

Goodfellow

Serving The Needs of Science and Industry Worldwide

Au service de la Science et de l'Industrie dans le monde entier

Weltweiter Lieferant für Wissenschaft und Industrie

Metals and Alloys
Métaux et Alliages
Metalle und Legierungen

Ceramics
Céramiques
Keramiken

Polymers
Polymères
Polymere

Composites
Composites
Verbundwerkstoffe



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Standard Price List for All Monofilaments

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Introduction

Goodfellow is well known as a specialist supplier of small to medium size quantities of metals, alloys, ceramics, polymers and other materials to meet the research, development and specialist production requirements of science and industry worldwide. We realise that "small" means different things to different people, but we consider small to mean any quantity from a few grammes to a few kilos.

Goodfellow offers two distinct services to meet the requirements of our customers:

- The first meets the needs of our customers who need small quantities of products from our standard range of materials within 24-48 hours.
- The second service is for those who require larger quantities or further processing of our standard products or who need an item which falls within our general area of supply expertise.

The range of materials offered by Goodfellow is extensive, as are the forms in which the various products are available. This Catalogue provides a detailed overview of our standard products which are available from stock. Full details of all of these items, including prices and technical information, can be found in our web Catalogue at www.goodfellow.com.

Materials

Metals and Alloys

Goodfellow supplies virtually all of the pure metals from Aluminium to Zirconium as well as a comprehensive range of alloys. Most are available in a variety of forms, including rod, wire and foil. The Catalog details those materials which are available as standard products from stock. Custom-made items are also available, so please contact us if you are unable to identify the item you require.

Ceramics

The ceramic materials offered by Goodfellow have been carefully chosen, and include both the established as well as more recently developed products. All are available as either standard or custom-made products in a variety of forms and sizes. The Catalog details those items which are

available from stock. For ceramic components made to customer drawings, our Ceramic and Glass Division would be delighted to help. Please visit www.goodfellow-ceramics.com for further information.

Polymers

The range of polymers supplied by Goodfellow is broad and includes both the familiar as well as some of the more unusual or recently developed materials. The Catalog details those items which are available from stock; please contact us if you are unable to find the item you specifically require.

Compounds & Intermetallics

Goodfellow can supply aluminides, borides and silicides as well as other intermetallics and compounds. The majority of these items are made to order and the Catalog details those which are available. Please contact us with details of your requirements.

Composites

Some examples of these materials are listed in the Catalog. As some of these are manufactured on a custom-made basis, please contact us with details of your requirements.

Glasses

Goodfellow offers two distinct types of glass products. The first are generally silica-based and transparent. Generally, these products are made to order for customers, so we do not list them in our Catalog, however, they are available through the Goodfellow Ceramic and Glass Division. Please contact us with your requirements.

The second type of glass product is commonly referred to as "metallic glasses" or "glassy metals". In contrast to crystalline metals and alloys with highly ordered atomic structures, these are non-crystalline (amorphous) metals or, more usually, alloys. Our Catalogue details those glassy metals which are available from stock; please contact us if you are unable to find the item you specifically require.

Product Descriptions



Bar

A straight length of rectangular, square or oval section material.

Tolerances

Section dimensions:	≤ 10mm	± 10%
	> 10mm	± 1mm
Length:	< 100mm	± 1mm
	≥ 100mm	+5% / -1%



Bolt

A threaded pin that can be screwed into a nut or a tapped hole to fasten items together. Bolts are available with different head styles and also in metric and inch-threaded sizes.

Tolerances

Ceramics: ANSI B18.6.7M-1985



Chopped Fibre

Fibres cut into short lengths called cut, staple or chopped fibre.

Tolerances

Fibre diameter:	± 25%
Number of strands:	± 10%
Tex number:	± 10%
Length:	+5% / - 1%



Crucible

A vessel in which other materials may be heated or melted, usually at high temperatures.

Tolerances

Height:	± 10%
Inside Dimensions:	± 10%
Outside Dimensions:	± 10%



Fabric

Woven fabrics are made by the regular interlacing of two arrays of yarns at right angles to each other, these being referred to as the warp and weft (see also Non-woven fabric).

Tolerances

Fabric thickness:	± 25%
Number of yarns:	± 10%
Tex number:	± 10%
Size (linear dimension):	< 100mm ± 5mm
	≥ 100mm ± 5%



Fibre

Yarns or tows consisting of several approximately parallel individual filaments, each filament usually being smaller in diameter than a monofilament. Yarns contain a defined number of filaments, typically three to several hundred; tows contain thousands of filaments whose number is only defined approximately. Both are primarily specified by their linear density measured in "tex", the weight in grams of a 1km length of material.

Tolerances

Fibre diameter:	± 25%
Number of strands:	± 10%
Tex number:	± 10%
Length:	+5% / -1%



Film

A non-metallic sheet material with a thickness < 0.5mm.

Tolerances

Thickness:	± 20%
Size (linear dimension):	< 100mm ± 1mm
	≥ 100mm + 2% / -1%



Flake

Flat, irregularly shaped pieces of material. A maximum flake size is indicated but individual flakes may vary greatly in size.

Tolerances

Dimensions shown are nominal

Product Descriptions



Foam

A low density, permeable structure of cells and continuous ligaments offering a high surface area to volume ratio, and also a high strength to weight ratio. Owing to the nature of this material, dimensions are nominal.



Foil

Thin sheets of pure metal and metal alloys. Due to their fragile nature, some foils are coated on one side with an acrylic or polyester support. Where foils are supported they are indicated in the detailed item description.

Tolerances

Thickness: < 0.010mm ± 25%
 0.01-0.05mm ± 15%
 > 0.050mm ± 10%
 Size (linear dimension): < 100mm ± 1mm
 ≥ 100mm + 2% / -1%



Granule

Pellets of an approximately regular shape. Granules may vary in size and, therefore, the dimensions stated are nominal. In addition, the shape of a granule may vary from item to item.

Tolerances

Dimensions shown are nominal



Honeycomb

A cellular structure similar in appearance to natural honeycomb. Owing to the nature of this material, dimensions are nominal.



Insulated Wire

A single or multiple flexible strand of metal or alloy with an insulating sheath.

Tolerances

Wire diameter: ± 10%
 Length: + 5% / -1%
 Insulation thickness: Nominal values only



Laminate

Layers of material which have been bonded together by the use of heat, pressure and, possibly, adhesive.

Tolerances

Thickness: ± 10%
 Size (linear dimension): ≤ 100mm ± 1mm
 > 100mm + 2% / -1%



Lump

A solid piece of material with no defined shape.

Tolerances

Dimensions shown are nominal



Mesh

Mesh is available as either a woven wire or electroformed product; in all cases, the quoted aperture sizes are nominal. Wire mesh: a material which is woven from metal wires to provide a thin grid with a regular series of holes. Electroformed mesh: a product made by electroplating the mesh geometry through a mask onto a substrate which is subsequently etched away.

Tolerances

Thickness: woven: ± 10%
 electroformed: ± 20%
 Wire diameter: ± 10%
 Size (linear dimension): < 100mm ± 1mm
 ≥ 100mm + 2% / -1%

Product Descriptions



Metallised Film

Film which is coated with a metal. The thickness of the metal is measured and described in terms of the material's specific electrical resistance in ohms per square.

Tolerances

Thickness: $\pm 10\%$
 Size (linear dimension): $< 100\text{mm}$ $\pm 1\text{mm}$
 $\geq 100\text{mm}$ $+2\% / -1\%$



Microfoil

An extremely thin sheet of metal or alloy mounted on a permanent support. This support **cannot** be removed without destroying the Microfoil.

Tolerances

Thickness: $\pm 30\%$
 Size: $\pm 20\%$



Microleaf

An extremely thin sheet of metal mounted on a removable support. Microleaf is not available for metals which are too brittle to be free standing.

Tolerances

Thickness: $\pm 30\%$
 Size: $\pm 20\%$



Monofilament

A single strand of a non-metallic material.

Tolerances

Diameter: $\pm 20\%$
 Length: $+5\% / -1\%$



Non-Woven Fabric

Non-woven fabrics are made by methods other than weaving or knitting, the yarns and fibres being held together, often quite loosely, by means other than geometric interlacing. Due to the open and porous nature of this material, all other dimensions are nominal. conventional textile fabrics. Due to the open and porous nature of this material, all other dimensions are nominal.

Tolerances

Size (linear dimension): $< 100\text{mm}$ $\pm 5\text{mm}$
 $> 100\text{mm}$ $\pm 5\%$



Nut

Generally a flat piece of material with a threaded hole which can be screwed onto a bolt to fasten items together. Nuts typically have a hexagonal external shape. Nuts are available in metric and inch-threaded sizes.

Tolerances

Ceramics: ANSI B18.2.4.1M-1979
 (R1995)



Powder

Small particles with an approximately defined size range. Those materials described as alloy precursors are not true alloys - they are made by sintering a blend of powders of the component metals to achieve alloying by diffusion. The resultant cake is ground and sieved to the required particle size range. Unless otherwise stated, the particle sizes shown are for guidance only. We do not guarantee either any particular size distribution between the quoted minimum and maximum sizes, or a specific particle shape.

Tolerances

Dimensions shown are nominal

Product Descriptions



Rod

A straight length of circular section material.

Tolerances

Diameter:	≤ 10mm	± 10%
	Polymer	+ 20%/-10%
	Ceramic	+ 20%/-10%
> 10mm	± 5%	
	Ceramic	+ 20%/-10%
	Polymer	+ 20%/-10%
Length:	< 100mm	± 1mm
	≥ 100mm	+ 5% / -1%



Sheet

Flat material with a thickness > 0.5mm.

Tolerances

Thickness:		± 10%
	Ceramic	± 20%
	Composite	± 20%
	Polymer	± 20%
Size (linear dimension):	< 100mm	± 1mm
	≥ 100mm	+ 2% / -1%



Single Crystal

A material grown as a monocrystal, generally to a specific orientation, dimension and surface finish. It may contain a dopant. Single crystals are usually made to order.

Tolerances

Orientation:	± 3°
Size:	Sizes shown are nominal



Sphere

A regular solid or hollow three-dimensional form in which every cross-section is a circle. Spheres are available with standard or precision tolerances, and can be supplied with different surface finishes depending on the material.

Tolerances

Diameter (standard):	± 5%
Diameter (precision):	see item



Sputtering Target

A high purity material used as a source for sputtering, a cold vapourisation process in which atoms are physically removed from the target surface by ion bombardment.

Tolerances

Thickness:	± 0.5mm
Size:	± 0.5mm



Tube

A hollow length of material normally circular in section. Most tubes are straight except those made of flexible polymer.

Tolerances

Outside diameter:	≤ 2mm	± 0.05mm
	Polymer	± 10%
	Ceramic	± 10%
≤ 5mm	± 0.1mm	
	Polymer	± 10%
	Ceramic	± 10%
> 5mm	± 5%	
	Polymer	± 10%
	Ceramic	± 10%
Wall thickness:		± 10%
	Polymer	± 20%
	Ceramic	± 20%
Length:	< 100mm	± 1mm
	≥ 100mm	+ 5% / -1%



Washer

A thin, flat piece of material with a hole in the middle, used in conjunction with bolts and nuts to distribute the load of a threaded fastener.

Tolerances

Ceramics:	see item
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Product Descriptions



Wire

A single or multiple flexible strand of pure metal or alloy.

Tolerances

Wire diameter: $\pm 10\%$
Length: $+5\% / -1\%$

Hazards Information

HAZARDS

All materials listed in this catalogue, whatever the quantity supplied, are sold for research or development purposes. We make no warranty that the materials are fit for a particular purpose. In purchasing materials from this catalogue, customers should be aware that there may be hazards associated with their use and in the handling of them. Complete toxicological or hazard investigations are the responsibility of the customer. Ingestion or contact with the human body may be harmful. The responsibility for the safe use of our products rests with the customer. All materials should be handled by qualified personnel familiar with laboratory procedures and who are familiar with the nature of the material and any necessary precautions which should be taken in the handling, use and storage of the products. The customer shall be responsible for the control and use of the products offered in this catalogue whether alone or in combination with other articles or substances or in any other manner whatsoever.

HAZARD SYMBOLS



C

Corrosive

Chemicals which may destroy living tissue when in contact with them.



D

Dangerous when wet

Chemicals which, in contact with water or damp air, evolve highly flammable or toxic gases and vapours in dangerous quantities.



E

Explosive

Chemicals which may react exothermically without atmospheric oxygen, quickly evolving gases, and which under defined test conditions detonate, quickly deflagrate or upon heating explode when partially confined.



F+

Extremely flammable

Chemicals which when finely divided (small particle size) are liable to ignite spontaneously.



Xn

Harmful

Chemicals which may cause death or acute or chronic damage to health when inhaled, ingested or absorbed via the skin.



F

Highly flammable

Chemicals which will ignite after contact with flame, or which will evolve highly flammable gases in contact with water.



Xi

Irritant

Non-corrosive chemicals which, through immediate, prolonged or repeated contact with the skin or mucous membrane may cause inflammation.



R

Radioactive

Chemicals which will emit ionising radiation without being subject to irradiation. General precautions for Toxic chemicals apply to those of low activity. For chemicals of medium or high activity special regulations apply.



T

Toxic

Chemicals which may cause death or acute or chronic damage to health when inhaled, ingested or absorbed via the skin.



T+

Very Toxic

Chemicals which in low quantities cause death or acute or chronic damage to health when inhaled, ingested or absorbed via the skin.

General Information

Analyses

Typical Analysis :

Where appropriate a typical analysis is given. All figures are parts per million (ppm) by weight unless otherwise stated. It must be emphasised that this data is "typical" and no guarantee is given that the material supplied will conform to these analyses. The compositions shown under alloy headings are generally weight percent. Exceptions are the glassy alloys and the rare earth magnets where the convention of using atomic ratio is followed.

Purity

Purities listed are quoted with respect to total metallic impurities. Typical analyses may give additional information about likely non-metallic impurities.

High Purity

For materials described as High Purity, the actual analysis of metallic impurities will be supplied free of charge. For other items, an actual analysis can be supplied and a charge will be made for the analysis and for the sample used.

If you require an analysis please tell us whether you require analysis of metallic impurities only or metallic and gaseous. Where an analysis is required the shipment of your order may be delayed.

Supports

Some items from our range of foils need to be supported on one side of the foil to enable both you and us to handle these very delicate materials. Two types of support can be used, the choice being governed by the material. Wherever possible we use a temporary support, a permanent support only being used when the material is brittle (for example Chromium or Manganese).

The temporary support is Acrylic, approximately 0.2mm thick. This may be removed by dissolving in 2-Propanone (Acetone).

Our permanent support is Polyester, thickness 0.125mm, which is hot-press laminated to one face of the foil. It **cannot** be removed without destroying the foil.

Microfoil is mounted on a permanent 3.5µm polyester support. This support **cannot** be removed without destroying the Microfoil.

Microleaf is mounted on a specially treated support which allows separation of the metal film from the support. Full instructions on the method of removal are issued with each Microleaf supplied.

Light Tight (LT) & Not Light Tested (NLT)

Light tight (LT) foils are supplied without visible pinholes after examination without magnification. Foils 0.025mm or more in thickness are supplied LT unless otherwise stated.

Foils less than 0.025mm thick are normally supplied Not-Light Tested (NLT), and will normally contain pinholes but may occasionally be free from pinholes. Foils less than 0.025mm in thickness can often be supplied LT but may incur additional charges. Please specify if you require LT foils

Vacuum tight

Vacuum tight foils show no detectable leakage when tested with a helium mass spectrometer with a sensitivity of 10^{-9} atm-cm³.s⁻¹.

Continuous Lengths

If you require material in continuous lengths please tell us when you place your order. Unless otherwise specified, we reserve the right to supply in more than one length.

Technical Data and Information

All information and technical data are given as a guide only. Although every effort has been made to ensure that the information is correct, no warranty is given as to its completeness or accuracy.

Tolerances

For details of our standard tolerances, please refer to the Product Description section. In many cases, closer tolerances are available but may be subject to an extra charge. If you have any special requirements it is important that you tell us at the time of ordering. This includes special tolerances, dimensional uniformity or any other special requirement which you may have (for example edge finish, packaging, labelling etc.). Please indicate precisely what is required and we shall do our best to meet your specification.

Order information

General Information

There are over 70,000 stock packs listed and if you cannot find what you need amongst them, please ask for special sizes, thicknesses, tolerances, dimensions or larger quantities. We are also able to offer many other pure metals, alloys, polymers and ceramics to special order.

Prices

All the prices listed are total (lot) prices for the sizes and quantities listed. Prices are subject to change without notice.

Prices shown include delivery except for those items marked as "special offer" or dangerous goods with transport restriction. They do not include value added tax, any import duties or local taxes.

Transport Restriction

Some of the materials supplied by Goodfellow are subject to special transport restrictions. Additional shipment charges may apply which are dependent on destination. Please check the individual item on our website or contact us for details of the charges.

If you intend to have the material transported or sent onwards please ensure that you are aware of the relevant transport restrictions.

Delivery

Split shipment

All orders are accepted for one shipment on one date to one address. A charge will be made for split shipments made at the customer's request.

Special Analysis, Supports or Tolerances

An extra charge is made for non-standard supports, alternative tolerances and certificates of analysis. The analysis is free of charge for items marked "High Purity".

Cancellations

A charge for cancellation of orders may be made. The amount will depend on the circumstances.

Express Service

An administration charge of £10 will be made for any order received for which same day shipment within the UK is requested.

Shipment

We aim to have all items listed in this catalogue in stock in the quantities and sizes listed. We can only undertake to despatch an order on a particular date. The date of delivery at the customer's address is subject to the normal variations of the delivery service used.

Despatch

Orders will normally be despatched within 48 hours of receipt.

Non delivery

If we have notified you of despatch of goods and you have not received delivery within 7 days, please contact us.

Insurance

All consignments will be insured by us against the usual risks unless we are instructed in writing to the contrary.

Export Restrictions

A UK Government export licence may be required for some items to some destinations. If the item you require needs a special export licence or an end-use statement we will inform you at the time you order.

Materials Handling

Many of our materials are extremely delicate and it is essential every care is taken when handling them. Special attention is drawn to the extreme fragility of Microfoil, Microleaf and thinner and finer materials.

All materials are carefully packed to ensure safe transport of goods to your address. We do not accept responsibility for damage caused by mishandling once the outer transit packaging has been removed.

Terms of payment

Our normal terms of payment are net 30 days from date of invoice. Any alternative terms of payment are to be agreed with us in writing at the time of placing an order. Customers may be asked to pay cash with order or cash against pro-forma invoice with their first order. In order to establish a credit account we will require details of your bankers, along with two trade references.

Order information

Credit account

We endeavour to keep our costs down and customers are requested to pay our invoices on time. We reserve the right to delay delivery if there are overdue invoices on the account. Accounts which remain unpaid beyond the due date may incur an interest charge at a rate of 2% per month.

Credit card payments

We also accept payment using the following credit and charge cards:

Mastercard, VISA, American Express, DELTA and Switch.

VAT

VAT number: GB 212 8527 79

UK

VAT will be added to the invoice at the rate ruling at the date of invoice. Where a customer is exempt, VAT will be charged unless we receive a copy of the exemption form at the time the order is placed.

EU

Customers registered for VAT who provide their local registration number will not be charged UK VAT.

Customers who are exempt from VAT will not be charged UK VAT provided we are given a copy of their exemption form at the time the goods are ordered.

Customers not registered for VAT or who fail to give us their registration number will be charged UK VAT at the current rate.

Export

All exports to countries outside the EU are zero-rated for UK VAT unless the invoice is being paid from within the EU.

Return of goods

We will only accept return of goods provided we are contacted BEFORE the goods are returned. When we agree to the return we will issue a Goods Return Number and give instructions for the method of return of the goods. Goods will not be accepted for return without a valid Goods Return Number. Due to the nature of some of our materials, it is imperative that you check any possible transport restrictions with your proposed freight company.

Claims

Great care is taken during manufacture and packing and all items are carefully inspected before shipment. Any claim in respect of short delivery, incorrect material or defective quality must be notified to us in writing within three days of delivery. Please retain ALL packaging for our inspection. Our liability for any such claim shall not exceed the cost of replacement of the goods free of charge, or crediting the customer with the invoice value thereof.

Goods ordered in error

We do not accept responsibility for customers' errors in ordering. The amount of credit for returned goods will be at our discretion. Where we accept returned goods a restocking charge will be made.

Conditions of sale

All orders, contracts and quotations are subject to our standard terms and conditions of sale.

Information and statements provided are indicative only and do not form part of any offer or contract.

Exclusions

We supply materials according to our specification. All conditions warranties and representations regarding the quality, fitness for purpose or state, size, shape, capacity or colour of goods supplied whether expressed or implied by common law or statute or otherwise are hereby expressly excluded. We shall not be liable for any damage direct or consequential arising from the use of goods supplied by us however such damage is caused, nor for delay in delivery.

Law

Customers in the USA: Contracts between Goodfellow Corporation and the customer shall be deemed to be subject in all respects to the laws of the Commonwealth of Pennsylvania, or the United States of America.

Customers in France: Contracts between Goodfellow SARL and the customer shall be deemed to be subject in all respects to French law unless otherwise agreed in writing

Customers in Germany: Contracts between Goodfellow GmbH and the customer shall be deemed to be subject in all respects to German law unless otherwise agreed in writing

Order information

Customers in the UK and all other countries: Contracts between Goodfellow Cambridge Limited and the customer shall be deemed to be subject in all respects to English law unless otherwise agreed in writing.

Copies of our General Terms and Conditions are available upon request or can be downloaded from our websites at www.goodfellow.com or www.goodfellowusa.com.

Company Details

Company Structure

The Goodfellow Group consists of five companies:

Goodfellow Cambridge Limited

Goodfellow was established in the City of London in 1946. The Company now has subsidiary operations in France, Germany and North America with the Group's research laboratories, workshop facilities & central administration located in Huntingdon, England.

Goodfellow Corporation

Established at the same time as our associate company in Germany, Goodfellow Corporation was set up to service the requirements of our customers in the USA.

Goodfellow GmbH

Since 1989, this member of the Goodfellow group of companies has been serving the needs of our German speaking customers within Europe.

Goodfellow SARL

Goodfellow established an operation in France in 1993 to meet the needs of our French-speaking customers in Europe.

Goodfellow (Shanghai) Trading Co., Ltd

Goodfellow established a representative office in Shanghai in 2006, and in 2012 followed this with the creation of a fully-fledged trading company, servicing the research and specialist manufacturing requirements of the Chinese market.

COMPANY DETAILS

Goodfellow Cambridge Limited

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USA
A Pennsylvania corporation
EIN 23-2557381

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Import VAT number DE112610478

Goodfellow (Shanghai) Trading Co., Ltd

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200040
The People's Republic of China

Conditions of Sale

1 GENERAL

1.1 In these Conditions:

1.1.1 the following expressions shall have the following meanings:-

- "Buyer" the individual firm company or other party from whom an order to supply Goods and/or Services is received by the Seller;
- "Conditions" the standard terms and conditions of sale of the Seller as set out herein and includes any additional terms and conditions of sale agreed in writing by the Seller;
- "Contract" a contract for the Supply of Goods and/or Services by the Seller to the Buyer;
- "Date of Delivery" the date on which delivery of the Goods or Services takes place pursuant to Condition 7;
- "Goods" the goods which the Seller is to supply (or, in relation to Condition 11, the goods in respect of which the Seller is to provide Services) under the Contract and includes any of them or any part of them and where the context so admits includes raw materials, processed materials and/or manufactured products whether processed or manufactured by the Seller or not;
- "Prepayment" a payment to be made by the Buyer pursuant to Condition 6.2 to be used at the Seller's discretion for the purchase of materials and/or towards the costs of labour and other costs relating to the supply of Goods;
- "Recommendations for Use" the recommendations (if any) relating to the storage, handling, application and/or use of the Goods contained in the published literature of the Seller (or, if relevant, a Supplier) or any recommendations made in Writing by an authorised representative of the Seller (or, if relevant, a Supplier);
- "Seller" Goodfellow Cambridge Limited and any subsidiary or holding company or associate (as such terms are defined in the Companies Act 1985 (as amended)) of the said company;
- "Services" the work or services or any of them to be provided by the Seller under the Contract;
- "Supplier" any person, firm or company who or which supplies materials to the Seller which make up the Goods which are to be supplied to the Buyer;

1.1.2 words importing the singular number shall include the plural and vice versa, words importing one gender shall include all genders, and words importing persons shall include bodies corporate, unincorporated associations and partnerships

- 1.2 If satisfactory references and information on the Buyer are not provided within seven days of a request therefore by the Seller, or if, following the provision of such information, the Seller is unable to obtain satisfactory trade indemnity or similar cover in respect of its dealings with the Buyer, the Seller may terminate the Contract and the rights and liabilities of the parties shall be the same as if the Contract had been cancelled in accordance with the provisions of Condition 10.2
- 1.3 The seller reserves the right to assign, sub-contract the Contract or any part thereof. The Buyer shall not be entitled to assign the benefit or burden of the Contract without the consent in writing of the Seller
- 1.4 In relation to all obligations of the Buyer under these Conditions, the time of performance is of the essence
- 1.5 The legal construction of these Conditions shall not be effected by their headings which are for convenience of reference only

2 ORDERS

- 2.1 Notwithstanding that the Seller may have given a detailed quotation or estimate either verbally or in writing no order shall be binding on the Seller unless and until it has been acknowledged in writing by the Seller or the Goods are delivered or the Services are provided by the Seller to the Buyer pursuant to the order
- 2.2 In order to avoid duplication of orders the Buyer shall be responsible for ensuring that any confirmation of an order previously placed is prominently marked as being a confirmation and not a new order. The Buyer acknowledges that any order or confirmation of order which is not so marked may be treated and accepted by the Seller as a new order to create a Contract in addition to any Contract arising out of the previously placed order
- 2.3 These Conditions are incorporated in the Contract and together with any matter set out in the Seller's quotation or acceptance/acknowledgement of order contain the entire obligations between the Seller and the Buyer. In the case of any inconsistency between any letter or quotation incorporating or referring to these Conditions and any order, letter or form of contract sent by the Buyer to the Seller, whatever may be their respective dates, the provisions of these Conditions shall prevail. In the event of the Seller entering into the Contract without the Seller having submitted a written quotation or other letter or document incorporating or referring to these Conditions but in circumstances where the Buyer has had prior notice of these Conditions then all Goods or Services supplied shall be subject to these Conditions
- 2.4 No variation of the Contract by the Buyer shall be binding upon the Seller unless made in Writing and signed on behalf of the Seller. In the event of such variation the Buyer shall indemnify and keep indemnified the Seller in full against all loss, which term shall include (but without prejudice to the generality thereof) loss of profit, costs (including the cost of labour and materials), damages, charges and expenses incurred (directly or indirectly) by the Seller as a result of such variation

2.5 Any representations (except fraudulent misrepresentations) or warranties made by or on behalf of the Seller prior to the Contract (whether verbally or in writing) are hereby expressly excluded and shall be of no effect

3 DESCRIPTION

- 3.1 Any figures, statements, descriptions, illustrations, photographs, drawings, weights or any other matters contained in the Seller's catalogues, pamphlets, price lists or advertising literature are not guaranteed to be accurate and are intended merely to represent a general picture of the Seller's products and shall not form part of the Contract nor be regarded as a warranty or representation relating to the Goods or Services
- 3.2 The Seller reserves the right to amend the specification of its products and services from time to time so that the descriptions thereof as set out in its catalogues, pamphlets, price lists or advertising literature may not be identical with those set out in the Seller's quotation and the Buyer is advised to check the specification set out in the Seller's quotation before placing an order

4 SPECIFICATIONS AND INTELLECTUAL PROPERTY

- 4.1 Where goods are supplied to the Buyer's own specification, or where standard goods of the Seller are altered in accordance with the Buyer's instructions the Buyer warrants and undertakes full responsibility for the suitability and fitness of the specification, pattern or design but also that such specification, pattern or design does not infringe any patent, trade mark, registered design, copyright or any other proprietary right of any third party and the Buyer shall indemnify and keep the Seller indemnified in full against any loss, damage or expense whatsoever (including costs) which the Seller may incur in or arising from the performance of the Contract by reason of any infringement of any such patent, trade mark, registered design, copyright or any other proprietary right
- 4.2 The Seller reserves the right to change the Buyer's specification as required to ensure that the Goods comply with any health, safety or other statutory requirement or provision and no such change by the Seller will constitute a breach of contract or impose upon the Seller any liability whatsoever
- 4.3 Unless otherwise agreed in writing, the Seller will be the sole owner of all inventions, formulations, tools, patterns, designs or other similar items and the copyright in all documents and drawings made or produced by it in preparing a quotation for the Buyer or in the course of work on any Contract with the Buyer

5 QUOTATIONS

- 5.1 The Seller's quotations are provisional in so far as they are subject to alteration by reference to any changes in the price of raw materials, any item to be acquired by the Seller from a third party, rates of wages, other costs of production and any other circumstances beyond the Seller's control taking place between the date of the quotation and the Buyer's placing of an order in respect thereof

6 PRICE

- 6.1 The Seller shall be entitled to adjust the Contract price of the Goods or Services whether before or after the making of the Contract in the event of any variation in the cost to the Seller of supplying the same or any part thereof caused by:-
- 6.1.1 any increase in the cost of materials required by the Seller for the completion of the Contract; or
- 6.1.2 any increase in wages or production and manufacturing costs or other overheads; or
- 6.1.3 any other reason whatsoever beyond the control of the Seller including (but without prejudice to the generality of the foregoing) fluctuations in exchange rates between monetary currencies the action of any government or any other authority or any labour problems
- 6.2 In the Seller's absolute discretion, a Prepayment in respect of the Contract may be required to be paid by the Buyer to the Seller on the terms set out in this Condition. The Prepayment shall be applied as follows:-
- 6.2.1 in the event that the Contract is performed in full by both parties the Prepayment shall be retained by the Seller in reduction of the total price payable by the Buyer under the Contract;
- 6.2.2 in the event that the Buyer is either in default of any of its obligations under the Contract or cancels or suspends the Contract in accordance with Condition 10 the Prepayment shall be set off by the Seller against its proper costs losses or damages arising in connection with the default and/or cancellation or suspension
- 6.3 Unless otherwise stated, the price set out in the Seller's quotation includes the cost of packaging, carriage, and (save as provided in Condition 6.4) insurance. In respect of supplies of Goods in the United States of America, Canada and Japan the price also includes import duties and sales taxes (if any). In respect of supplies of Goods in other countries the price does not include import duties or VAT or sales taxes which will be extra charges based on prevailing rates
- 6.4 Where the Buyer requests a particular means of delivery, the price set out in the Seller's quotation does not include insurance, which is to be arranged at the responsibility of the Buyer.

7 DELIVERY

- 7.1 Delivery of Goods shall be deemed to be effected by the Seller at the following times:-
- 7.1.1 where Goods are collected by or on behalf of the Buyer by its servants or agents, or where Goods are collected in

Conditions of Sale

- accordance with a means of delivery specifically requested by the Buyer, when the same are collected;
- 7.1.2 where delivery of the Goods is to be the responsibility of the Seller, when they arrive prior to unloading at the Buyer's premises;
- 7.1.3 where Goods are sold FOB or CIF, when they pass the ship's rail or are loaded onto the aircraft
- 7.2 Delivery of Services shall be deemed to be effected by the Seller at the time of completion by the Seller of the Services
- 7.3 Whilst the Seller will make every reasonable effort to complete the Contract by the date or dates therein specified for delivery of Goods or provision of Services such date or dates shall only constitute the times by which the Seller expects to effect such delivery and if no time is agreed delivery will be within a reasonable time but the performance of the Contract by the Seller shall not be the essence of the Contract, the Seller's failure to so deliver by the due date or dates shall not constitute a breach of Contract and the Seller shall not in any circumstances be responsible for any direct or consequential loss or damage of any kind whatsoever resulting therefrom. The Seller may wholly or partly suspend deliveries of Goods or provision of Services and the Buyer shall accept late delivery of such Goods or Services unless the Buyer has cancelled the Contract in accordance with the provisions of Condition 10.3

8 QUANTITIES INSTALMENTS AND STORAGE

- 8.1 Where Goods are delivered or Services are by instalment each instalment shall be deemed to be sold under a separate Contract and the party in default in respect of any instalment shall be liable accordingly, but no default in respect of any one instalment shall effect due performance of the Contract as regards other instalments
- 8.2 The Seller will endeavour to deliver the quantity of Goods ordered and every delivery shall be deemed to comply with the order. If there is a surplus or shortage of Goods which is no more than 10% of the quantity specified in the order the Buyer shall be deemed to have accepted the Goods and shall pay for the actual quantity delivered
- 8.3 If Goods or Services are to be delivered by instalments, the Seller shall be entitled to invoice each instalment as and when delivery is made and payment for all delivered instalments shall be due notwithstanding the non-delivery of other instalments or other default by the Seller. Failure by the Buyer to make payment by the due date for any one instalment for whatever reason shall entitle the Seller to suspend deliveries of Goods or provision of Services under the Contract but without prejudice to any other right the Seller may have under any of the other provisions of these Conditions
- 8.4 Notwithstanding that risk shall have passed to the Buyer pursuant to Condition 15 the Seller may in its absolute discretion arrange for storage of the Goods either at the request of the Buyer or as a result of the failure by the Buyer to take delivery of the Goods under Condition 7. The Seller may insure the goods whilst in storage and the Buyer shall indemnify and keep indemnified the Seller in full against all costs, losses, damages and expenses whatsoever arising in connection with the storage provided for hereunder and such costs, losses, damages and expenses will be added to and form part of the price of the Goods
- 8.5 Unless otherwise agreed between the Buyer and the Seller, the Seller shall be entitled in its absolute discretion and without giving prior notice to the Buyer at the expiration of 3 months to sell or otherwise dispose of Goods kept in storage as provided in Condition 8.4

9 TERMS OF PAYMENT

- 9.1 Unless otherwise agreed the price shall be due and payable at the Seller's offices 30 days after the date of the Seller's invoice
- 9.2 If the Buyer does not pay the whole or any part of the price on the required day then the Buyer shall pay to the Seller on request interest on the amount outstanding from the required day until the actual date of payment at the rate of 2% p.a. over the base rate of Barclays Bank plc from time to time in force which shall accrue on a daily basis
- 9.3 Condition 12 shall apply in the event of any alleged defect or failure in or of the Goods or Services and the Buyer shall not delay or refuse to make payment in any such event
- 9.4 The Buyer shall not be entitled to withhold payment of any amount due to the Seller by reason of any disputed claim by the Buyer in connection with the Contract nor shall the Buyer be entitled to set off against any amount payable under the Contract to the Seller any amount which is not then due and payable by the Seller or for which the Seller disputes liability
- 9.5 All payments payable to the Seller under the Contract shall become due immediately upon termination of the Contract despite any other provision.

10 SUSPENSION AND CANCELLATION

- 10.1 If the Buyer shall commit any breach of the Contract and fail to remedy the same within 7 days of receiving the Seller's request in writing so to do or any distress or execution is levied upon any goods or property of the Buyer or the Buyer makes any voluntary arrangement with its creditors or becomes subject to an administration order or (being an individual or firm) becomes bankrupt or (being an incorporated company) passes a resolution for winding up (otherwise than for the purpose of amalgamation or reconstruction), or a Court makes an order to that effect, or an encumbrancer takes possession, or an administrative receiver or receiver is appointed, of any of the property or assets of the Buyer, or the Buyer ceases, or threatens to cease, to carry on business or is unable to pay its debts within the meaning of section 123 Insolvency Act, 1986, or the Seller reasonably apprehends that any of the events mentioned above is about to occur in relation to the Buyer and notifies the Buyer accordingly, the Seller may:-
- 10.1.1 stop any Goods in transit and suspend any further deliveries;

and/or

- 10.1.2 suspend work on the Contract; and/or
- 10.1.3 determine the Contract forthwith and if the Goods or Services, or any part of them have been delivered but not paid for, the price shall become immediately due and payable notwithstanding any previous agreement to the contrary but without prejudice to the Seller's right to any unpaid price for Goods or Services delivered under the Contract and to damages for loss (both direct and consequential) suffered in consequence of such determination
- 10.2 If the Buyer requires cancellation of the Contract this will only be accepted at the sole discretion of the Seller and unless otherwise agreed in writing only upon condition that any costs, charges or expenses (both direct and consequential) incurred by the Seller up to the date of cancellation and the value of all loss or damage (both direct and consequential) incurred by the Seller by reason of such cancellation will be reimbursed by the Buyer to the Seller forthwith. Acceptance by the Seller of any cancellation by the Buyer will only be binding upon the Seller if it is made in writing
- 10.3 In the event of the Seller other than in any of the circumstances set out in Condition 10.1 being prevented or hindered from completing the Contract either wholly or in part in accordance with the terms thereof for any reason whatsoever beyond its reasonable control which, for the avoidance of doubt and without prejudice to the generality of the foregoing, shall include governmental action, war, riot, civil commotion, fire, flood, epidemic, labour disputes (including labour disputes involving the work force or any part thereof of the Seller or Supplier), restraints or delays affecting shipping or carriers, licensing, exporting or importing restrictions, currency restrictions and Acts of God then further performance of the Contract shall be suspended for the period during which the Seller is so prevented provided that in the event of the Contract being suspended for a continuous period of more than 3 months then either party may give the other notice in writing to terminate the Contract forthwith and in such circumstances the Buyer shall pay for all Goods or Services supplied to the date of such termination such payment to be made on or before the last day following the month during which termination was effected. The Seller shall be under no liability whatsoever to the Buyer for any direct or consequential loss or damage suffered by the Buyer as a result of the Seller's inability to perform its obligations under the Contract in these circumstances
- 10.4 The Seller's rights contained in Condition 17 (but not the Buyer's rights) shall continue beyond the discharge of the parties' primary obligations under the Contract consequent upon its termination
- 10.5 The termination of the Contract for whatever reason will be without prejudice to the rights and duties of either party accrued prior to termination

11 INSPECTION AND CLAIMS FOR DEFECTS

- 11.1 The Goods are of a highly specialised nature and must be treated with the utmost care. It is essential that the Buyer checks that they correspond in all respects with the Buyer's requirements. Any discrepancies should be notified to the Seller immediately. The Buyer undertakes to ensure that all Goods are unpacked and handled only by persons qualified to deal with such specialised products, to safeguard against injury to the Goods or to the Buyer's personnel
- 11.2 The Buyer shall inspect the Goods and carry out tests to ensure the Goods conform with the description of the Goods or Services in the Buyer's orders within 7 days of Delivery and whether or not the Buyer carries out such obligation to inspect and test no claims for non-delivery, shortages in quantity of units delivered, defective Goods or Services, non-conformity to description or partial loss or damage to Goods will be accepted by the Seller unless:-
- 11.2.1 they are notified in writing by the Buyer to the Seller within 10 days after the Date of Delivery (in the case of partial loss, damage, non-conforming or defective Goods or Services) or 14 days after the date of the invoice (in the case of non-delivery);
- 11.2.2 the Goods in respect of which a claim is made together with all the relevant packing are preserved intact as received for a period of 35 days from notification of any such claim and the Buyer permits the Seller or its servants or agents full and free right of access to inspect the Goods and investigate the claim; and
- 11.2.3 if the Buyer fails to give the appropriate notice as specified in Condition 11.2.1, the Buyer's claim will be deemed to have been waived and will be absolutely barred
- 11.3 It is in all cases the responsibility of the Buyer to ensure by testing or otherwise that the Goods are fit and suitable for the purposes for which the Buyer requires them in the conditions in which they will be used. The Buyer acknowledges that the Seller shall be under no liability of any description to the Buyer if the Goods prove to be unsuitable for whatever reason for application or use notwithstanding that the Seller may, at the request of the Buyer, have given in good faith technical or other advice in relation to the proposed application or use of the Goods and the Buyer shall indemnify and keep indemnified the Seller in full against any and all liability of any kind arising out of or connected with the application or use of the Goods
- 11.4 Section 3 Sale and Supply of Goods Act 1994 shall not apply
- 11.5 The Seller will not accept the return of Goods in any circumstances unless it has first issued a Goods return number and such number is quoted with the returned Goods

12 WARRANTY

- 12.1 In substitution for all and any other rights which the Buyer might or would have had but for these Conditions and subject to Condition 11,

Conditions of Sale

the Seller shall make good by replacement any failure in the Goods or Services which results from defects in the Seller's materials or workmanship and which appear not later than 2 months after the Date of Delivery and shall replace any Goods or Services which do not conform with the description in the Buyer's order

- 12.2 Notwithstanding the provisions of Condition 12.1, in the case of a claim falling within Condition 12.1, the Seller reserves the right at its sole discretion to credit the Buyer in full the price paid by the Buyer to the Seller
- 12.3 The Seller's liability under this Condition shall automatically cease if:
- 12.3.1 the Buyer has not paid for all Goods or Services supplied under any Contract by the due date or is otherwise in breach of this or any other Contract made with the Seller; or
- 12.3.2 the Seller or its servants or agents are denied full and free right of access to the allegedly defective Goods; or
- 12.3.3 the Buyer has not properly maintained the Goods or has not complied with any Recommendations for Use; or
- 12.3.4 the defect or failure is caused by a breach by the Buyer of its undertakings and warranties contained in Condition 17; or
- 12.3.5 the Buyer has failed to notify the Seller in writing of any defect or suspected defect within 14 days of the same coming to the knowledge of the Buyer
- 12.4 The warranty set out in Condition 12.1 shall be in lieu of any warranties conditions or undertakings whether express or implied by statute, common law or otherwise howsoever which warranties, conditions and undertakings are hereby expressly excluded, except that such exclusions will not apply to any implied condition that the Seller has or will have the right to sell the Goods when the property is to pass
- 12.5 Nothing in these Conditions excludes or limits the liability of the Seller for death or personal injury caused by the Seller's negligence or fraudulent misrepresentation
- 12.6 SUBJECT TO CONDITIONS 12.4 AND 12.5
- 12.6.1 the seller's total liability in contract, tort (including negligence or breach of statutory duty), misrepresentation or otherwise, arising in connection with the performance or contemplated performance of the contract shall be limited to the price paid for the goods or services under the contract; and
- 12.6.2 the seller shall not be liable to the buyer for any indirect or consequential loss or damage (whether for loss of profit, loss of business, depletion of goodwill or otherwise), costs, expenses or other claims for consequential compensation whatsoever (however caused) which arise out of or in connection with the contract

13 CONSUMER SALES

- 13.1 Where the Goods are sold under a consumer sale (as defined by the Sale of Goods Act 1979) the statutory rights of the Buyer are not affected by these conditions

14 TITLE TO GOODS

- 14.1 Full legal and beneficial ownership of the Goods shall be retained by the Seller notwithstanding that the risk in the same shall pass to the Buyer at the time of delivery until the Seller has received payment in full in respect of
- 14.1.1 The Goods; and
- 14.1.2 All other sums which become due and owing by the Buyer to the Seller on any account whatsoever
- 14.2 Until ownership of the Goods has passed to the Buyer the Buyer shall hold the Goods in a fiduciary capacity and as bailee of the Seller and shall at all times take proper care of the same and will not obliterate or obscure any identifying mark or their packaging and will keep the Goods separate from any other goods and in such manner that they may be clearly identified as belonging to the Seller and the Buyer hereby grants to the Seller the right to enter on the Buyer's premises at any time during the continuation of the Contract to check that the Buyer is complying with the obligation contained in this Condition. The Buyer will return the Goods to the Seller if it receives a request whether verbally or in Writing so to do prior to payment in full as aforesaid having been made and the Seller will then repay any part of the purchase price it has already received in respect of the Goods less a reasonable amount in respect of its costs and expenses in connection with the Contract
- 14.3 For the purposes of Condition 14.1, the expression "the Buyer" includes any subsidiary or holding company or associate of the Buyer (as such terms are defined in the Companies Act 1985 (as amended))
- 14.4 The Seller will have the right to maintain an action against the Buyer for the price of the Goods notwithstanding that property in the Goods has not been passed

15 RISK AND INSURANCE

- 15.1 The risk in the Goods shall pass to the Buyer at the time of delivery as provided for in Condition 7
- 15.2 Notwithstanding the reservation of title contained in Condition 14, the Buyer shall insure the Goods and/or any products made wholly or partly therefrom for the full amount of the price payable under the Contract with an insurance office of repute from the time of delivery of the Goods until the date title in the Goods passes to the Buyer pursuant to Condition 14.1

16 EXPORT TERMS

- 16.1 In these Conditions "Incoterms" means the international rules for the interpretation of trade terms of the International Chamber of Commerce

as in force at the date when the Contract is made. Unless the context otherwise requires, any term or expression which is defined in or given a particular meaning by the provisions of Incoterms has the same meaning in the Contract

- 16.2 Where the Goods are supplied for export from the United Kingdom then unless otherwise agreed in writing between the Buyer and the Seller

- 16.2.1 the provisions of Incoterms shall (subject to any special terms agreed in writing between the Buyer and the Seller) apply but if there is any conflict between the provisions of Incoterms and these Conditions, the latter shall prevail.
- 16.2.2 the Buyer shall be responsible for complying with any legislation or regulations governing the importation of the Goods into the country of destination and (save in respect of the United States of America, Canada and Japan) for the payment of any duties and taxes thereon unless payment for these is included in the Contract
- 16.2.3 the Buyer shall be deemed to have satisfied itself that such Goods comply with the safety regulations of any country or state in which the Goods are to be used outside the United Kingdom and the Buyer shall indemnify and keep indemnified the Seller in full for any loss or damage whatsoever which the Seller may incur if such Goods do not comply with such safety regulations

- 16.3 The Goods shall not be used in any country other than that for which the Seller was aware they were originally ordered without the Seller's consent in writing

- 16.4 The Buyer undertakes not to offer the Goods for resale in any country notified by the Seller at or before the time the Buyer's order is placed, or to sell the Goods to any person if the Buyer knows or has reason to believe that person intends to resell the Goods in any such country

17 BUYER'S WARRANTIES

- 17.1 The Buyer warrants to the Seller that:
- 17.1.1 the Buyer will install, operate or otherwise use or store the Goods strictly in accordance with the Recommendations for Use and with all relevant or applicable statutory or other regulations governing the installation, operation, use or storage of the Goods; and
- 17.1.2 any collection vehicle, container, ship or other means of transport provided by the Buyer or any agent of the Buyer will comply with all relevant legislation and regulations relating to health and safety requirements; and
- 17.1.3 the storage and transport facilities and all parts thereof and all equipment used in connection therewith is suitable for storage (both short term and long term) and transport of the Goods and complies with any statute, regulation, bye law or other rule having the force of law and relating to the storage of goods of the nature of the Goods; and
- 17.1.4 the Buyer will ensure that the Goods are stored in conditions appropriate to goods of that nature and will comply with any recommendations as to the storage of Goods notified to it by the Seller from time to time; and
- 17.2 The Buyer shall indemnify and keep indemnified the Seller in full against any claim, loss or damage (including, without limitation, damage to the reputation of the Seller) arising directly or indirectly from any breach of the warranty contained in Condition 17.1

18 SEVERANCE

- 18.1 If at any time any one or more of the provisions or part thereof of these Conditions becomes or is invalid, illegal or unenforceable in any respect under any law or is held by a court to be invalid, illegal or unenforceable, the validity and enforceability of the remaining provisions hereof and the remainder of such provision shall not in any way be affected or impaired thereby

19 JURISDICTION

- 19.1 These Conditions and each and every Contract made pursuant to them shall be governed by and construed in all respects in accordance with the laws of England and the Seller and the Buyer hereby agree to submit to the non-exclusive jurisdiction of the English Courts

20 NOTICES

- 20.1 Any notice required or permitted to be given by either party to the other under these Conditions shall be in writing addressed to that other party at its registered office or principal place of business or such other address as may at the relevant time have been notified pursuant to this provision to the party giving notice
- 20.2 Any notice given pursuant to clause 20.1 shall be deemed to have been served:
- 20.2.1 if delivered by hand, on the first Business Day following delivery;
- 20.2.2 if sent by post, on the third Business Day after posting if the address of the recipient is in the country of despatch, otherwise on the seventh Business Day after posting;
- 20.2.3 if sent by facsimile transmission, on the first Business Day following successful transmission
- 20.3 In proving service it shall be sufficient proof in the case of a notice sent by post, that the envelope containing the same was properly stamped, addressed and placed in the post and, in the case of facsimile transmission, that it was properly addressed and successfully transmitted
- 20.4 In this Condition 20, "Business Day" shall mean any day other than Saturday, Sunday or any other day which is a public holiday in the place at which the notice is left or to which such notice is despatched

21 WAIVER

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21.1 No waiver by the Seller of any breach of any provision of the Contract by the Buyer shall be considered as a waiver of any subsequent breach

of the same or any other provision and the Seller shall not be prejudiced by any forbearance or indulgence granted by it to the Buyer

Boron

B

Discovered in 1808 by L.J. Lussac and L.J. Thenard (in Paris) and Sir Humphrey Davy (in London).

Boron is a non-metallic element which occurs in several allotropes. It is rarely found in nature, normally occurring as borates or orthoboric acid (the abundance of boron in the earth's crust is 10 ppm, the principal ore being borax, $\text{Na}_2\text{B}_4\text{O}_7 \cdot x\text{H}_2\text{O}$). Amorphous boron is the more common allotrope and exists as a dark powder which is unreactive towards water, oxygen, acids and alkalis. Boron finds importance within nuclear reactors due to its neutron absorbing capabilities, boron steel being used as control rod material. Boron compounds are used for a number of applications including the manufacture of certain grades of glass and detergents.

Boron will react directly with most metals to produce metal borides which are hard, inert binary compounds of various formulae and arrangements of the boron atoms. For example, as single atoms (M_2B), pairs (M_3B_2), single and double chains (MB , M_3B_4), sheets (MB_2), B_6 octahedra (MB_6) and B_{12} clusters (MB_{12}). Boron also forms the binary compound, boron nitride, which is of interest as it is isoelectronic with carbon and occurs in two structural modifications; one is a layer structure similar to graphite which is soft and lubricating, whilst the other (formed under high pressure) has a very hard, stable, tetrahedral structure as found in diamond.

Atomic Properties

Atomic number	5
Atomic radius - Goldschmidt	0.097 nm
Atomic weight	10.81 amu
Crystal structure	Tetragonal
Electronic structure	He $2s^2 2p^1$
Photo-electric work function	4.5 eV
Thermal neutron absorption cross-section	672 Barns
Valences shown	3

Natural isotope distribution	Mass No.	%
	10	19.8
	11	80.2
Ionisation potential	No.	eV
	1	8.30
	2	25.2
	3	37.9
	4	259
	5	340

Physical Properties

Boiling point	3700 C
Density @20C	2.34-2.37 g cm ⁻³
Melting point	2180 C

Electrical Properties

Electrical resistivity @27C	1.8x10 ¹² μOhmcm
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Thermal Properties

Coefficient of thermal expansion @0-100C	8.3 x10 ⁻⁶ K ⁻¹
Latent heat of evaporation	35000 J g ⁻¹
Latent heat of fusion	2090 J g ⁻¹
Specific heat @25C	1030 J K ⁻¹ kg ⁻¹

Mechanical Properties

Material condition	Arc melted
Hardness - Mohs	9.5
Tensile modulus	441 GPa
Tensile strength	1580-2410 MPa



Monofilament

B 005908 Diameter 0.080mm

Length

Web Code
533-039-030
493-372-314
536-531-589
667-747-522
124-341-509
988-318-186

Quantity	
Length	1 Reel
5 m	YEN 14900
10 m	YEN 16900
20 m	YEN 20400
50 m	YEN 29600
100 m	YEN 44200
200 m	YEN 76500

Supplied on a nominal 5 micron diameter Tungsten core.

B 005910 Diameter 0.1mm

Length

Web Code
988-350-696
543-828-886
978-612-471
326-553-151
819-148-341
393-540-486

Quantity	
Length	1 Reel
5 m	YEN 14300
10 m	YEN 16000
20 m	YEN 19200
50 m	YEN 27800
100 m	YEN 41200
200 m	YEN 67500

Continuous single filament with zero twist. Supplied on a nominal 5 micron diameter Tungsten core.

B 005915 Diameter 0.2mm

Length

Web Code
403-381-327
746-870-803
041-445-863
703-758-334

Quantity	
Length	1 Reel
5 m	YEN 20400
10 m	YEN 24600
20 m	YEN 35800
50 m	YEN 71500

Continuous single filament with zero twist. Supplied on a nominal 5 micron diameter Tungsten core.

Quartz - Fused



Silicon dioxide occurs naturally as sand or rock and when melted, the resulting product is called Fused Quartz. If the silicon dioxide is synthetically derived, the material is often called Fused Silica. Fused Quartz is very pure, has a high chemical resistance, good thermal shock resistance and is very strong in compression. The low thermal expansion coefficient makes it ideal for mirrors and optical flats. It is used for viewing windows, being transparent to wavelengths from around 0.2 to 3.5µm, insulators for electronic applications and for semi-conductor manufacturing.

Physical Properties

Apparent porosity	0 %
Density	2.2 g cm ⁻³
Refractive index	1.46
Useful optical transmission range	180-2500nm
Water absorption - saturation	0 %

Electrical Properties

Dielectric constant	3.8
Dielectric strength	25-40 kV mm ⁻¹
Volume resistivity @25C	10 ¹⁸ Ohmcm

Thermal Properties

Coefficient of thermal expansion @20-1000C	0.54 x10 ⁻⁶ K ⁻¹
Melting point	1715 C
Specific heat @25C	670-740 J K ⁻¹ kg ⁻¹
Thermal conductivity @20C	1.46 W m ⁻¹ K ⁻¹
Upper continuous use temperature	1100-1400 C

Mechanical Properties

Compressive strength	1100 MPa
Hardness - Knoop	820 kgf mm ⁻²
Hardness - Vickers	1000 kgf mm ⁻²
Shear strength	70 MPa
Tensile modulus	72-74 GPa
Tensile strength	48 MPa

Chemical Resistance

Acids - concentrated	Good
Acids - dilute	Good
Alkalies	Fair
Halogens	Good
Metals	Fair



Monofilament

SI615910

Diameter..... 0.1mm

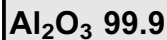
Size

Web Code

Length

	Quantity		
	1pc	2pcs	10pcs
			5pcs
			10pcs
			5pcs
			10pcs
			5pcs
			10pcs

Sapphire



This is synthetically produced Sapphire. Single crystal Sapphire has a high thermal conductivity, volume resistivity, hardness and wear resistance, as well as a high upper use temperature. The energy band gap is large (10eV). Sapphire is a transparent material having useful transmission of wavelengths in the range 0.2 to 5.5 microns. It is much stronger than glass and can be used as viewing windows in high pressure and vacuum applications.

Physical Properties

Apparent porosity	0 %
Density	3.985 g cm ⁻³
Refractive index	1.71-1.79
Useful optical transmission range	200-5500nm
Water absorption - saturation	0 %

Electrical Properties

Dielectric constant	7.5-11.5
Dielectric strength	15-50 kV mm ⁻¹
Volume resistivity @25C	> 10 ¹⁴ Ohmcm

Thermal Properties

Coefficient of thermal expansion @20-1000C	5.8 x10 ⁻⁶ K ⁻¹
Melting point	2050 C
Specific heat @25C	750 J K ⁻¹ kg ⁻¹
Thermal conductivity @20C	35-40 W m ⁻¹ K ⁻¹
Upper continuous use temperature	1800-1950 C

Mechanical Properties

Compressive strength	2100 MPa
Hardness - Knoop	2000 kgf mm ⁻²
Hardness - Vickers	1600-1800 kgf mm ⁻²
Tensile modulus	350-390 GPa
Tensile strength	250-400 MPa

Chemical Resistance

Acids - concentrated	Good
Acids - dilute	Good
Alkalies	Good
Halogens	Good
Metals	Good



Monofilament

Filament diameter		0.11mm
Density	g cm ⁻³	3.97
Melting point	C	2050
Orientation		< 0001 >
Tensile modulus	GPa	410
Tensile strength	GPa	2.1-3.4

AL665905

Diameter..... 0.075mm

Grade..... Structural

Length

Web Code

032-773-573
 585-163-088
 841-497-694
 705-519-966

	Quantity	
	Length	1 Reel
	0.2 m	YEN 27400
	0.5 m	YEN 38000
	1 m	YEN 50500
	2 m	YEN 78000

Sapphire

Al₂O₃ 99.9



Monofilament

AL665920

Diameter 0.125mm

Grade Structural

Length

Web Code
 484-911-415
 750-159-411
 878-730-819
 895-774-553

Quantity	
Length	1 Reel
0.2 m	YEN 25200
0.5 m	YEN 34400
1 m	YEN 45400
2 m	YEN 62000

AL665922

Diameter 0.165mm

Grade Structural

Length

Web Code
 593-693-279
 164-707-385
 482-214-906
 393-943-451

Quantity	
Length	1 Reel
0.2 m	YEN 25400
0.5 m	YEN 34800
1 m	YEN 46000
2 m	YEN 64000

AL665925

Diameter 0.185mm

Grade Structural

Length

Web Code
 632-019-567
 630-482-580
 776-267-500
 477-356-356

Quantity	
Length	1 Reel
0.2 m	YEN 25600
0.5 m	YEN 35200
1 m	YEN 46600
2 m	YEN 65500

AL665927

Diameter 0.215mm

Grade Structural

Length

Web Code
 897-221-326
 322-951-025
 305-716-804
 387-930-442

Quantity	
Length	1 Reel
0.2 m	YEN 26000
0.5 m	YEN 35600
1 m	YEN 47200
2 m	YEN 67500

AL665930

Diameter 0.25mm

Grade Structural

Length

Web Code
 927-103-464
 378-669-876
 073-635-932
 687-259-521

Quantity	
Length	1 Reel
0.2 m	YEN 26200
0.5 m	YEN 36000
1 m	YEN 47800
2 m	YEN 69000

Silicon Carbide

SiC

Common Brand Names : Nicalon

Silicon Carbide was first prepared in the early 1800's. It was in commercial production by 1892, as a powder for grinding and cutting, having a Mohs hardness of 9-10 (almost as hard as Diamond).

Nicalon continuous multi-filament tow consists of fine filaments of ultra-fine β-SiC crystals, giving strong particle bonding. This fibre has high strength and a high modulus in a high temperature atmosphere. It is oxidation resistant, with a high wettability and is consequently used in composites with metals, plastics and ceramics.

A thicker monofilament, also used for composites, is also available from Goodfellow in 3 versions which differ only in their outer coating (used to improve adhesion to, and resist degradation by, the matrix of a composite). This monofilament is made by a chemical vapour deposition (CVD) process around a fine tungsten wire.

Physical Properties

Density 3.2 g cm⁻³

Thermal Properties

Melting point 2650-2950 C

Mechanical Properties

Hardness - Vickers 2500 kgf mm⁻²

Ceramic – Sapphire

Silicon Carbide

SiC



Monofilament

Filament diameter		0.1mm
Density	g cm ⁻³	3.4
Tensile modulus	GPa	400
Tensile strength	GPa	3.5-3.75

SI675920 Diameter 0.1mm Core Tungsten 0.01mm diameter



Xi

Length

Web Code
 626-808-220
 351-026-304
 878-296-774
 787-093-487
 386-678-208

Quantity

Length	1 Reel
1 m	YEN 20400
2 m	YEN 25400
5 m	YEN 36000
10 m	YEN 57000
20 m	YEN 99500

Coated with 0.001mm of pyrolytic carbon to improve adhesion to aluminium- alloys, glasses and glass ceramics.

SI675930 Diameter 0.1mm Core Tungsten 0.01mm diameter



Xi

Length

Web Code
 038-974-905
 871-874-493
 984-308-354
 038-545-495

Quantity

Length	1 Reel
1 m	YEN 20400
2 m	YEN 25400
5 m	YEN 36000
10 m	YEN 57000

Coated with 0.001mm pyrolytic Carbon and 0.001mm of Titanium Diboride to resist degradation by, and improve adhesion to, Titanium alloys.

Ceramic – Silicon Carbide

Fluorinated Ethylene Propylene Copolymer

FEP

Common Brand Names : Hostaflon FEP

Physical Properties

Density	2.15 g cm ⁻³
Flammability	V0
Limiting oxygen index	95 %
Radiation resistance	Poor
Refractive index	1.344
Resistance to Ultra-violet	Excellent
Water absorption	0.01 %

Electrical Properties

Dielectric constant @1MHz	2.1
Dielectric strength	20 @ 3.2mm kV mm ⁻¹
Dissipation factor @ 1MHz	0.0007
Surface resistivity	10 ¹⁶ Ohm/sq
Volume resistivity	10 ¹⁸ Ohmcm

Thermal Properties

Coefficient of thermal expansion	83 - 104 x10 ⁻⁶ K ⁻¹
Heat-deflection temperature - 0.45MPa	50 C
Heat-deflection temperature - 1.8MPa	70 C
Lower working temperature	-250 C
Specific heat	1100 J K ⁻¹ kg ⁻¹
Thermal conductivity @23C	0.19 - 0.24 W m ⁻¹ K ⁻¹
Upper working temperature	150 - 200 C

Mechanical Properties

Coefficient of friction	0.27-0.67
Elongation at break	150-300 %
Hardness - Rockwell	R25-45, 60 Shore D
Izod impact strength	No break J m ⁻¹
Poisson's ratio	0.48
Tensile modulus	0.5 - 0.6 GPa
Tensile strength	14 - 30 MPa

Chemical Resistance

Acids - concentrated	Good
Acids - dilute	Good
Alcohols	Good
Alkalis	Good
Aromatic hydrocarbons	Good
Greases and Oils	Good
Halogenated Hydrocarbons	Good
Halogens	Good
Ketones	Good



Monofilament

FP345925 Diameter **0.28mm**



Length
Web Code
 341-863-270
 732-904-277
 613-028-443
 628-556-685

Quantity

Length	1 Reel
10 m	YEN 11600
50 m	YEN 14200
100 m	YEN 16800
200 m	YEN 21400

FP345971 Diameter **0.71mm**

Tolerance +/-0.05 mm



Colour **Natural**
Length
Web Code
 940-363-834

Quantity

Length	1 Reel
10 m	YEN 20000

Polymer – Fluorinated Ethylene Propylene Copolymer

Polyamide - Nylon 6

PA 6

Common Brand Names : Akulon K and F, Capron, Maranyl B, Nylacast, Orgamid, Ultramid B

See also General Information under Nylon 6,6.

General Description : A semi-crystalline, white engineering thermoplastic very similar to nylon 6,6 with which it is in many respects interchangeable. Its melt viscosity is not quite as low as 6,6 so it is generally slightly easier to process and often preferred for moulding. Relative to 6,6 it has somewhat higher impact strength but somewhat lower strength and stiffness and higher water absorption (the highest of all nylons).

It can be monomer cast, commonly called just cast - ie. polymerised in a mould direct to a semi-fabricated shape. This allows the production of thick sections without voiding and gives a product with a slightly different balance of properties - a little stronger and stiffer, slightly reduced extensibility and impact strength.

Its applications are similar to those of nylon 6,6.

Physical Properties

Density	1.13 g cm ⁻³
Flammability	HB
Limiting oxygen index	25 %
Radiation resistance	Fair
Refractive index	1.53
Resistance to Ultra-violet	Poor
Water absorption - equilibrium	> 8 %
Water absorption - over 24 hours	2.7 %

Electrical Properties

Dielectric constant @1MHz	3.6
Dielectric strength	25 kV mm ⁻¹
Dissipation factor @ 1kHz	0.2
Surface resistivity	5x10 ¹⁰ Ohm/sq
Volume resistivity	5x10 ¹² Ohmcm

Thermal Properties

Coefficient of thermal expansion	95 x10 ⁻⁶ K ⁻¹
Heat-deflection temperature - 0.45MPa	200 C
Heat-deflection temperature - 1.8MPa	80 C
Lower working temperature	-40 C
Specific heat	1700 J K ⁻¹ kg ⁻¹
Thermal conductivity @23C	0.24-0.28 W m ⁻¹ K ⁻¹
Upper working temperature	80-160 C

Mechanical Properties

Abrasive resistance - ASTM D1044	5 mg/1000 cycles
Coefficient of friction	0.2-0.3
Hardness - Rockwell	M82
Izod impact strength	30-250 J m ⁻¹
Poisson's ratio	0.39
Tensile modulus	2.6-3.0 GPa
Tensile strength	78 MPa

Chemical Resistance

Acids - concentrated	Poor
Acids - dilute	Poor
Alcohols	Good
Alkalis	Good-Fair
Aromatic hydrocarbons	Good
Greases and Oils	Good
Halogenated Hydrocarbons	Good-Poor
Halogens	Poor
Ketones	Good



Monofilament

AM305915	Diameter..... 0.15mm	Condition..... Nylon 6/66 copolymer
Length		Quantity
Web Code		Length 1 Reel
801-062-072		100 m YEN 12900

AM305918	Diameter..... 0.16mm Colour..... Pale grey	Condition..... Nylon 6/66 copolymer
Length		Quantity
Web Code		Length 1 Reel
321-523-738		100 m YEN 13300

AM305925	Diameter..... 0.25mm	Condition..... Nylon 6/66 copolymer
Length		Quantity
Web Code		Length 1 Reel
173-864-327		100 m YEN 13300
733-042-989		200 m YEN 16200
630-373-466		500 m YEN 19100
796-675-333		1000 m YEN 23200

AM305938	Diameter..... 0.35mm	Condition..... Nylon 6/66 copolymer
Length		Quantity
Web Code		Length 1 Reel
979-036-937		50 m YEN 11600
545-438-768		100 m YEN 13700
135-502-407		200 m YEN 17400
357-061-571		500 m YEN 20800
709-332-268		1000 m YEN 26600

AM305950	Diameter..... 0.5mm	Condition..... Nylon 6/66 copolymer
Length		Quantity
Web Code		Length 1 Reel
584-418-559		50 m YEN 11800
052-323-059		100 m YEN 14000
580-005-080		200 m YEN 17900
540-387-073		500 m YEN 21400
548-386-154		1000 m YEN 29200

Polymer - Polyamide - Nylon 6

Polyamide - Nylon 6

PA 6



Monofilament

AM305970 Diameter 0.7mm Condition Nylon 6/66 copolymer

Length
Web Code
 839-476-630

Quantity	
Length	1 Reel
50 m	YEN 12600

AM305990 Diameter 1.0mm Condition Nylon 6/66 copolymer

Length
Web Code
 533-606-146

Quantity	
Length	1 Reel
50 m	YEN 12900

AM305992 Diameter 1.2mm Condition Nylon 6/66 copolymer

Length
Web Code
 588-403-194

Quantity	
Length	1 Reel
50 m	YEN 11900

AM305994 Diameter 1.4mm Condition Nylon 6/66 copolymer

Length
Web Code
 383-090-815

Quantity	
Length	1 Reel
50 m	YEN 14700

Polybutylene terephthalate

PBT

Common Brand Names : Celanex, Orgater, Valox

General Description : A semi-crystalline, white or off-white polyester, similar in both composition and properties to polyethyleneterephthalate (PET). It has somewhat lower strength and stiffness than PET, is a little softer but has higher impact strength and very similar chemical resistance. As it crystallises more rapidly than PET, it tends to be preferred for industrial scale moulding.

Applications include electrical and automotive components (including "under-bonnet") and power tool casings.

Physical Properties

Density	1.31 g cm ⁻³
Flammability	HB
Limiting oxygen index	25 %
Radiation resistance	Good
Resistance to Ultra-violet	Fair?
Water absorption - over 24 hours	0.1 %

Electrical Properties

Dielectric constant @1kHz	3.2
Dielectric strength	20 kV mm ⁻¹
Dissipation factor @ 1kHz	0.002
Volume resistivity	10 ¹⁵ Ohmcm

Thermal Properties

Heat-deflection temperature - 0.45MPa	150 C
Heat-deflection temperature - 1.8MPa	60 C
Specific heat	1200-2300 J K ⁻¹ kg ⁻¹
Upper working temperature	120-? C

Mechanical Properties

Elongation at break	250 %
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Hardness - Rockwell	M70
Izod impact strength	60 J m ⁻¹
Tensile modulus	2 GPa
Tensile strength	50 MPa

Chemical Resistance

Acids - concentrated	Good-Poor
Acids - dilute	Good
Alcohols	Good
Alkalis	Fair
Aromatic hydrocarbons	Good
Greases and Oils	Good
Halogenated Hydrocarbons	Good-Poor
Halogens	Poor
Ketones	Good-Poor

Polybutylene terephthalate

PBT



Monofilament

Density	g cm ⁻³	1.31
Extension to break	%	26
Shrinkage @100C	%	3
Tensile strength	GPa	0.5

ES345910 Diameter 0.18mm

Length	Quantity
Web Code	1 Reel
808-285-012	10 m YEN 14300
035-627-584	20 m YEN 18100
453-449-987	50 m YEN 29200
681-238-868	100 m YEN 31800
154-851-043	200 m YEN 36400
356-382-524	500 m YEN 49000
547-820-733	1000 m YEN 69000

ES345930 Diameter 0.8mm

Length	Quantity
Web Code	1 Reel
477-592-601	10 m YEN 17700
699-081-251	20 m YEN 23000
385-152-267	50 m YEN 37000
144-036-750	100 m YEN 42800
004-594-027	200 m YEN 52000

Polyetheretherketone

PEEK

Common Brand Names : Victrex PEEK, Zyx, Vestakeep

General Description : A high performance thermoplastic with the characteristics common to this group - strong, stiff, hard, high temperature resistance, good chemical resistance and inherently low flammability and smoke emission. PEEK is amber in colour and usually semi-crystalline and opaque, except thin films are usually amorphous and transparent. It also has very good resistance to wear, dynamic fatigue and radiation, but it is difficult to process and very expensive. Filled grades, including ones designed for bearing-type applications are also available as special order items.

Applications include flexible PCBs (film), fibres and monofilaments, injection moulded engineering components and items used in aerospace and radiation environments.

Physical Properties		Elongation at break	50 %
Density	1.26 - 1.32 g cm ⁻³	Hardness - Rockwell	M99
Flammability	V-0 @ 1.5mm	Izod impact strength	85 J m ⁻¹
Limiting oxygen index	35 %	Poisson's ratio	0.4
Radiation resistance	Good	Tensile modulus	3.7-4.0 GPa
Resistance to Ultra-violet	Fair	Tensile strength	70-100 MPa
Water absorption - equilibrium	0.5 %		
Water absorption - over 24 hours	0.1-0.3 %	Chemical Resistance	
Electrical Properties		Acids - concentrated	Good-Poor
Dielectric constant @1kHz	3.2-3.3 @ 50Hz-10KHz	Acids - dilute	Good
Dielectric strength	190 @ 50µm kV mm ⁻¹	Alcohols	Good
Dissipation factor @ 1MHz	0.003	Alkalis	Good
Volume resistivity	10 ¹⁵ -10 ¹⁶ Ohmcm	Aromatic hydrocarbons	Good
Thermal Properties		Greases and Oils	Good
Coefficient of thermal expansion	47/108 x10 ⁻⁶ K ⁻¹	Halogenated Hydrocarbons	Good
Heat-deflection temperature - 0.45MPa	> 260 C	Halogens	Good-Poor
Heat-deflection temperature - 1.8MPa	160 C	Ketones	Good-Poor
Specific heat	1340 J K ⁻¹ kg ⁻¹		
Thermal conductivity @23C	0.25 W m ⁻¹ K ⁻¹		
Upper working temperature	250 C		
Mechanical Properties			
Coefficient of friction	0.18		

Polymer – Polybutylene terephthalate

Polyetheretherketone

PEEK



Monofilament

Material		Type A	Type B	Type C
Density	g cm ⁻³	1.30	1.30	1.30
Extension to break	%	38	35	20
Modulus - 10 %	GPa	1.85	2.8	3.4
Modulus - 2 %	cN/Tex	382	438	474
Modulus - 5 %	GPa	2.7	3.7	3.9
Shrinkage @180C	%	1.8	8.4	3.0
Tenacity	cN/Tex	34	30	60
Tenacity - Knot	cN/Tex	28	23	34
Tenacity - Loop	cN/Tex	25	19	17
Tensile strength	GPa	0.44	0.39	0.78

EK305915 Diameter 0.15mm Condition Type C, pigmented

Length	Quantity
Web Code	1 Reel
976-792-441	1 m YEN 14800
099-057-113	2 m YEN 16900
382-148-283	5 m YEN 22800
768-527-507	10 m YEN 32200
065-941-948	20 m YEN 50500

EK305920 Diameter 0.2mm Condition Type A

Length	Quantity
Web Code	1 Reel
242-740-212	1 m YEN 14800
342-530-527	2 m YEN 16800
816-320-993	5 m YEN 22600
040-114-773	10 m YEN 32000
014-344-406	20 m YEN 50500

EK305945 Diameter 0.45mm Condition Type C, additive free

Length	Quantity
Web Code	1 Reel
793-056-551	1 m YEN 15500
132-064-061	2 m YEN 17900
508-011-051	5 m YEN 24200
501-380-291	10 m YEN 34400
672-533-063	20 m YEN 53500

EK305990 Diameter 0.9mm Condition Type A

Length	Quantity
Web Code	1 Reel
066-634-270	1 m YEN 17100
329-286-111	2 m YEN 20000
160-772-365	5 m YEN 27800
096-538-015	10 m YEN 39200
067-256-950	20 m YEN 60500

EK305995 Diameter 1.2mm Condition Type B

Length	Quantity
Web Code	1 Reel
407-114-968	1 m YEN 17400
889-366-779	2 m YEN 20400
170-844-820	5 m YEN 28400
355-611-567	10 m YEN 40000
451-440-088	20 m YEN 61500

Polymer – Polyetheretherketone

Polyethylene terephthalate

Polyester, PET, PETP

Common Brand Names : Arnite, Dacron, Hostaphan, Impet, Melinar, Melinex, Mylar, Rynite, Terylene, Trevira

General Description: The most common thermoplastic polyester, this polymer is often called just "polyester". This often causes confusion - not only is the chemically similar PBT also a (thermoplastic) polyester, the most common resin system used in GRP is also a polyester system - and also often called just "polyester". (In this latter case, however, the polyesters are chemically unsaturated and are "free-radical polymerised" into a thermoset).

PET is a hard, stiff, strong dimensionally stable material that absorbs very little water. It has good gas barrier properties and good chemical resistance except to alkalis (which hydrolyse it). Its crystallinity varies from amorphous to fairly high crystalline; it can be highly transparent and colourless but thicker sections are usually opaque and off-white.

Applications include bottles and electrical components but it is probably most widely known as the biaxially oriented and thermally stabilised films used for capacitors, graphics, film base and recording tapes etc.

Physical Properties

Density	1.3-1.4 g cm ⁻³
Flammability	HB
Limiting oxygen index	21 %
Radiation resistance	Good
Refractive index	1.58-1.64
Resistance to Ultra-violet	Fair?
Water absorption - equilibrium	<0.7 %
Water absorption - over 24 hours	0.1 %

Electrical Properties

Dielectric constant @1MHz	3.0
Dielectric strength	17 kV mm ⁻¹
Dissipation factor @ 1kHz	0.002
Surface resistivity	10 ¹³ Ohm/sq
Volume resistivity	> 10 ¹⁴ Ohmcm

Thermal Properties

Coefficient of thermal expansion	20-80 x10 ⁻⁶ K ⁻¹
Heat-deflection temperature - 0.45MPa	115 C
Heat-deflection temperature - 1.8MPa	80 C
Lower working temperature	-40 to -60 C
Specific heat	1200 - 1350 J K ⁻¹ kg ⁻¹
Thermal conductivity @23C	0.15-0.4 W m ⁻¹ K ⁻¹
Upper working temperature	115-170 C

Mechanical Properties

Coefficient of friction	0.2-0.4
Hardness - Rockwell	M94-101
Izod impact strength	13-35 J m ⁻¹
Poisson's ratio	0.37-0.44(oriented)
Tensile modulus	2-4 GPa
Tensile strength	80, for biax film 190-260 MPa

Chemical Resistance

Acids - concentrated	Good-Poor
Acids - dilute	Good
Alcohols	Good
Alkalis	Poor
Aromatic hydrocarbons	Good-Fair
Greases and Oils	Good
Halogenated Hydrocarbons	Good-Poor
Halogens	Fair-Poor
Ketones	Good-Fair



Monofilament

ES305910 Diameter 0.1mm

Length

Web Code
573-563-543
695-438-494
929-802-666
225-333-084
166-633-493

Quantity

Length	1 Reel
10 m	YEN 14200
20 m	YEN 18000
50 m	YEN 29000
100 m	YEN 31600
200 m	YEN 36200

ES305920 Diameter 0.2mm

Length

Web Code
451-623-015
997-046-278
497-367-172
571-347-306
361-694-981

Quantity

Length	1 Reel
10 m	YEN 14500
20 m	YEN 18500
50 m	YEN 29800
100 m	YEN 32600
200 m	YEN 37600

ES305940 Diameter 0.4mm

Length

Web Code
277-380-299
383-530-808
364-034-005
767-626-047
647-311-134

Quantity

Length	1 Reel
10 m	YEN 15500
20 m	YEN 19800
50 m	YEN 31800
100 m	YEN 35600
200 m	YEN 41800

ES305950 Diameter 0.5mm

Length

Web Code
641-027-998
958-198-114
960-056-400
951-260-474
104-188-351

Quantity

Length	1 Reel
10 m	YEN 15900
20 m	YEN 20400
50 m	YEN 33000
100 m	YEN 37000
200 m	YEN 43800

ES305980 Diameter 0.8mm

Length

Web Code
454-001-715
677-067-707
120-586-028
951-489-407
153-489-339

Quantity

Length	1 Reel
10 m	YEN 17400
20 m	YEN 22600
50 m	YEN 36400
100 m	YEN 41800
200 m	YEN 50500

Polyethylene terephthalate

Polyester, PET, PETP



Monofilament

ES305990

Diameter 0.9mm

Length

Web Code

878-017-786
 929-521-644
 938-049-140
 215-332-409
 547-971-472

Quantity

Length	1 Reel
10 m	YEN 17800
20 m	YEN 23000
50 m	YEN 37200
100 m	YEN 43000
200 m	YEN 52000

Polymethylmethacrylate

PMMA, Acrylic

Common Brand Names : Diakon, Lucite, Oroglas, Perspex, Plexiglas

General Description : Often just called "acrylic" - though this really describes a large family of chemically related polymers - PMMA is an amorphous, transparent and colourless thermoplastic that is hard and stiff but brittle and notch-sensitive. It has good abrasion and UV resistance and excellent optical clarity but poor low temperature, fatigue and solvent resistances. Though flammable, it has low smoke emission.

General purpose grades can be extruded and injection moulded. Monomer casting (for a description, see Nylon 6) is also used to achieve much higher molecular weights - which are not melt processable because of their extremely high melt viscosity - with somewhat improved properties. The monomer cast items most commonly encountered are sheets and novelty displays in which e.g. insects or watch parts are embedded.

Thin films are normally made from impact modified grades, which incorporate a small proportion of elastomer(s), in order to improve their flexibility.

Applications include sinks, baths, displays, signs, glazing (especially aircraft), lenses and light covers. Cast sheet is also used for guards and the like.

Physical Properties

Abbe number	57.2
Density	1.19 g cm ⁻³
Flammability	HB
Limiting oxygen index	17-20 %
Radiation resistance	Fair
Refractive index	1.49
Resistance to Ultra-violet	Good
Water absorption - over 24 hours	0.2 %

Electrical Properties

Dielectric constant @1MHz	2.6
Dielectric strength	15 kV mm ⁻¹
Dissipation factor @ 1MHz	0.014
Surface resistivity	10 ¹⁴ Ohm/sq
Volume resistivity	2-14 x 10 ¹⁵ Ohmcm

Thermal Properties

Coefficient of thermal expansion	70-77 x10 ⁻⁶ K ⁻¹
Heat-deflection temperature - 0.45MPa	105 C
Heat-deflection temperature - 1.8MPa	95 C
Lower working temperature	-40 C
Specific heat	1400 - 1500 J K ⁻¹ kg ⁻¹
Thermal conductivity @23C	0.17-0.19 W m ⁻¹ K ⁻¹
Upper working temperature	50 to 90 C

Mechanical Properties

Elongation at break	2.5-4 %
Hardness - Rockwell	M92-100
Izod impact strength	16-32 J m ⁻¹
Poisson's ratio	0.35 - 0.4
Tensile modulus	2.4-3.3 GPa
Tensile strength	80 MPa

Chemical Resistance

Acids - concentrated	Good-Poor
Acids - dilute	Good-Poor
Alcohols	Good-Poor
Alkalis	Good
Aromatic hydrocarbons	Poor
Greases and Oils	Good
Halogenated Hydrocarbons	Poor
Halogens	Poor
Ketones	Poor



Monofilament

Material		1.0/2.2
Extension to break	%	< 8
Maximum Use temperature	C	85
Minimum bending radius	mm	90 - > 25
Minimum Use temperature	C	-55
Tensile force	N	> 90

ME305910

Diameter 1.0mm

Condition Optical fibre

Length

Web Code

726-071-361
 758-923-710
 865-474-712
 184-339-642
 042-452-521

Quantity

Length	1 Reel
1 m	YEN 13900
2 m	YEN 15700
5 m	YEN 20000
10 m	YEN 25800
20 m	YEN 33400

Infolite[®] Optical fibre comprising a high purity PMMA core, coated with a fluoropolymer 'skin' approx 0.15mm thick to maximise internal reflection and coated with a protective jacket of polyethylene giving an overall diameter of 2.2mm.

Polymethylpentene

TPX[®]

Common Brand Names : TPX[®]

General Description : A linear isotactic polyolefin more properly called poly 4-methyl pentene-1 which is made by Ziegler-Natta type catalysis (see also General Information under Polyethylene - Low Density). Commercially available grades are copolymers. It is semi-crystalline, transparent and usually colourless (one common grade is slightly yellow), very light and - for a polyolefin - expensive. [Its density of 0.83g.cm⁻³ is very close to the theoretical minimum for thermoplastics].

Its properties are reasonably similar to those of other polyolefins, compared to which it is more brittle and more gas permeable. It has a higher melting point (240C) than most polyolefins and retains form stability up to temperatures close to this i.e. it softens more slowly with increasing temperature than is normal for thermoplastics. It has good release characteristics and good high frequency electrical and valuable acoustic/ultrasonic properties.

Applications include medical and laboratory apparatus, microwave components and cookware and electronic components.

Grades of TPX[®]

TPX[®] is available in a range of grades with different melt flow rates (MFR) covering injection moulding, extrusion, blow moulding and coating. The list shown below gives details of the main processing methods and the MFR for each grade:

DX845	- MFR of 9 g/10 min - highly recommended for film fibre extrusion and blow moulding.	extrusion, possible use for injection moulding,
RT31 & RT31XB	- MFR of 21 g/10 min - highly recommended for injection and fibre extrusion.	moulding, possible use for film
MX002	- MFR of 21 g/10 min - highly recommended for injection possible use for	moulding, film and mandrel extrusion, fibre extrusion and blow moulding.
MX002O	- MFR of 21 g/10 min - highly recommended for injection use for mandrel	moulding and film extrusion, possible and fibre extrusion, and blow moulding.
MX004 & MX004XB	- MFR of 25 g/10 min - highly recommended for injection extrusion, possible use for	moulding, film and mandrel fibre extrusion and blow moulding.
RT18 & RT18XB	- MFR of 26 g/10 min - highly recommended for injection and fibre extrusion.	moulding, possible use for film
DX231 & DX310	- MFR of 100 g/10 min - highly recommended for paper extrusion.	coating and possible use for fibre
DX350	- MFR of 110 g/10 min - highly recommended for paper extrusion.	coating and possible use for fibre
DX820	- MFR of 180 g/10 min - highly recommended for paper	coating and fibre extrusion.

RT31 & RT31XB: low odor grades RT18XB, RT31XB & MX004XB: blue tint grades

Physical Properties

Density	0.835 g cm ⁻³
Flammability	HB
Limiting oxygen index	17 %
Refractive index	1.463
Resistance to Ultra-violet	Poor
Water absorption - over 24 hours	0.01 %

Electrical Properties

Dielectric constant @1MHz	2.12
Dissipation factor @ 1kHz	0.0002
Volume resistivity	> 10 ¹⁶ Ohmcm

Thermal Properties

Coefficient of thermal expansion	117 x10 ⁻⁶ K ⁻¹
Heat-deflection temperature - 0.45MPa	100 C
Heat-deflection temperature - 1.8MPa	40 C
Lower working temperature	-20 to -40 C
Specific heat	2000 J K ⁻¹ kg ⁻¹
Thermal conductivity @23C	0.17 W m ⁻¹ K ⁻¹
Upper working temperature	75-115 C

Mechanical Properties

Elongation at break	15 %
Hardness - Rockwell	R85
Izod impact strength	49 J m ⁻¹
Tensile modulus	1.5 GPa
Tensile strength	25.5 MPa

Chemical Resistance

Acids - concentrated	Good-Fair
Acids - dilute	Good
Alcohols	Good
Alkalis	Good
Aromatic hydrocarbons	Fair-Poor
Greases and Oils	Good-Fair
Halogenated Hydrocarbons	Fair-Poor
Halogens	Fair-Poor
Ketones	Good-Fair



Monofilament

ME315914 Diameter **1.4mm**
 Grade **MX002**

Colour **Yellow**

Length
Web Code
 165-791-320

	Quantity
Length	1 Reel
10 m	YEN 17700

Polyphenylenesulphide

PPS

Physical Properties

Density 1.35 g cm⁻³
 Flammability V0
 Water absorption - over 24 hours 0.02 %
 0.3 W m⁻¹ K⁻¹

Electrical Properties

Surface resistivity 1x10¹⁶ Ohm/sq
 Volume resistivity 1x10¹³ Ohmcm

Thermal Properties

Coefficient of thermal expansion 4.0 x10⁻⁶ K⁻¹
 Heat-deflection temperature - 1.8MPa 104 C
 Thermal conductivity @ °C 23/
 Upper working temperature 170 C

Chemical Resistance

Acids - concentrated Poor
 Acids - dilute Fair



Monofilament

SU325950

Diameter **0.5mm**
 Condition **Unfilled**

Colour **Transparent pale amber**



Length

Web Code
 726-823-750
 058-174-276
 725-205-230
 652-231-652
 137-134-981

Quantity

Length	1 Reel
10 m	YEN 12800
20 m	YEN 19000
50 m	YEN 24600
100 m	YEN 33200
200 m	YEN 49200

Polymer – Polyphenylenesulphide

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