook Section - in which the associated raw material property information appears. In a final alphabetical listing of the same manufacturers, their subsidiaries, sales offices, agents, distributors and wholesalers, are then shown alongside, alphabetically by country,

A comprehensive list of the address, telephone and facsimile number of every company mentioned concludes the Directory. Included there, as a convenient reader reference, is a short list of the major authoritative bodies now supporting in a variety of ways, the world-wide composites industry. Telex numbers are no longer quoted owing to the steady decline in favour of facsimile. The same applies to contact names. The major market changes already referred to have, since the Fifth Edition was published, also had their adverse affect on employment stability. As a consequence sales and marketing personnel change much more frequently than in the past, making the inclusion of contact names prone to marked inaccuracy.

Two very important closing comments regarding the Directory are essential. Care has been taken, wherever possible, to ensure that only the latest German postal codes which became operative during the summer of 1993, have been employed. Secondly the British Telcom changes due on 1 April 1995, must be emphasised. These will affect every telephone and facsimile number in the UK. Readers' attention is therefore drawn to the full details given on page 55 and repeated on page 73 of the Directory.

The Databook, Part Two, employs sub-dividers between the ten main raw material-type classifications. Each section opens with a further raw material, page, trade name and property tabulation reference, followed in most cases by any necessary notes, to allow for example those situations where only outline data has been received. Ranking tables allowing rapid comparison of for example, filaments/tow; tex; weave; areal weight; modulus; elongation; specific modulus and specific strength, are then provided, all classified as applicable by fibre-type or some other suitable parameter.

Finally the raw material - property tabulations as already described follow, to conclude the whole volume.

CHANGES FOR THIS EDITION

No publication of this nature stands still and in addition to the already reported Directory changes and deletion of telex and contact names, established readers will immediately notice one major difference with the Databook section. All the raw material - property tabulations have been rearranged, not only to safe space and avoid with the passage of time a major increase in the number of pages, but to provide a layout more in common with the companion volume, "Glassfibre Databook", first published by Chapman & Hall in 1993. (ISBN 0 412 46280 X). At the same time, change for its own sake has been avoided; all the layout and other alterations and additions - with many continued from those made between the Fourth & Fifth Editions - have the one aim of making the volume even more user-friendly.

For example wherever possible there is the inclusion of additional fibre properties (fibre area in tow cross-section, thermal conductivity, coefficient of thermal expansion and specific modulus and strength), as well as the division of preimpregnated materials into thermoset and thermoplastics-based. Introduced for the Fifth Edition, the latter also continues to include a listing of the resin matrix systems employed.

As with all previous editions, considerable effort has been taken to ensure that the data received for collation and publication, is obtained from as wide a global selection as possible. However like the continued lack of information from some countries - noteably China and the whole geographical area of Russia - there are still some known omissions. The overall content is entirely dependent on those who can be persuaded to respond, plus the comprehensive nature of the

technical and other information that is eventually provided. As before neither the publisher, nor the authors can therefore accept any responsibility for errors or omissions. Where manufacturers have not responded to requests for their latest sales and technical data, such information has been repeated from the Fifth Edition, as long as this is still considered valid. The information included in this Sixth Edition is judged correct up to typically April 1994, the date of the JEC Exhibition in Paris when final discussion was held with those raw material suppliers present.

Finally the continuing effect of changes of company ownership and manufacturing activity has meant the deletion of a number of reinforcement and prepreg types perhaps previously judged as 'standard', and therefore by some readers, still expected to be included. That is a situation which in addition must undoubtedly also mean that some data which should have been included, may have been missed, or is now not as accurate as it might otherwise be. Most of those at present working within the now frequently changing composites industry, will be sensitive to this situation.

REVIEW

Although the market and supply changes noted in the Preface, have and still are having their effect in reducing their overall number, a wide and in some areas growing variety of first-quality, high-performance fibres, fabrics and prepregs, remains available to the composites industry. In addition there is steadily increasing interest in many which must still be considered somewhat esoteric such as those based on alumina, alumina-silicate or silicon carbide. More down-to-earth and becoming adopted on the shopfloor, are the hybrid fibres and fabrics, which continue to be developed in an ever-wider range of combinations and weave etc. It is valuable to therefore repeat on the next page, the summary diagram and tabulation which appeared in the Fifth Edition.

CARBON FIBRES

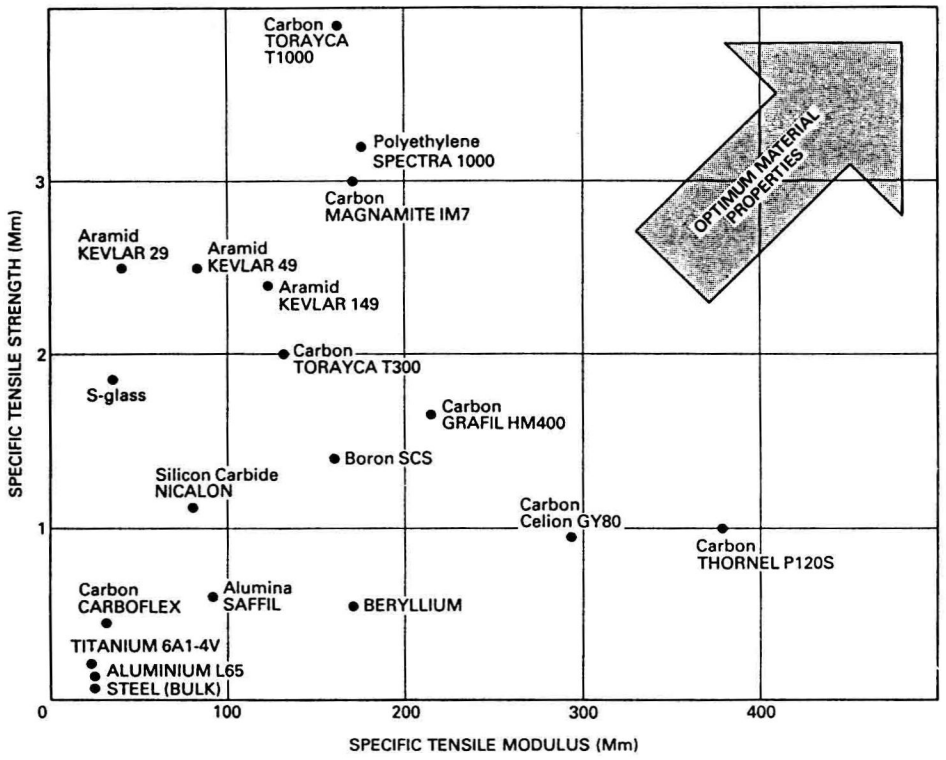
Changes in the nomenclature of carbon fibres by modulus, reported in the Fifth Edition are now universal, being the four grades, UHM (ultra-high modulus); HM (high modulus); IM (intermediate modulus) and SM (standard modulus) or HT (high strength-high strain). The fibrous carbons and graphites typically manufactured in the first instance for furnace insulation and gland packing, are now increasingly used as reinforcement to provide toughness rather than stiffness, should logically be called low modulus or LM.

Otherwise, whilst there has been a considerable reduction in the overall demand, with several production plant cutbacks and a marked reduction in the number of plant and production capacity improvements, raw material developments do continue. Like pitch-based grades and in particular work in Japan, the objective has been to reduce supply costs and in turn therefore widen the application range in to take one example, a reinforcement grade for concrete. Other improvements to gain even higher modulus levels also continue and so in summary perhaps the current period can be best considered as a period of consolidation.

However, unlike earlier editions, the policy of quoting carbon fibre production output by company has been discontinued as their accuracy remains in doubt; some for example quote production capacity as actual output.

PREPREGS

With the growing interest in, but as a result of their stiffness also the associated moulding difficulty of conventionally manufactured thermoplastic (TP) preimpregnated tapes and fabrics, (or even cowoven grades with the separate 'ends'), the development and commercialisation of 'flexible prepreg' employing hybrid yarns and fabrics, continues apace. Composed of carbon (typically) and polymer filaments which are either comingled or plied (twisted) together, or where



Comparison of High-Performance Fibres

Fibre	Modulus (GPa)	Strength (GPa)	Density (g/cc)	Specific Modulus (Mm)
Carbon				
UHM (Thornel P-120S)	827	2.2	2.18	379
UHM (Celion GY-80)	572	1.86	1.96	291
UM (Microfil 55)	379	3.45	1.83	207
IM (Magnamite IM 8)	303	5.3	1.80	168
SM (Torayca T300)	230	3.53	1.75	131
LM (Kureha T 101F)	33	0.79	1.65	20
Aramid				
HM (Kevlar 149)	179	3.45	1.47	122
IM (Twaron HM)	121	3.15	1.45	83
LM (Kevlar 29)	58	3.62	1.44	40
Polymer				
PE (Spectra 1000)	172	3.09	0.97	177
PI (P-84)	5	0.54	1.41	3.5
PBI (hoechst pbi)	5.5	0.38	1.43	3.8
Glass & Quartz				
S-Glass (Owens Corning)	86	3.45	2.55	34
Quartz (Quartz & Silice)	69	3.69	2.2	31
E-Glass	69	2.4	2.54	27
Ceramic				
Silicon carbide (Nicalon)	193	2.76	2.55	76
Alumina-silicate (Saffil)	300	2.0	3.3	91
Silicon-titanium (Tyranno)	206	2.74	2.35	87
Boron (SCS)	400	3.6	2.57	156
Metal				
Stainless steel fibre	197	1.45	7.9	25
Steel, piano wire	207	2.41	7.8	26

the reinforcement and matrix are otherwise 'mixed' together by powder-coating or sheathing (encapsulating) the filament with the polymer, these prepregs ease the moulding of complex curved components. These yarns can then be formed into fabrics by most of the standard weaving, knitting and braiding techniques. In total the result is an enhanced ability to mould increasingly massive, more complex shapes, an increasing requirement of for example the aerospace industry.

However the thermoset impregnated high-performance materials are not loosing out. Here there has been the development of epoxy and bismaleimide grades offering improved toughness and 'hot-wet' properties. Other grades, which can be employed for tooling manufacture and may also employ phenolic resin matrices, will cure at perhaps lower than 60°C whilst permitting use at 170°C or above. Typically these prepregs are not supplied 'B-staged', but are in effect a 'wet-prepreg' lay-up of reinforcement and resin.

CERAMIC FIBRES

The demands of higher temperature resistance in particular, with freedom from oxidation and a higher modulus than glass - or even quartz - have lead to the increasing availability of ceramic fibres such as those of silicon carbon, silicon nitride and alumina-silicate. Used in ceramic and metal matrix composites, the attraction is for a finished product capable of high-load and temperature resistance such as for the gas turbine blades of aero-engines, valves and other engine components in high-performance cars. That search continues as a very large market is said to exist, and experimental work continues on other formulations such as boron nitride, titanium boride and single crystal sapphire and zirconia.

POLYMER FIBRES

Besides the polyethylene fibres which have been available for some time, there are now polyetheretherketone (PEEK), polyetherimide (PEI), polyphenylene sulphide (PPS) and polyimide (PI) fibres and yarns. Other polymer fibres will undoubtedly appear and like Dow Chemical's polybenzobisazole (PBZ), will be steadily commercialised. Overall the attempt will be to provide fibres with the strength and modulus of carbon, but with 'added-on' properties such as resistance to oxidation. As the demands of the component performance specification steadily increase (at more often than not, the requirement for a lower supply cost), other parameters such as ultraviolet radiation and higher temperature resistance will become of increasing importance.

AUTHOR'S NOTE

All previous editions of this Directory & Databook have been prepared by Donald R. Lovell, who indeed started work on this volume. Owing to the illness of his wife, Ursula, completion had to become the responsibility of Trevor Starr. Employing a quotation from the last edition, the new author wishes to acknowledge that former involvement and the genesis from the first edition published in 1981, of "...a book that, for its size and price, cannot be rivalled". The present author, who is also much indebted to his wife Mary for her assistance in the preparation of this Sixth Edition, sincerely hopes that objective has been retained.

TECHNICAL VOCABULARY : TRANSLATION

English	French	German	Italian
Aligned	Aligné	Ausgerichtet	Allineato
Areal Weight	Poids Superficiel	Flächengewicht	Peso Superficiale
Ash Content	Contenance de Cendre	Asheinhalt	Contenuto di Cenere
Braid	Tresse	Flechte	Treccia
Breaking Load	Force de Cassure	Reisshöchstkraft	Carico de Rottura
Carbon	Carbone	Kohlenstoff	Carbone
Chopped	Coupe	Zerhackt	Fibra Tagliata
Cloth	Toile	Tuch	Telo
Coating	Couche	Schicht	Rivestimento
Coef. Thermal Expansion	Coef. de Dilatation Linear	Längsdehnungszahi	Coef. di Espansione Termica
Collimation	Collimation	Geschtlinie	Collimazione
Compressive	Compression	Druck-	Compressione
Content	Contenance	Inhalt	Contenuto
Creep	Subir un Fluage	Kriechen	Scorrimento
Cross-ply	Stratification Croisse	Kreuzweise Schichtung	Strao Incrociato
Cross-Section	Section Droite	Querschnitt	Sezione Traversale
Cross-Twill	Sergé Croisé	Kreuzköper	Incrociato
Cure Temperature	Temperature de Cuisson	Hartungstemperatur	Temperatura di Polymerizzazione
Datasheet	Feuille de Data	Datablatt	Data Sheet
Density	Densité	Dichte	Densità
Diameter	Diametre	Durchmesser	Diametro
Direction	Direction	Richtung	Direzione
Drape	Draper	Drapieren	Drappo
Edge	Bord	Kante	Bordo
Electrical	Electrique	Elektrisch	Elettrico
Elongation	Etirage	Reissdehnung	Allungamento
Expansion	Dilatation	Ausdehnung	Espansione
Fabric	Tissu	Gewebe	Tessuto
Fatigue	Fatigué	Ermüdung	Fatica
Felt	Feutre	Filz	Feltro
Fibre	Fibre	Faser	Fibra
Fibre Area (Tow X-Section)	Aire de Fibre en Vue en Cope de Méche	Flächeninhalt in Querschnitt den Tau	Superficie Della Nella Sezione
Filament	Filament	Faden	Filamenti
Flexural	Flexure	Biege-	Flessione
Flow	Flux	Fliessen	Flusso
Glass	Verre	Glas	Vetro
Grade	Grade	Bezeichnung	Grado
Humidity	Humidité	Feuchtigkeit	Umidità
Hybrid	Hybride	Kreuzung	Ibride
Impact	Chocs	Stoss	Urto
Interlaminar	Interlaminaire	Zwischen Schichten	Interlaminare
Knitted	Tricot	Stricken	Maglia
Laminate	Stratifié	Schichtstoff	Laminato
Length	Longuer	Länge	Lunghezza
Load	Charge	Belastung	Carico
Longitudinal	Longitudinal	Längsrichtung	Longitudinale
Manufacturer	Fabricant	Fabrikant	Fabricante
Mat	Tapis	Matte	Stuoia
Matrix	Matrice	Matrix	Matrice

English	French	German	Italian
Modulus	Module	Modul	Modulo
Moisture	Humiidité	Feutigkeit	Umidità
Moulded Ply Thickness	Epaisser de Pli Aprés	Dicke Lage Ausgehärte	Spessore dei Fogli Dopo Cuisson al Lavoraazione
Oxidation Temperature	Temperatur d'Oxidation	Oxydationtemperatur	Temperatura di Ossigen
Package	Ensemble	Packung	Imballaggio
Plain	Toile	Leinwand	Tessuto Semplice
Plastics	Matiére Plastique	Kunststoffe	Materie Plastiche
Ply	Pli	Gewebelage	Strato
Precursor	Précurseur	Ausgangsmaterial	Precursore
Prepreg	Préimprégné	Vorimpragnierung	Preimpregnato
Pressure	Pression	Druck	Pressione
Reinforced	Armé	Verstärkt	Reinforzato
Resin	Résine	Harz	Resina
Resin Content	Contenance de Résine	Harzinhalt	Contenuto di Resina
Resistivity	Resistance Specifique	Spechifische Widerstand	Resistenza
Roving	Stratifil	Vorgespinst	Tessuto di Filo Continuo
Satin	Satin	Satin	Satin
Shear	Cisaillement	Scher-	Taglio
Size	Apprêt	Appretur	Ensimaggio
Specific Gravity	Poids Spécifique	Spezifisches Gewicht	Peso Specifico
Specific Modulus	Module Specifique	Spechifische Modul	Modulo Specifico
Specific Strength	Resistance Specific	Spechifische Zugfestigkeit	Resistenza Specifico
Staple Fibre	Fibres Droites	Stapelfaser	Fiocco
Strength	Résistance	Festigkeit	Resistenza
Tape	Ruban	Band	Nastro
Tensile	de Traction	Zug-	di Tensione
Thermal Conductivity	Conductivité Thermique	Leitfähigkeit Thermisch	Condutiviá Termica
Thickness	Epaisseur	Dicke	Spessore
Tow	Méche	Tau	Tow
Transverse	Transversal	Querrichtung	Transversale
Twille	Sergé	Köper	Spigato
Twist	Torde	Drehung	Torsione
Ultimate Tensile Strength	Resistance à la Traction	Zugfestigkeit	Resistenza a Trazione
Unidirectional	Unidirectionel	Unidirektionale	Unidirezionale
Vacuum	Vide	Vakuum	Vuoto
Volatile	Volatil	Fluchtig	Volatile
Warp	Chaî	Kette	Ordipo
Weave	Tisse	Webe	Tessitura
Weft (Fill)	Trame	Schuss	Trama
Weight (Unit Length)	Mass par Unité de Longeur	Langengewicht	Peso Unitario
Width	Largeur	Breite	Larghezza
Woven	Tissé	Gewebt	Tessuto
Yield	Rendement	Ertrag	Rendimento
Young's Modulus	Module de Young	Elastizitätmodul(zug)	Modulo di Young

GLOSSARY OF TERMS

ACCELERATOR	A material which is added to a mixture of resin and catalyst to speed up the curing (polymerisation) reaction.
ANISOTROPIC	Not isotropic, having different properties along axes in different directions.
CATALYST	An active reagent which causes the matrix resin to polymerise (cure), often called the hardener.
CATENARY	A defect in a roving or tow, caused by uneven tension in the filaments or strands, resulting in some fibres hanging below the remainder when the tow or roving is stretched horizontally.
COMPOSITE	A material consisting of two or more different constituents which retain their separate identity, when combined together to provide properties unobtainable with either constituent.
COUNT	A number indicating the mass per unit length, or length per unit mass of a yarn.
CURE	To irreversibly change the properties of a thermosetting resin by the chemical reaction of the catalyst (plus accelerator where applicable), with or without heat.
DELAMINATION	The failure of a laminate due to the separation of the respective layers or plies.
DENIER	The weight in grams of 9,000 metres of roving, tow, yarn or strand.
DRAPE	The ability of a woven fabric or prepreg to conform to an irregular shape, especially in double-curvature.
END	An individual roving, tow, thread, yarn or filament, specially in the warp direction.
FABRIC	A manufactured assemblage of fibres or yarns with sufficient mechanical strength to hold the assembly together when handled.
FIBRE	Material in a form which has a high length-to-thickness ratio and is characterised by flexibility and fineness.
FILAMENT	A single fibre of indefinite length.
FLOW	The movement of the resin matrix during moulding.
ISOTROPIC	Having uniform properties in all directions.
LAMINA, Ply	A single layer of impregnated reinforcement.
LAMINATE	A moulded assembly of plies.
LAY-UP	The description of the components and arrangement of the reinforcement in a laminate.
MATRIX	The component of a composite which surrounds the reinforcement.
MODULUS	A measure of the stiffness or rigidity of a material which is independent of the geometric shape of the component. The numerical value is obtained by dividing the stress by the strain, when a specimen is loaded within its elastic limit.
PICK	An end in the weft (fill) direction.
POLYMERISATION	A cross-linking process building long-chain molecules.

POST-CURE The additional processing of a laminate at an elevated temperature to complete the cure (polymerisation) of the resin matrix and thereby improve the finished properties.

POT LIFE (OUT-TIME) The length of time a resin system, comprising the mixed resin, catalyst and accelerator, retains a viscosity low enough to be used satisfactorily in the moulding process.

PREPREG (Preimprenated Reinforcement) A combination of reinforcement with the optimum quantity of resin, prepared for moulding, usually cured to the B-Stage and capable of shipment and handling. In other words a preimpregnated reinforcement, but having a limited storage life.

ROVING An untwisted assemblage of strands.

SIZE A compound applied to the reinforcement which bonds the filaments together lightly for ease of handling and may provide improved properties in the laminate.

SPECIFIC MODULUS The modulus value divided by specific gravity or density in consistent units.

SPECIFIC STRENGTH The ultimate tensile strength divided by specific gravity (or density) in consistent units which take into account the effect of gravity.

SPECIFIC STRESS The ratio of the force to the mass per unit length, (equal to the stress per unit density). The units are N/tex.

SPLICE A join in a tow, roving, strand or yarn made by an adhesively-bonded lap joint rather than by a knot.

SPUN YARN A yarn consisting of fibres of regular or irregular lengths, usually bound together by twist.

STAPLE FIBRE Fibres cut or broken into pre-determined lengths, typically 30 - 480mm (1.25 - 19")

STRAND An untwisted, compact bundle of filaments.

TACK The stickiness of the partially cured prepreg.

TENACITY The maximum specific stress developed in a tensile test to rupture.

TEX The weight in grams of 1,000 metres of roving, tow, yarn or strand.

TOW, SIIver A loose bundle of filaments, substantially without twist.

WARP The end running lengthwise in a woven fabric.

WEFT The end running across the width of a woven fabric, often termed the 'fill'.

YARN A twisted bundle of strands.

YIELD The length of material equivalent to unit weight.

INDEX OF TRADE NAMES

Trade Name	Company
Almax	Mitsui Mining Co Ltd
Altex	Sumitomo Chemical Eng. Co Ltd
Altra	RATH Advanced Materials GmbH
Ampreg	SP Systems Ltd
Aralok	Heinsco Ltd
Aramat	Chomarat et Cie
Arasox	Atkins & Pearce Inc
Aravolle	Chomarat et Cie
Arpylene	Hydro Polymers Ltd
Ash-Deceram	Ash Fibre Processors Ltd
Astroquartz	JPS Glass Fibers
Avcarb	Textron Specialty Materials
Avox	Textron Specialty Materials
Avtel	Phillips 66 Company
Baycomp	Bay Mills Ltd
Bekinox	Bekaert NV SA
Bekitherm	Bekaert NV SA
Besfight	Toho Rayon Co Ltd
Brunsmet	Brunswick Technologies Inc
CCC	Cramer C & Co
C-I	Composites Inc
C-S	Clark-Schwebel Fiber Glass Corp
Calcarb	Calcarb Ltd
Carboflex	Ashland Petroleum Co
Carbolon	Nippon Carbon Co Ltd
Carbonic	Petoca Ltd (Kashima Oil Co Ltd)
Carbotex	Aerotex GmbH
Carrfibre	Carr Reinforcements Ltd
Cerachem	Schuller International
Cerachrome	Schuller International
Cerablanket	Schuller International
Cerafelt	Schuller International
Cerafibre	Schuller International
Cerawool	Schuller International
Cetex	Ten Cate Advanced Comp. BV
ChemteX	Verseidag Industrietextilien GmbH
Compuweave	Textile Technologies Inc
Conform	JPS Glass Fibres Inc
Cotech	Tech Textiles Ltd
CyPac	Cytec Engineered Materials
CyCom	Cytec Engineered Materials
CyForm	Cytec Engineered Materials
Dalfratex	Cape Insulation Co LtdDivision
Dialead	Mitsubishi Kasei Corporation
Donacarbo -	Osaka Gas Co Ltd
Durestos	TBA Composites Ltd
Dyneema	Dyneema VoF
EMI-X	Kawasaki Steel Co Ltd
Electrafil	Akzo Engineering Plastics Inc
Elitrex	AIK Faserverbundtechnik GmbH
Enkamat	Akzo Industrial Systems
Extrasint	Italcompositi SpA
Eymyd	Ethyl Corporation
FMI	Fiber Materials Inc
FR	Fiber-Resin Corp
FRT	Lewcott Corporation
FX	Fiberite Corporation
Fensor	National Standard Co Ltd
Ferropreg	Ferro Corporation
Fibercord	Carborundum Res. Materials Ltd
Fiberfrax	Carborundum Res. Materials Ltd
Fiber G	Du Pont de Nemours Inc
Fibermax	Carborundum Res. Materials Ltd
Fibermet	Memtec America Corp
Fiberod	Polymer Composites Inc
Fibertec	Technical Fibre Products Ltd
Fibral	SP Systems
Fibredux	Ciba Polymers
Fibrex	National Standard Inc
Filcaron	Kawasaki Steel Co Ltd
Flexwrap	Fiberite Corporation
Forca	Tonen Corporation
Fortafil	Akzo Nobel Fortafil Fibers Inc
Gammasox	Atkins & Pearce Inc
Grafil	Grafil Inc
Graflok	Heinsco Ltd
Granoc	Nippon Petrochemicals Co Ltd
Grayon	RK Carbon Fibres Ltd
Grilimid	EMS Chemie AG
HMF	Fiberite Corporation
Hi-Carbolon	Asahi Kasei Carbon Fiber Co Ltd
Himont	Texmet SrL
Hi-Tex	BP Chemicals (Hitco) Ltd
Hy-Bor	Textron Specialty Materials
Hy-E	Fiberite Corporation
Interglas	CS-Interglas AG
Kaowool	Thermal Ceramics Ltd
Karbon	Fiberite Corporation
Kera-Siw	Keramont Corp
Kermel	Rhône - Poulenc
Ketama	Textile Products Inc
Kevlar	Du Pont de Nemours Inc
Knytex	Knytex Corporation
Kosca	Korea Steel Chemical Co Ltd
Krempel	Krempel Soehne August GmbH
Kureha	Kureha Chemical Industry Co Ltd
LTM	Advanced Composites Group
Lantorine	Lantor (UK) Ltd
Latamid	Lati Industria Termoplastici SpA
Latan	Lati Industria Termoplastici SpA
Latilon	Lati Industria Termoplastici SpA
Layrite	RK Carbon Fibres Ltd
Lexan	General Electric Plastics
Lytec	Quantun Composites Inc
Lyvertex	Brochier SA
MCS	Du Pont de Nemours Inc

Trade Name	Company
MI	Mutual Industries Inc
MX-	Fiberite Corporation
Magnamite	Hercules Inc
Martinply	J B Martin Co Inc
Microfil	Fiber Materials Inc
Micropreg	Advanced Polymer Industries Inc
Narmco	Cytec Engineered Materials
Nextel	3M Company
Nicalon	Nippon Carbon Co Ltd
Nittobo	Nitto Boseki Co Ltd
Nomex	Du Pont de Nemours Inc
Nortex	North American Textiles Inc
Orcoweb	Orcon Corporation
Oxipan	Korea Steel Chemical Co Ltd
pbi	Hoechst Celanese Corporation
PDL	Plastic Developments Ltd
PRF	Plastic Reinforcement Fabrics Ltd
Panex	Zoltek Corporation
Panotex	Universal Carbon Fibres Ltd
Panox	RK Carbon Composite Fibres Ltd
Polycarbon	Polycarbon Inc
Polystal	Bayer AG
Prepsox	Atkins & Pearce Inc
Primco	Primco Ltd
Pyrofil	Mitsubishi Rayon Co Ltd
Pyromex	Toho Rayon Co Ltd
Pyron	Zoltek Corporation
Quadran	SP Systems Ltd
Quadrax	Quadrax Corporation
Quartzel	Quartz et Silice
RK	RK Carbon Fibres Ltd
RTC	Ahlstrom Glassfibre Ltd
RTP	RTP Company
Rigidite	Cytec Engineered Materials
Rilsan SR	Atochemie
Ryton	Phillips 66 Corporation
SCS	Textron Speciality Materials
SCW	Tateho Chem Industries Co Ltd
SFT	Santa Fe Textiles Inc
Saffil	ICI Chemicals & Polymers
Scotchply	3M Company
Sigmatex	Sigmatex (UK) Ltd
Sigrafil	Sigri Great Lakes Carbon GmbH
Sigratex	Sigri Great Lakes Carbon GmbH
Sigratherm	Sigri Graet Lakes Carbon GmbH
Siltemp	Amatek
Spanset	Sigmatex (UK) Ltd
Spectra	Allied Signal Inc
Star-C	Ferro-Eurostar SA
Stesapreg	Stesalit AG
Stesatape	Stesalit AG
Strafil	Danutec Werkstoff GmbH
Stratipreg	Vetrotex
Structil	Structil SA
Te	Nitto Boseki Co Ltd
TTI	Textile Technologies Inc
TWF	Sakase Adtech Co Ltd
Taffen	Exxon Chemicals France
Technimat	Lydall Inc
Technoglass	Synoglas NV SA
Technora	Teijin Ltd
Teijinconex	Teijin Ltd
Tekmilon	Mitsui Petrochemical Industries
Teletex HP	Swiss Silk Zurich
Tenax	Tenax Fibres GmbH
Tenfor	SNIA Fibre SpA
Tepex	Du Pont de Nemours Inc
Tetex HP	Swiss Silk Zurich
Textron	Textron Specialty Materials
Texxes	Nitto Boseki Co Ltd
Thermatex	Ash Fibre Processors Ltd
Thermeez	Cotronic Corporation
Thermocomp	LNP Corporation
Thermofil	LNP Corporation
Thornel	Amoco Performance Products Inc
Thorstrand	Hexcel Corporation
Through-The-Thickness	Atlantic Research Corporation
Tismo	Osaka Chemical Co
Tokawhisker	Tokai Carbon Co Ltd
Tool-Rite	Fiberite Corporation
Torayca	Toray Industries Inc
Towflex	Custom Composite Materials Inc
Twaron	Akzo Nobel Fortafil Fibres Inc
Tygamesh	Courtaulds Aerospace Ltd
Tyranno	Ube Industries Ltd
USP	BP Chemicals (Hitco) Inc
Ultisil	Amatek
Ultra-Tape	Cotronic Ltd
Ultra-Temp	Cotronic Ltd
Unilay	RK Carbon Fibres Ltd
Uniloc	Plastic Developments Ltd
Varicut	Polymer Composites Inc
Vectran	Hoechst Celanese Corporation
Verlok	Heinsco Ltd
Verton	Fiberite Corporation
Vicotex	Brochier SA
Weav-Rite	Fiberite Corporation
Wrap-It	Cotronic Corporation
Xylus	Nitto Boseki Co Ltd

Contents

PART ONE

DIRECTORY SECTION