

# 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 Fibres

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## Introduction

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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](http://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](http://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): < 100mm  $\pm 1\text{mm}$   
 $\geq 100\text{mm}$   $+2\% / -1\%$



**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): < 100mm  $\pm 5\text{mm}$   
 $> 100\text{mm}$   $\pm 5\%$



**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

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### 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-cm<sup>3</sup>.s<sup>-1</sup>.

### 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.

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## Order information

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### 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.

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## Order information

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### 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

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## Order information

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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](http://www.goodfellow.com) or [www.goodfellowusa.com](http://www.goodfellowusa.com).

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## Company Details

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### 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**

Ermine Business Park  
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#### **Goodfellow Corporation**

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Siren : 381486836  
Numéro de TVA Intracommunitaire :  
FR 06 381 486 836

#### **Goodfellow GmbH**

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#### **Goodfellow (Shanghai) Trading Co., Ltd**

Room 803, Centro Build, No. 568 Hengfeng Road  
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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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## Conditions of Sale

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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

## Carbon

### C

Carbon has been known since prehistoric times.

Carbon occurs naturally in two allotropic forms, namely graphite and diamond; the discovery in 1985 of fullerenes has increased the number of allotropic forms of this element. Its abundance in the Earth's crust is 480 ppm. The study of carbon and its organic compounds is the basis of organic chemistry.

The applications for carbon are many and include its use as an alloying element with iron in the manufacture of steel, its use as brushes in electrical generators and motors, the use of colloidal graphite or carbon to coat surfaces (e.g. glass), in electrical assemblies to absorb microwaves and inhibit photoelectrons and secondary electrons, and the use of high purity carbon (graphite) in nuclear reactors to moderate neutrons.

Diamond has unique properties, being one of the hardest materials known and with excellent corrosion resistance and thermal transfer. Industrial diamond is used in rock drilling equipment and abrasive materials. CVD diamond has been the subject of extensive research and development over the past several years and applications for this material are only just being realised.

Carbon is a fundamental part of all life, it being a prime constituent of DNA. On average, the human body contains approximately 16kg of carbon in one form or another.

#### Atomic Properties

Atomic number	6
Atomic radius - Goldschmidt	0.077 nm
Atomic weight	12.011 amu
Crystal structure	Hexagonal/Diamond
Electronic structure	He 2s <sup>2</sup> 2p <sup>2</sup>
Photo-electric work function	4.8 eV
Thermal neutron absorption cross-section	0.0034 Barns
Valences shown	2, 3, 4

#### Physical Properties

Boiling point	5000 C
Density @20C	2.25 g cm <sup>-3</sup>
Melting point	3650 C

#### Electrical Properties

Electrical resistivity @0C	1375 μOhmcm
Thermal emf against Pt (cold 0C - hot 100C)	+0.70 mV

#### Thermal Properties

Coefficient of thermal expansion @0-100C	0.6-4.3 x10 <sup>-6</sup> K <sup>-1</sup>
Specific heat @25C	712 J K <sup>-1</sup> kg <sup>-1</sup>
Thermal conductivity @0-100C	80-240 W m <sup>-1</sup> K <sup>-1</sup>

Natural isotope distribution	Mass No.	%
	12	98.89
	13	1.11

Ionisation potential	No.	eV
	1	11.26
	2	24.38
	3	47.9
	4	64.5
	5	392
6	490	

#### Mechanical Properties

Material condition	Graphite	Diamond	
Bulk modulus	33	542	GPa
Hardness - Mohs	0.5-1.0	10	
Tensile modulus	4.8 GPa		



## Fibre

Material		XAS,HTA,T300	34-700, T650/35	UMS2526	HM	HS40	P25	P100	F180	F500
Coefficient of thermal expansion - Longitudinal	x10 <sup>-6</sup> K <sup>-1</sup>	-0.1to-0.5	-0.6	-0.7	-1.3	-0.5	-	-1.5		
Coefficient of thermal expansion - Transverse	x10 <sup>-6</sup> K <sup>-1</sup>	+26	-	+37	+25					
Density	g cm <sup>-3</sup>	1.76-1.8	1.77-1.8	1.78	1.86	1.85	1.87	2.15	-	2.1
Extension to break	%	1.5-1.7	1.7-1.9	1.2	0.8	0.9	1.0	0.3	-	2.1
Filament diameter	μm	7	7	4.8	8	5	11	10	-	9
Precursor		PAN	PAN	PAN	PAN	PAN	Pitch	Pitch	Pitch	Pitch
Tensile modulus	GPa	230-40	230-40	380	350-70	450	140-60	720	180	500
Tensile strength	GPa	3.6-4	4.5	4.9	2.5-2.7	4.4	1.4	2.2	2.0	3.0
Thermal Conductivity	W m <sup>-1</sup> K <sup>-1</sup>	17-24	14	46	105	52	22	520		
Volume Resistivity	μOhmcm	1400-1600	1500	1000	900	1000	1300	250	1100	400

Continuous multi-filament TOW. The most common form of carbon fibre is the high strength, high stiffness form commonly used in composites. These are made by a complicated process from textile pre-cursor yarns made from either polyacrylonitrile (PAN) or pitch that results in a predominantly graphitic structure highly oriented in the direction of the fibre axis. This high orientation gives them their remarkable properties which include a small negative coefficient of thermal expansion in the axial direction as well as remarkably high specific strength and stiffness. These fibres are available from stock in a range of stiffnesses and, to a lesser extent, strengths, together with several types of fabric all made from carbon fibre of the most

### C 005735

Tex Number ..... 200  
 Number of filaments ..... 3000  
 Condition ..... Epoxy sized

Filament diameter ..... 0.007mm  
 Grade ..... Tenax HTA



#### Length

Web Code  
 356-795-611  
 785-492-053  
 599-453-271  
 931-657-343

#### Quantity

Length 1 Reel  
 10 m POA  
 20 m POA  
 50 m POA  
 100 m POA

### C 005780

Tex Number ..... 280  
 Number of filaments ..... 2000  
 Condition ..... Epoxy sized (1.0%)

Filament diameter ..... 0.009mm  
 Grade ..... F500



#### Length

Web Code  
 917-720-954  
 715-115-441  
 389-432-766  
 679-092-695  
 886-585-447

#### Quantity

Length 1 Reel  
 10 m POA  
 50 m POA  
 100 m POA  
 200 m POA  
 500 m POA

**Carbon**

**C**



**Fibre**

**C 005785**

Tex Number ..... **320** Filament diameter ..... **0.01mm**  
 Number of filaments ..... **2000** Grade ..... **P100**  
 Condition ..... **Epoxy sized**



Length		Quantity	
<b>Web Code</b>	<b>Length</b>	<b>1 Reel</b>	
576-250-724	5 m	POA	

Typical Analysis : Not applicable

**C 005711**

Tex Number ..... **400** Filament diameter ..... **0.007mm**  
 Number of filaments ..... **6000** Grade ..... **Tenax HTA**  
 Condition ..... **Epoxy sized (1.2%)**



Length		Quantity	
<b>Web Code</b>	<b>Length</b>	<b>1 Reel</b>	
239-507-620	10 m	POA	
938-455-827	20 m	POA	
306-978-471	50 m	POA	
372-303-424	100 m	POA	
537-930-182	200 m	POA	

**C 005731**

Tex Number ..... **400** Filament diameter ..... **0.0048mm**  
 Number of filaments ..... **12000** Condition ..... **Continuous multi-filament TOW.**



Length		Quantity	
<b>Web Code</b>	<b>Length</b>	<b>1 Reel</b>	
380-636-621	10 m	POA	
187-731-411	20 m	POA	
106-169-924	50 m	POA	
197-031-561	100 m	POA	
114-948-741	200 m	POA	

Typical Analysis : Not applicable

**C 005732**

Tex Number ..... **430** Number of filaments ..... **12000**



Length		Quantity	
<b>Web Code</b>	<b>Length</b>	<b>1 Reel</b>	
928-135-645	10 m	POA	
689-951-207	50 m	POA	
345-798-064	100 m	POA	
428-837-791	200 m	POA	

**C 005725**

Tex Number ..... **795** Filament diameter ..... **0.007mm**  
 Number of filaments ..... **12000** Grade ..... **XAS**  
 Condition ..... **Epoxy sized (1.6%)**



Length		Quantity	
<b>Web Code</b>	<b>Length</b>	<b>1 Reel</b>	
618-131-889	10 m	POA	

Typical Analysis : Not applicable

**C 005722**

Tex Number ..... **795** Filament diameter ..... **0.007mm**  
 Number of filaments ..... **12000** Grade ..... **34-700**  
 Condition ..... **Unsize**



Length		Quantity	
<b>Web Code</b>	<b>Length</b>	<b>1 Reel</b>	
946-245-330	10 m	POA	
822-037-912	20 m	POA	
280-664-846	50 m	POA	
083-110-922	100 m	POA	

**C 005730**

Tex Number ..... **900** Filament diameter ..... **0.008mm**  
 Number of filaments ..... **10000** Grade ..... **HM**  
 Condition ..... **Epoxy sized (0.7%)**



Length		Quantity	
<b>Web Code</b>	<b>Length</b>	<b>1 Reel</b>	
852-659-499	10 m	POA	
121-301-648	20 m	POA	
582-435-186	50 m	POA	
804-397-678	100 m	POA	

**Metal – Carbon**

## Alumina



Minerals containing Alumina represent some 15% of the earth's crust. It is therefore an abundant material and virtually inexhaustable, unlike raw materials for many alloys developed for special applications. The combination of high thermal conductivity, low thermal expansion and high compressive strength leads to good thermal shock resistance, so Alumina is suited to furnace use as crucibles, tubes and thermocouple sheaths. High purity Alumina can be used up to 1700C and is gas tight up to 1300C. Few chemicals attack Alumina. Alumina also shows good electrical insulation at high temperatures, good wear resistance and high hardness, making it suitable for components such as ball valves, piston pumps and deep drawing tools. Diamond tools are needed to machine or grind Alumina.

Remarkably, continuous filament yarns have been made from alumina with reasonable but not complete success and two, similar, versions are available from Goodfellow. They are both much less flexible than normal continuous filament yarns and are rather "hairy" i.e. have broken filaments - especially the FP version.

**Physical Properties**

Apparent porosity	0 %
Density	3.9 g cm <sup>-3</sup>
Water absorption - saturation	0 %

**Electrical Properties**

Dielectric constant	9.0-10.1
Dielectric strength	10-35 kV mm <sup>-1</sup>
Volume resistivity @25C	> 10 <sup>14</sup> Ohmcm

**Thermal Properties**

Coefficient of thermal expansion @20-1000C	8.0 x10 <sup>-6</sup> K <sup>-1</sup>
Melting point	2100 C
Specific heat @25C	850-900 J K <sup>-1</sup> kg <sup>-1</sup>
Thermal conductivity @20C	26-35 W m <sup>-1</sup> K <sup>-1</sup>
Upper continuous use temperature	1700 C

**Mechanical Properties**

Compressive strength	2200-2600 MPa
Hardness - Knoop	2100 kgf mm <sup>-2</sup>
Hardness - Vickers	1500-1650 kgf mm <sup>-2</sup>
Shear strength	330 MPa
Tensile modulus	300-400 GPa
Tensile strength	260-300 MPa

**Chemical Resistance**

Acids - concentrated	Good
Acids - dilute	Good
Alkalis	Good
Halogens	Good
Metals	Good



## Fibre

Coefficient of thermal expansion - Longitudinal	x10 <sup>-6</sup> K <sup>-1</sup>	5.7
Density	g cm <sup>-3</sup>	3.9
Modulus	GPa	380
Tenacity	GPa	1.4

**AL605720**

Tex Number . . . . . 210  
 Number of filaments . . . . . 200

Filament diameter . . . . . 0.02mm  
 Grade . . . . . FP



**Length**

**Web Code**  
 211-103-753  
 387-971-492  
 496-434-220  
 054-283-919  
 785-496-213  
 187-032-568  
 379-069-714

**Quantity**

<b>Length</b>	<b>1 Reel</b>
1 m	GBP 82.50
2 m	GBP 92.50
5 m	GBP 116.00
10 m	GBP 150.00
20 m	GBP 210.00
50 m	GBP 373.00
100 m	GBP 518.00

Made from Alpha grade

**AL605725**

Tex Number . . . . . 250  
 Number of filaments . . . . . 1000

Filament diameter . . . . . 0.01mm  
 Grade . . . . . AMX



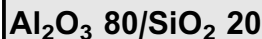
**Length**

**Web Code**  
 383-719-904  
 964-999-399  
 624-915-295  
 114-410-898  
 301-357-986

**Quantity**

<b>Length</b>	<b>1 Reel</b>
1 m	GBP 82.00
2 m	GBP 92.00
5 m	GBP 116.00
10 m	GBP 149.00
20 m	GBP 209.00

## Alumina/Silica



A continuous multi-filament yarn similar to those made wholly from alumina, relative to which it has a lower upper-use temperature but is more flexible. Similarly, it is used for composites and thermal insulation.

**Physical Properties**

Density	3.1 g cm <sup>-3</sup>
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**Thermal Properties**

Upper continuous use temperature	1600 C
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Ceramic - Alumina

## Alumina/Silica

Al<sub>2</sub>O<sub>3</sub> 80/SiO<sub>2</sub> 20



### Fibre

Density	g cm <sup>-3</sup>	3.1
Tenacity	GPa	1.6

AJ615720 Tex Number . . . . . 205  
 Number of filaments . . . . . 960

Filament diameter . . . . . 0.01mm



#### Length

**Web Code**  
 318-110-609  
 763-833-333  
 479-164-011  
 895-508-386  
 938-537-727  
 317-215-541  
 651-940-508

#### Quantity

Length	1 Reel
1 m	GBP 77.00
2 m	GBP 84.00
5 m	GBP 101.00
10 m	GBP 128.00
20 m	GBP 178.00
50 m	GBP 321.00
100 m	GBP 444.00

## Alumina/Silica/Boria

Al<sub>2</sub>O<sub>3</sub> 70/SiO<sub>2</sub> 28/B<sub>2</sub>O<sub>3</sub> 2

**Common Brand Names :** Nextel<sup>®</sup> 440

This and Nextel<sup>®</sup> 312 are two similar materials - compositions of ceramic specially developed for the production of continuous filament yarns which are sufficiently flexible to manufacture conventional textile articles such as fabrics and sewing threads whilst retaining much of the high temperature and chemical resistance typical of ceramics. Nextel<sup>®</sup> 440 has somewhat better tensile properties and a higher upper working temperature but is less flexible than Nextel<sup>®</sup> 312 and is available from Goodfellow as a yarn.

The fibres are coated with finishes during manufacture which can be removed, if desired, by "heat cleaning" at about 550C. If the best possible properties are required, further heat treatment at about 1215C should be used. More details of recommended treatment methods are available on request.

#### Physical Properties

Density 3.05 g cm<sup>-3</sup>  
 Refractive index 1.62

#### Mechanical Properties

Tensile modulus 185 GPa  
 Tensile strength 2000 MPa

#### Electrical Properties

Dielectric constant 5.7 @ 9.4GHz

#### Chemical Resistance

Acids - concentrated Fair  
 Acids - dilute Good  
 Alkalis Poor-Fair

#### Thermal Properties

Coefficient of thermal expansion @20-1000C 5 x10<sup>-6</sup> K<sup>-1</sup>  
 Specific heat @500C 1000 J K<sup>-1</sup> kg<sup>-1</sup>  
 Sublimation point 1800 C  
 Upper continuous use temperature 1350-1650 C



### Fibre

Coefficient of thermal expansion - Longitudinal	x10 <sup>-6</sup> K <sup>-1</sup>	4.4
Density	g cm <sup>-3</sup>	3.05
Modulus	GPa	180
Tenacity	GPa	2.0

AJ625710 Tex Number . . . . . 110  
 Number of filaments . . . . . 390

Filament diameter . . . . . 0.011mm  
 Grade . . . . . Nextel 440<sup>®</sup>



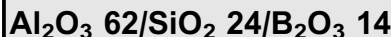
#### Length

**Web Code**  
 492-563-322  
 570-413-552  
 301-690-105  
 711-273-122  
 909-138-559  
 642-321-310  
 290-173-804

#### Quantity

Length	1 Reel
1 m	GBP 77.50
2 m	GBP 82.00
5 m	GBP 93.00
10 m	GBP 109.00
20 m	GBP 127.00
50 m	GBP 172.00
100 m	GBP 239.00

## Alumina/Silica/Boria



**Common Brand Names :** Nextel<sup>®</sup> 312

This and Nextel<sup>®</sup> 440 are two similar materials - compositions of ceramic specially developed for the production of continuous filament yarns which are sufficiently flexible to manufacture conventional textile articles such as fabrics and sewing threads whilst retaining much of the high temperature and chemical resistance typical of ceramics. Nextel<sup>®</sup> 440 has somewhat better tensile properties and higher upper working temperature but is less flexible than Nextel<sup>®</sup> 312. Nextel<sup>®</sup> 312 is available from Goodfellow as a yarn, a narrow fabric and sewing thread sizes. Sewing threads are made from individual yarns, known as "singles", wrapped around the outside with rayon and then twisted together in two stages to give a balanced, non-snarl, construction. The rayon comprises about 20% of the initial weight of the thread and will "burn" out by about 300C if/when the sewn article is subsequently heated.

The fibres are coated with finishes during manufacture which can be removed, if desired, by "heat cleaning" at about 550C. If the best possible properties are required, further heat treatment at about 920C should be used. More details of the recommended methods of treatment are available on request.

**Physical Properties**

Apparent porosity	0 %
Density	2.7 g cm <sup>-3</sup>
Refractive index	1.57
Water absorption - saturation	0 %

**Electrical Properties**

Dielectric constant	5.2 @ 9.4GHz
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**Thermal Properties**

Coefficient of thermal expansion @20-1000C	3 x10 <sup>-6</sup> K <sup>-1</sup>
Specific heat @25C	1100 J K <sup>-1</sup> kg <sup>-1</sup>
Sublimation point	1800 C
Upper continuous use temperature	1200-1400 C

**Mechanical Properties**

Tensile modulus	140 GPa
Tensile strength	1700 MPa

**Chemical Resistance**

Acids - concentrated	Fair
Acids - dilute	Good
Alkalis	Poor-Fair
Metals	Good



## Fibre

Coefficient of thermal expansion - Longitudinal	x10 <sup>-6</sup> K <sup>-1</sup>	3.0
Density	g cm <sup>-3</sup>	2.7
Extension to break	%	1.2
Modulus	GPa	140
Tenacity	GPa	1.7

**AL625710** Tex Number ..... **100**  
 Number of filaments ..... **390**

Filament diameter ..... **0.011mm**  
 Grade ..... **Nextel 312<sup>®</sup>**



**Length**

**Web Code**

238-941-186
867-645-513
455-689-749
961-216-616
152-086-570

**Quantity**

**Length 1 Reel**

1 m	GBP 76.50
2 m	GBP 81.00
5 m	GBP 91.50
10 m	GBP 106.00
20 m	GBP 123.00

**AL625720** Tex Number ..... **500**  
 Number of yarns ..... **6**  
 Thread diameter ..... **0.7mm nominal**

Number of filaments .....  
 Grade ..... **Nextel 312<sup>®</sup>**



**Length**

**Web Code**

135-609-934
951-246-078
905-753-655
219-202-952
400-371-165

**Quantity**

**Length 1 Reel**

1 m	GBP 82.50
2 m	GBP 92.50
5 m	GBP 113.00
10 m	GBP 140.00
20 m	GBP 207.00

Sewing thread construction. The single yarn is 67 tex, 390 filaments (filament diameter approx 9 µm) wrapped in rayon.

**AL625725** Tex Number ..... **680**  
 Number of yarns ..... **8**  
 Thread diameter ..... **0.8mm nominal**

Number of filaments .....  
 Grade ..... **Nextel 312<sup>®</sup>**



**Length**

**Web Code**

894-839-560
854-942-248
867-777-469
472-185-300
023-164-628

**Quantity**

**Length 1 Reel**

1 m	GBP 83.00
2 m	GBP 93.00
5 m	GBP 114.00
10 m	GBP 141.00
20 m	GBP 210.00

Sewing thread construction. The single yarn is 67 tex, 390 filaments (filament diameter approx 9 µm) wrapped in rayon.



## 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  $\beta$ -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<sup>-3</sup>

**Thermal Properties**

Melting point 2650-2950 C

**Mechanical Properties**

Hardness - Vickers 2500 kgf mm<sup>-2</sup>



## Fibre

Material		Nicalon SiC CF tow
Coefficient of thermal expansion - Longitudinal	x10 <sup>-6</sup> K <sup>-1</sup>	3
Density	g cm <sup>-3</sup>	2.55
Dielectric Constant		7-9
Extension to break	%	1.4
Modulus	GPa	200
Specific Heat @25C	J K <sup>-1</sup> kg <sup>-1</sup>	1.1
Tenacity	GPa	2.8
Thermal Conductivity	W m <sup>-1</sup> K <sup>-1</sup>	12
Volume Resistivity @25C	Ohmcm	10 <sup>9</sup>

SI675721

Tex Number ..... 209  
 Number of filaments ..... 500

Filament diameter ..... 0.015mm



Xi

**Length**

**Web Code**  
 407-704-351  
 379-761-475  
 470-176-504  
 772-065-186  
 508-148-734  
 022-863-894

**Quantity**

**Length 1 Reel**  
 1 m GBP 75.50  
 5 m GBP 95.00  
 10 m GBP 111.00  
 20 m GBP 137.00  
 50 m GBP 198.00  
 100 m GBP 254.00

Ceramic – Silicon Carbide

## Cellulose Regenerated Cellulose

**Common Brand Names :** Cellophane, Rayophane

**Physical Properties**

Density 1.44 g cm<sup>-3</sup>  
 Limiting oxygen index ~ 18 %  
 Radiation resistance Fair  
 Refractive index 1.47  
 Water absorption - equilibrium 50 %

**Electrical Properties**

Dielectric constant @1MHz 4 (dry)  
 Dielectric strength 30-50 @ 1mm kV mm<sup>-1</sup>  
 Dissipation factor @ 1kHz 0.06  
 Volume resistivity 10<sup>10</sup> - 10<sup>12</sup> Ohmcm

**Thermal Properties**

Specific heat ~ 1400 J K<sup>-1</sup> kg<sup>-1</sup>  
 Thermal conductivity @10C 0.0035 W m<sup>-1</sup> K<sup>-1</sup>

**Mechanical Properties**

Elongation at break 18/55 %  
 Tensile modulus 5/3 GPa  
 Tensile strength 120/55 MPa

**Chemical Resistance**

Acids - dilute Good  
 Alkalis Good  
 Greases and Oils Good



### Fibre

Material		Medium tenacity rayon
Coefficient of thermal expansion	x10 <sup>-6</sup> K <sup>-1</sup>	~80
Density	g cm <sup>-3</sup>	1.5 - 1.55
Extension to break	%	20 - 40
Specific Modulus	cN/tex	300 - 700
Tenacity	cN/Tex	13 - 23
Thermal Conductivity @23C	W m <sup>-1</sup> K <sup>-1</sup>	~0.06

**AC325717** Tex Number ..... 16.7 Number of filaments ..... 60  
 Condition ..... Medium Tenacity

**Length**

**Web Code**  
 315-735-594  
 594-047-650  
 002-773-544  
 668-716-593

**Quantity**

**Length 1 Reel**  
 100 m GBP 84.50  
 200 m GBP 98.50  
 500 m GBP 139.00  
 1000 m GBP 205.00

## Flax Flax



### Fibre

**FL305710** Tex Number ..... 24000 Condition ..... Multi-filament Yarn  
 Colour ..... Natural

**Length**

**Web Code**  
 842-616-632

**Quantity**

**Length 1 Reel**  
 1 m GBP 77.50

Polymer – Cellulose

## Polyamide - Nylon 4, 6

### PA 4,6

**Common Brand Names :** Stanyl

**See also General information under Nylon 6**

**General Description :** A semi-crystalline, yellowish engineering thermoplastic that is often coloured brick red. It has higher crystallinity and better chemical resistance than nylon 6 or 6,6 and similar water absorption, though the associated dimensional change is less. Compared to other (aliphatic) nylons it has much better retention of properties at elevated temperatures, reportedly because of the "highly symmetrical" polymer chain and its relatively high concentration of amide groups (four methylene groups in both the acid and the amine segments).

Applications are broadly similar to other nylons - engineering, electrical and electronic components particularly those exposed to (sustained) high temperatures.

#### Physical Properties

Density	1.18 g cm <sup>-3</sup>
Flammability	V2 @ 0.8mm
Limiting oxygen index	24 %
Radiation resistance	Fair
Water absorption - equilibrium	3.7 %
Water absorption - over 24 hours	1.3 %

#### Electrical Properties

Dielectric constant @1MHz	3.8-4.3
Dielectric strength	20 kV mm <sup>-1</sup>
Dissipation factor @ 1kHz	0.35
Surface resistivity	10 <sup>12</sup> -10 <sup>14</sup> Ohm/sq
Volume resistivity	10 <sup>13</sup> -10 <sup>15</sup> Ohmcm

#### Thermal Properties

Coefficient of thermal expansion	80-90 x10 <sup>-6</sup> K <sup>-1</sup>
Heat-deflection temperature - 0.45MPa	220 C
Heat-deflection temperature - 1.8MPa	160 C
Lower working temperature	-40 C
Thermal conductivity @23C	0.30 W m <sup>-1</sup> K <sup>-1</sup>
Upper working temperature	100-200 C

#### Mechanical Properties

Hardness - Rockwell	M92
Izod impact strength	80 J m <sup>-1</sup>
Tensile modulus	3.1-3.3 GPa
Tensile strength	55-100 MPa



## Fibre

AM345724

Tex Number ..... 24  
 Condition ..... High Tenacity

Number of filaments ..... 36

#### Length

<b>Web Code</b>
543-182-921
724-149-529
019-135-090
568-818-287
308-052-084

#### Quantity

<b>Length</b>	<b>1 Reel</b>
100 m	GBP 77.50
200 m	GBP 89.00
500 m	GBP 123.00
1000 m	GBP 178.00
2000 m	GBP 287.00

Polymer – Polyamide - Nylon 4, 6

## Polyamide - Nylon 6, 6

### PA 6,6

**Common Brand Names :** Akulon S, Maranyl A, Utramid A, Zytel

**General Information for 'Nylons'**

A family of similar semi-crystalline engineering thermoplastics generally synthesised from straight chain aliphatic acids and amines. Each particular nylon is described by one or two numbers eg nylon 6 or 6,6 where the number is the number of carbon atoms in the amine and acid monomers. Where a single number is used the monomer is an Alpha amino-acid (or its lactam) and the amide links in the polymer are all "head-to-tail". Where two numbers are used the monomers are a diamine and diacid and the amide links alternate "head-to-tail"/"tail-to-head". The first number refers to the diamine, the second to the diacid. Some nylons use aromatic monomers which are denoted by letters eg T for terephthalic and I for isophthalic components.

Nylons generally are strong, tough (but notch-sensitive), rather resilient polymers with good barrier properties and high fatigue and abrasion resistance but high water absorption (slow in thick sections) accompanied by an increase in dimensions which can be as much as 3% under extreme circumstances. Nylons have good resistance to oils, greases, solvents and alkalis but not to acids which tend to hydrolyse them. The most common nylons are 6 and 6,6 and in the individual descriptions the others are described in relation to them.

**General Description :** A semi-crystalline, off-white engineering thermoplastic that is the strongest and most abrasion resistant unreinforced aliphatic nylon with better low temperature toughness than Nylon 6 or acetal. Its very low melt viscosity can give industrial processing difficulties and weathering can cause embrittlement and colour change unless it is stabilised or protected. Available with a wide range of fillers, notably glass fibre which gives a marked increase in stiffness and solid and liquid (oil) lubricants. Super-tough grades are also available whose impact properties and low notch sensitivity are amongst the best of all engineering thermoplastics.

Applications include mainly engineering components eg gears, bearings, nuts, bolts, rivets and wheels and power tool casings and rocker box covers. Widely used as monofilament for brushes etc and fibre, notable for its resilience and high abrasion resistance, for apparel, carpet and industrial end-uses.

**Physical Properties**

Density	1.14 g cm <sup>-3</sup>
Flammability	HB
Limiting oxygen index	23 %
Radiation resistance	Fair
Refractive index	1.53
Resistance to Ultra-violet	Poor
Water absorption	8.5 %
Water absorption - equilibrium	8 %
Water absorption - over 24 hours	2.3 %

**Electrical Properties**

Dielectric constant @1MHz	3.4
Dielectric strength	25 kV mm <sup>-1</sup>
Dissipation factor @ 1kHz	0.2
Surface resistivity	10 <sup>11</sup> Ohm/sq
Volume resistivity	10 <sup>13</sup> Ohmcm

**Thermal Properties**

Coefficient of thermal expansion	90 x10 <sup>-6</sup> K <sup>-1</sup>
Heat-deflection temperature - 0.45MPa	200 C
Heat-deflection temperature - 1.8MPa	100 C
Lower working temperature	-30 C
Specific heat	1670 J K <sup>-1</sup> kg <sup>-1</sup>
Thermal conductivity @23C	0.25 W m <sup>-1</sup> K <sup>-1</sup>
Upper working temperature	80-180 C

**Mechanical Properties**

Abrasive resistance - ASTM D1044	3-5 mg/1000 cycles
Coefficient of friction	0.2-0.3
Elongation at break	40 %
Hardness - Rockwell	M89
Izod impact strength	40-110 J m <sup>-1</sup>
Poisson's ratio	0.41
Tensile modulus	3.3 GPa
Tensile strength	82 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



Material		Medium	High tenacity
Density	g cm <sup>-3</sup>	1.14	1.14
Extension to break	%	37	14-22
Shrinkage @100C	%	9	9-11
Specific Tenacity	cN/tex	43	60-80

**AM325705** Tex Number . . . . . 1.3  
 Number of filaments . . . . . 14

Filament diameter . . . . . 0.01mm  
 Condition . . . . . Medium Tenacity

Length Web Code	Quantity	
	Length	1 Reel
265-248-293	100 m	GBP 99.00
156-033-312	200 m	GBP 122.00
504-172-215	500 m	GBP 187.00
021-533-159	1000 m	GBP 296.00

Continuous multi-filament yarn

**AM325710** Tex Number . . . . . 1.7  
 Number of filaments . . . . . 3

Filament diameter . . . . . 0.025mm  
 Condition . . . . . Medium Tenacity

Length Web Code	Quantity	
	Length	1 Reel
691-641-186	100 m	GBP 84.50
455-141-112	200 m	GBP 98.50
892-641-556	500 m	GBP 139.00
580-194-633	1000 m	GBP 205.00

Continuous multi-filament yarn

Polymer – Polyamide - Nylon 6, 6

## Polyamide - Nylon 6, 6

### PA 6,6



## Fibre

**AM325720**

Tex Number ..... 3.3  
 Number of filaments ..... 10

Filament diameter ..... 0.019mm  
 Condition ..... High Tenacity

#### Length

**Web Code**  
 524-330-307  
 541-289-322  
 661-173-044  
 646-628-351

#### Quantity

**Length 1 Reel**  
 100 m GBP 79.00  
 200 m GBP 91.00  
 500 m GBP 126.00  
 1000 m GBP 182.00

Continuous multi-filament yarn

**AM325750**

Tex Number ..... 15.6  
 Number of filaments ..... 34

Filament diameter ..... 0.023mm  
 Condition ..... High Tenacity

#### Length

**Web Code**  
 828-537-819  
 567-230-256  
 903-784-563  
 973-065-664

#### Quantity

**Length 1 Reel**  
 100 m GBP 84.50  
 200 m GBP 98.50  
 500 m GBP 139.00  
 1000 m GBP 205.00

Continuous multi-filament yarn

**AM325790**

Tex Number ..... 94  
 Number of filaments ..... 140

Filament diameter ..... 0.0275mm  
 Condition ..... High Tenacity

#### Length

**Web Code**  
 633-202-289  
 150-279-829  
 784-982-751  
 122-838-375

#### Quantity

**Length 1 Reel**  
 100 m GBP 97.00  
 200 m GBP 113.00  
 500 m GBP 159.00  
 1000 m GBP 236.00

Continuous multi-filament yarn

## Polyaramid

### Polyparaphenylene terephthalamide

**Common Brand Names :** DuPont™ Kevlar®, Twaron

**General Description :** An infusible, wholly aromatic polymer that can strictly be described as nylon T,T - but rarely is. Manufactured only as a fibre (by solution spinning), it has a very high thermal stability and temperature and flame resistance. In contrast to its chemical isomer Nomex®, its tensile properties are up to an order of magnitude greater than those of normal textile fibres, because of a high degree of molecular orientation resulting from its stiff linear molecules and their propensity for forming liquid crystals in the spinning solution. In common with the small number of other highly oriented materials, these fibres have a (small) negative CTE in the axial direction.

Quite widely used in composites which are lighter than those based on carbon fibre and electrically insulating. Their mechanical properties are generally inferior; more specifically they have a high specific tensile strength approaching that of carbon fibre composites, but quite low strength in compression.

In addition to composites, applications include protective clothing and body armour, friction products, elastomer reinforcement (e.g. hoses and drive belts), ropes and cords and as high strength high modulus fabrics e.g. high performance sailcloths.

#### Physical Properties

Density 1.44 g cm<sup>-3</sup>  
 Resistance to Ultra-violet Fair  
 Water absorption 3.5 %  
 Water absorption - equilibrium 3.5 %

#### Thermal Properties

Coefficient of thermal expansion -2 along axis x10<sup>-6</sup> K<sup>-1</sup>  
 Lower working temperature -200 C  
 Specific heat 1400 J K<sup>-1</sup> kg<sup>-1</sup>  
 Thermal conductivity @23C 0.04 W m<sup>-1</sup> K<sup>-1</sup>  
 Upper working temperature 180-245 C

#### Mechanical Properties

Tensile modulus 59-124 GPa  
 Tensile strength 2760 MPa

#### Chemical Resistance

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

**Polyaramid**  
**Polyparaphenylene terephthalamide**



Material		Kevlar 29 <sup>®</sup>	Kevlar 49 <sup>®</sup>	Kevlar Ht (T129)
Density	g cm <sup>-3</sup>	1.44	1.45	1.44
Extension to break	%	3.7	1.9	3.6
Modulus	GPa	58	120	75
Specific Modulus	cN/tex	4000	8300	5200
Shrinkage @100C	%		0.02	
Specific Tenacity	cN/tex	190	190	235

**AR305722** Tex Number ..... **22** Filament diameter ..... **0.017mm**  
 Number of filaments ..... **70** Type ..... **DuPont™ Kevlar 29<sup>®</sup>**

		Quantity	
Length	Web Code	Length	1 Reel
100 m	631-716-267	100 m	GBP 90.50
200 m	964-536-928	200 m	GBP 105.00
500 m	567-113-693	500 m	GBP 140.00
1000 m	889-211-107	1000 m	GBP 190.00

Continuous multi-filament Yarn

**AR305744** Tex Number ..... **44** Filament diameter ..... **0.018mm**  
 Number of filaments ..... **120** Type ..... **DuPont™ Kevlar 29<sup>®</sup>**

		Quantity	
Length	Web Code	Length	1 Reel
100 m	151-398-859	100 m	GBP 98.00
200 m	924-859-853	200 m	GBP 116.00
500 m	607-486-230	500 m	GBP 157.00
1000 m	935-786-867	1000 m	GBP 214.00

Continuous multi-filament Yarn

**AR305745** Tex Number ..... **44** Number of filaments ..... **267**  
 Type ..... **DuPont™ Kevlar 29<sup>®</sup>**

		Quantity	
Length	Web Code	Length	1 Reel
100 m	572-191-494	100 m	GBP 98.00
200 m	833-554-646	200 m	GBP 116.00
500 m	739-148-574	500 m	GBP 157.00
1000 m	401-765-708	1000 m	GBP 214.00
2000 m	339-196-011	2000 m	GBP 314.00

Continuous multi-filament Yarn

**AR305779** Tex Number ..... **790** Filament diameter ..... **0.012mm**  
 Number of filaments ..... **5000** Type ..... **DuPont™ Kevlar<sup>®</sup> 49**

		Quantity	
Length	Web Code	Length	1 Reel
10 m	431-601-389	10 m	GBP 94.50
20 m	950-169-224	20 m	GBP 112.00
50 m	771-151-467	50 m	GBP 161.00
100 m	393-931-318	100 m	GBP 226.00
200 m	241-417-760	200 m	GBP 348.00

Continuous multi-filament Yarn

**AR305783** Tex Number ..... **830** Cord diameter ..... **0.8mm**  
 Condition ..... **Braided Cord**

		Quantity	
Length	Web Code	Length	1 Reel
1 m	177-217-165	1 m	GBP 74.50
2 m	152-138-007	2 m	GBP 80.00
5 m	017-261-969	5 m	GBP 93.00
10 m	157-747-454	10 m	GBP 111.00
20 m	718-436-099	20 m	GBP 132.00
50 m	804-504-563	50 m	GBP 184.00

Breaking load : 75kg.

**AR305770** Tex Number ..... **1680** Type ..... **Twaron<sup>®</sup> T2000 Z90**

		Quantity	
Length	Web Code	Length	1 Reel
10 m	822-290-816	10 m	GBP 103.00

Continuous multi-filament Yarn

Polymer – Polyaramid

**Polyaramid**

**Polyparaphenylene terephthalamide**



**Fibre**

**AR305762**

Tex Number ..... **6250**  
 Condition ..... **Braided Cord**

Cord diameter ..... **3mm**

Length	Quantity
<b>Web Code</b>	<b>1 Reel</b>
693-270-855	5 m GBP 109.00
658-854-849	10 m GBP 134.00
356-860-319	20 m GBP 164.00
607-544-514	50 m GBP 241.00

Breaking load : 720kg.

**Polyaramid**

**Polymetaphenylene isophthalamide**

**Common Brand Names : DuPont™ Nomex®**

**Physical Properties**

Density	1.38 g cm <sup>-3</sup>
Limiting oxygen index	29 %
Radiation resistance	Good
Water absorption - equilibrium	9 %
Water absorption - over 24 hours	0.08 %

**Electrical Properties**

Dielectric constant @1kHz	2.3
Dielectric strength	32 kV mm <sup>-1</sup>
Volume resistivity	6x10 <sup>16</sup> Ohmcm

**Thermal Properties**

Coefficient of thermal expansion	20 x10 <sup>-6</sup> K <sup>-1</sup>
----------------------------------	--------------------------------------

Heat-deflection temperature - 1.8MPa

Specific heat	149 C	1200 J K <sup>-1</sup> kg <sup>-1</sup>
Thermal conductivity @23C		0.13 W m <sup>-1</sup> K <sup>-1</sup>
Upper working temperature		200 - 300 C

**Mechanical Properties**

Elongation at break	< 9 %
Izod impact strength	533 unnotched J m <sup>-1</sup>
Tensile strength	1800-3900 MPa

**Chemical Resistance**

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



**Fibre**

Density	g cm <sup>-3</sup>	1.38
Extension to break	%	16 - 25
Specific Modulus	cN/tex	1100
Specific Tenacity	cN/tex	35 - 44

**AR315722**

Tex Number ..... **22**  
 Number of filaments ..... **100**

Filament diameter ..... **0.01mm**

Length	Quantity
<b>Web Code</b>	<b>1 Reel</b>
777-140-285	100 m GBP 94.50
230-236-172	200 m GBP 117.00
779-518-185	500 m GBP 179.00
439-769-205	1000 m GBP 199.00

Continuous multi-filament Yarn

**Polymer - Polyaramid**

## 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**

Density	1.26 - 1.32 g cm <sup>-3</sup>
Flammability	V-0 @ 1.5mm
Limiting oxygen index	35 %
Radiation resistance	Good
Resistance to Ultra-violet	Fair
Water absorption - equilibrium	0.5 %
Water absorption - over 24 hours	0.1-0.3 %

Elongation at break	50 %
Hardness - Rockwell	M99
Izod impact strength	85 J m <sup>-1</sup>
Poisson's ratio	0.4
Tensile modulus	3.7-4.0 GPa
Tensile strength	70-100 MPa

**Electrical Properties**

Dielectric constant @1kHz	3.2-3.3 @ 50Hz-10Khz
Dielectric strength	190 @ 50µm kV mm <sup>-1</sup>
Dissipation factor @ 1MHz	0.003
Volume resistivity	10 <sup>15</sup> -10 <sup>16</sup> Ohmcm

**Chemical Resistance**

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

**Thermal Properties**

Coefficient of thermal expansion	47/108 x10 <sup>-6</sup> K <sup>-1</sup>
Heat-deflection temperature - 0.45MPa	> 260 C
Heat-deflection temperature - 1.8MPa	160 C
Specific heat	1340 J K <sup>-1</sup> kg <sup>-1</sup>
Thermal conductivity @23C	0.25 W m <sup>-1</sup> K <sup>-1</sup>
Upper working temperature	250 C

**Mechanical Properties**

Coefficient of friction	0.18
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### Fibre

Density	g cm <sup>-3</sup>	1.30
Extension to break	%	19
Modulus - 10 %	GPa	4.2
Modulus - 2 %	cN/Tex	500
Modulus - 5 %	GPa	4.35
Shrinkage @180C	%	1.1
Tenacity - Knot	cN/Tex	36
Tenacity - Loop	cN/Tex	40
Specific Tenacity	cN/tex	61
Tensile strength	MPa	790

**EK305723** Tex Number ..... 23  
 Number of filaments ..... 30

Filament diameter ..... 0.034mm

**Length**

<b>Web Code</b>
237-293-280
661-651-836
706-486-235
310-782-568
847-814-350

**Quantity**

<b>Length</b>	<b>1 Reel</b>
1 m	GBP 90.50
2 m	GBP 103.00
5 m	GBP 138.00
10 m	GBP 195.00
20 m	GBP 307.00

Polymer – Polyetheretherketone



## Polyethylene - Low Density

### LDPE

**Common Brand Names** : Alkathene, Carlona, Lacqtene, Lupolen, Stamylan LD

**Polyethylenes General** : A family of closely related commodity thermoplastics that are manufactured in large volumes in a very wide range of grades. Traditionally differentiated by their density (a good measure of degree of crystallinity), from a scientist's point of view the better distinction is the degree of chain branching. The first polyethylene, later called LDPE, was and is made by a high pressure process using a free radical initiator/catalyst and is a polymer with a high degree of chain branching. Subsequently low pressure processes using Ziegler-Natta or related catalysts were developed which produce a much more linear molecule and generally higher crystallinities. These were and are called high density polyethylene (HDPE); this technology is now used to make a family of (chemically) closely related PE's all of which are linear - ULDPE (ultra low density ..), LLDPE (linear low ..), MDPE (medium ..), HMWPE (high molecular weight ..) and UHMWPE (ultra high molecular weight ..). On the other hand, PE copolymers (e.g. with vinyl acetate or acrylates) are normally branched polymers.

**General Description** : A semi-crystalline (typically around 50%), whitish, semi-opaque commodity thermoplastic that is soft, flexible and tough - even at low temperatures - with outstanding electrical properties but poor temperature resistance. It also has very good chemical resistance but is prone to environmental stress cracking; it has poor UV resistance (unless modified) and poor barrier properties, except to water.

Applications include containers, chemically resistant linings, films (which are transparent if thin) for packaging etc. and electrical/electronic applications including cable insulation and cores in UHF cables.

#### Physical Properties

Density	0.92 g cm <sup>-3</sup>
Flammability	HB
Limiting oxygen index	17 %
Radiation resistance	Fair
Refractive index	1.51
Resistance to Ultra-violet	Poor
Water absorption - over 24 hours	< 0.015 %

#### Electrical Properties

Dielectric constant @1MHz	2.2-2.35
Dielectric strength	27 kV mm <sup>-1</sup>
Dissipation factor @ 1MHz	1-10 x 10 <sup>-4</sup>
Surface resistivity	10 <sup>13</sup> Ohm/sq
Volume resistivity	10 <sup>15</sup> -10 <sup>18</sup> Ohmcm

#### Thermal Properties

Coefficient of thermal expansion	100-200 x10 <sup>-6</sup> K <sup>-1</sup>
Heat-deflection temperature - 0.45MPa	50 C
Heat-deflection temperature - 1.8MPa	35 C
Lower working temperature	-60 C
Specific heat	1900-2300 J K <sup>-1</sup> kg <sup>-1</sup>
Thermal conductivity @23C	0.33 W m <sup>-1</sup> K <sup>-1</sup>
Upper working temperature	50-90 C

#### Mechanical Properties

Elongation at break	400 %
Hardness - Rockwell	D41-46 - Shore
Izod impact strength	> 1000 J m <sup>-1</sup>
Tensile modulus	0.1-0.3 GPa
Tensile strength	5-25 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



## Fibre

ET315710

Tex Number ..... 110  
 Condition..... Multi-filament Yarn

Number of filaments ..... 90  
 Condition..... Textile grade

#### Length

Web Code
684-016-612
128-463-711
233-965-202
329-134-138
442-378-197

#### Quantity

Length	1 Reel
50 m	GBP 110.00
100 m	GBP 131.00
200 m	GBP 162.00
500 m	GBP 230.00
1000 m	GBP 339.00

## Polyethylene - U.H.M.W.

### UHMW PE

**Common Brand Names** : Hostalen GUR, Stamylan UH

**See also General Information under Polyethylene - Low density**

**General Description** : A semi-crystalline, whitish and effectively opaque engineering thermoplastic which, chemically, is a very high molecular weight (3-6 million) HDPE. As a result it has an extremely high (effectively infinite) melt viscosity and can only be processed by powder sintering methods. It also has outstanding toughness and cut and wear resistance and very good chemical resistance, somewhat better than that of HDPE.

Applications include many "wear parts" (eg bottle handling machine components), gears, bearings, artificial joints and marine quay headings.

Fibres of very high molecular orientation can also be made from polyethylene of very high molecular weight by gel spinning and subsequent drawing to give fibres which are reported to be up to 85% crystalline and with 95% parallel orientation. They are known as Ultra High Modulus or High Performance Polyethylene fibre (UHMPE or HPPE). A modest range of fibre, braided cord and fabrics are available from Goodfellow.

Like Kevlar, these fibres have very high tensile properties and (small) negative CTE's. On a volume basis, their tensile properties are broadly similar to Kevlar's but, on a weight basis, they are superior thanks to an almost 50% density advantage - but they are not up to the properties of carbon fibre on either basis. Their energy absorption and acoustic velocity characteristics are superior to Kevlar's both as fabric and composite. Applications are being developed particularly in the areas of ballistic protection and ropes (in the widest sense).

**Physical Properties**

Density	0.94 g cm <sup>-3</sup>
Flammability	HB
Limiting oxygen index	17 %
Radiation resistance	Fair
Resistance to Ultra-violet	Poor
Water absorption - over 24 hours	< 0.01 %

**Electrical Properties**

Dielectric constant @1MHz	2.3
Dielectric strength	28 kV mm <sup>-1</sup>
Dissipation factor @ 1MHz	1-10 x 10 <sup>-4</sup>
Surface resistivity	10 <sup>13</sup> Ohm/sq
Volume resistivity	10 <sup>18</sup> Ohmcm

**Thermal Properties**

Coefficient of thermal expansion	130-200 x10 <sup>-6</sup> K <sup>-1</sup>
Heat-deflection temperature - 0.45MPa	69 C
Heat-deflection temperature - 1.8MPa	42 C
Specific heat	1900 J K <sup>-1</sup> kg <sup>-1</sup>
Thermal conductivity @23C	0.42-0.51 W m <sup>-1</sup> K <sup>-1</sup>
Upper working temperature	55-95 C

**Mechanical Properties**

Coefficient of friction	0.1-0.2
Elongation at break	500 %
Hardness - Rockwell	R50-70
Izod impact strength	> 1000 J m <sup>-2</sup>
Poisson's ratio	0.46
Tensile modulus	0.2-1.2 GPa
Tensile strength	20-40 MPa

**Chemical Resistance**

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



## Fibre

Material		Dyneema <sup>®</sup>	Spectra A <sup>®</sup>	Spectra B <sup>®</sup>
Density	g cm <sup>-3</sup>	0.97	0.97	0.97
Extension to break	%	3.5	3.5	2.7
Modulus	GPa	87	120	170
Specific Modulus	cN/tex	9000	12500	17500
Shrinkage @100C	%	< 1		
Specific Tenacity	cN/tex	265	265	310
Thermal Conductivity @23C	W m <sup>-1</sup> K <sup>-1</sup>	20 (axial)		

**ET305711** Tex Number ..... **145** Number of filaments ..... **1300**  
 Condition ..... **Multi-filament Yarn**

Length	Quantity	
	Length	1 Reel
768-432-553	50 m	GBP 105.00
409-850-176	100 m	GBP 126.00
952-730-516	200 m	GBP 161.00
659-986-810	500 m	GBP 246.00
451-493-739	1000 m	GBP 360.00

Yarn grade : Dyneema<sup>®</sup> Ultra-high strength and modulus.

**ET305720** Tex Number ..... **1670** Cord diameter ..... **1.5mm**  
 Condition ..... **Braided Cord**

Length	Quantity	
	Length	1 Reel
027-575-953	1 m	GBP 75.50
446-995-852	2 m	GBP 83.50
874-475-163	5 m	GBP 103.00
309-392-061	10 m	GBP 133.00
674-007-265	20 m	GBP 165.00
250-902-080	50 m	GBP 251.00
362-753-399	100 m	GBP 383.00

Yarn grade : Dyneema<sup>®</sup> Breaking load : 720kg.

Polymer – Polyethylene - U.H.M.W.

## Polyethylene - U.H.M.W.

### UHMW PE



## Fibre

ET305740

Tex Number ..... 26720  
 Condition..... Braided Cord

Cord diameter ..... 6mm  
 Condition..... Supplied with a Polyester over-braid

#### Length

**Web Code**  
 537-753-776  
 209-669-137  
 241-655-702  
 685-569-325  
 987-819-687

#### Quantity

**Length 1 Reel**  
 1 m GBP 94.50  
 2 m GBP 110.00  
 5 m GBP 146.00  
 10 m GBP 193.00  
 20 m GBP 278.00

Yarn grade : Dyneema<sup>®</sup> Breaking load : 720kg.

## 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<sup>-3</sup>  
 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 %

#### Mechanical Properties

Coefficient of friction 0.2-0.4  
 Hardness - Rockwell M94-101  
 Izod impact strength 13-35 J m<sup>-1</sup>  
 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

#### Electrical Properties

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

#### Thermal Properties

Coefficient of thermal expansion 20-80 x10<sup>-6</sup> K<sup>-1</sup>  
 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<sup>-1</sup> kg<sup>-1</sup>  
 Thermal conductivity @23C 0.15-0.4 W m<sup>-1</sup> K<sup>-1</sup>  
 Upper working temperature 115-170 C



## Fibre

Material		Medium	High tenacity
Density	g cm <sup>-3</sup>	1.39	1.39
Extension to break	%	36	13-16
Modulus	GPa		9-11
Specific Modulus	cN/tex		700-800
Shrinkage @100C	%	4	1.5-6
Specific Tenacity	cN/tex	36	70-80

ES305710

Tex Number ..... 3.3  
 Number of filaments ..... 15

Filament diameter ..... 0.014mm  
 Condition..... Medium Tenacity

#### Length

**Web Code**  
 015-523-954  
 940-488-582  
 561-072-909  
 134-124-725

#### Quantity

**Length 1 Reel**  
 100 m GBP 77.00  
 200 m GBP 88.50  
 500 m GBP 122.00  
 1000 m GBP 177.00

Continuous multi-filament yarn

Polymer - Polyethylene - U.H.M.W.

## Polyethylene terephthalate

### Polyester, PET, PETP



## Fibre

**ES305720**

Tex Number ..... **7.4**  
 Number of filaments ..... **24**

Filament diameter ..... **0.017mm**  
 Condition ..... **High Tenacity**

#### Length

**Web Code**  
 765-592-482  
 699-060-446  
 382-559-462  
 819-936-513

#### Quantity

**Length 1 Reel**  
 100 m GBP 77.50  
 200 m GBP 89.00  
 500 m GBP 123.00  
 1000 m GBP 178.00

Continuous multi-filament yarn

**ES305730**

Tex Number ..... **110**  
 Number of filaments ..... **192**

Filament diameter ..... **0.023mm**  
 Condition ..... **High Tenacity**

#### Length

**Web Code**  
 492-066-966  
 508-365-072  
 545-636-762  
 204-588-524

#### Quantity

**Length 1 Reel**  
 100 m GBP 99.00  
 200 m GBP 118.00  
 500 m GBP 174.00  
 1000 m GBP 266.00

Continuous multi-filament yarn

## Polypropylene

### PP

**Common Brand Names :** Appryl, Hostalen PP, Lacqtene, Novolen, Propathene

**General Description :** A semi-crystalline, white, semi-opaque commodity thermoplastic made in a very wide variety of grades and modifications. It is a linear polyolefin which can be compared in many ways to high density polyethylene (HDPE) and that is manufactured in a very similar way. The catalysts used control the polymer's stereoregularity quite well so that commercial polypropylenes are usually predominantly isotactic. Polypropylene homopolymer is harder and has a higher temperature resistance than HDPE but lower impact resistance and becomes brittle below 0°C. Hence copolymer grades are preferred for all applications exposed to cold/winter conditions. These copolymers have better impact strength, maintained down to lower temperatures, than homopolymer at the expense of quite small reductions in other properties. Like polyethylenes, polypropylene has good chemical but poor UV resistance (unless stabilised or protected).

Applications include (for homopolymers) appliance housings, housewares, packaging, cassette holders and fibres, monofilaments and slit-film tapes; for copolymers pipes, containers, boat hulls, seat shells and automotive parts e.g. battery cases and bumpers though the latter are often made from more heavily elastomer-modified polypropylenes.

#### Physical Properties

Density 0.9 g cm<sup>-3</sup>  
 Flammability HB  
 Limiting oxygen index 18 %  
 Radiation resistance Fair  
 Refractive index 1.49  
 Resistance to Ultra-violet Poor  
 Water absorption - equilibrium 0.03 %

#### Mechanical Properties

Abrasive resistance - ASTM D1044 13-16 mg/1000 cycles  
 Coefficient of friction 0.1-0.3  
 Elongation at break 150-300, for biax film > 50 %  
 Hardness - Rockwell R80-100  
 Izod impact strength 20-100 J m<sup>-1</sup>  
 Tensile modulus 0.9-1.5, for biax film 2.2-4.2, GPa  
 Tensile strength 25-40, for biax film 130-300, MPa

#### Electrical Properties

Dielectric constant @1MHz 2.2-2.6  
 Dielectric strength 30-40 kV mm<sup>-1</sup>  
 Dissipation factor @ 1MHz 0.0003 - 0.0005  
 Surface resistivity 10<sup>13</sup> Ohm/sq  
 Volume resistivity 10<sup>16</sup>-10<sup>18</sup> Ohmcm

#### Chemical Resistance

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

#### Thermal Properties

Coefficient of thermal expansion 100-180 x10<sup>-6</sup> K<sup>-1</sup>  
 Heat-deflection temperature - 0.45MPa 100-105 C  
 Heat-deflection temperature - 1.8MPa 60-65 C  
 Lower working temperature -10 to -60 C  
 Specific heat 1700 - 1900 J K<sup>-1</sup> kg<sup>-1</sup>  
 Thermal conductivity @23C 0.1-0.22 W m<sup>-1</sup> K<sup>-1</sup>  
 Upper working temperature 90-120 C



## Fibre

**PP305747**

Tex Number ..... **47**  
 Condition ..... **Medium Tenacity**

Number of filaments ..... **86**

#### Length

**Web Code**  
 318-176-732  
 268-039-975  
 414-553-240  
 767-836-967  
 384-127-617

#### Quantity

**Length 1 Reel**  
 100 m GBP 77.50  
 200 m GBP 89.00  
 500 m GBP 123.00  
 1000 m GBP 178.00  
 2000 m GBP 287.00

## Polytetrafluoroethylene

### PTFE

**Common Brand Names :** Fluon, Hostaflon TF

**General Description :** A totally fluorinated polymer that is semi-crystalline, semi-opaque and white. It has outstanding chemical resistance being unaffected by almost all chemicals and also has a very high oxygen index (i.e. is inherently non-flam). It has a very low coefficient of friction and is stable to high temperatures. It is soft, easily deformed, very prone to creep and low in strength with poor radiation resistance. It is very expensive and cannot be melt-processed (although in theory it melts at 327°C, its melt viscosity is virtually infinite) and so is formed by powder sintering methods.

Industrial applications include bearings, seals, O-rings, high temperature electrical insulation, non-stick coatings and linings for vessels etc, etc. Its unusual properties make it invaluable for a wide range of laboratory applications.

**Physical Properties**

Density	2.2 g cm <sup>-3</sup>
Flammability	V0
Limiting oxygen index	95 %
Radiation resistance	Poor
Refractive index	1.38
Resistance to Ultra-violet	Excellent
Water absorption - over 24 hours	0.01 %

**Electrical Properties**

Dielectric constant @1MHz	2.0-2.1
Dielectric strength	50-170 kV mm <sup>-1</sup>
Dissipation factor @ 1MHz	0.0003 - 0.0007
Surface resistivity	10 <sup>17</sup> Ohm/sq
Volume resistivity	10 <sup>18</sup> -10 <sup>19</sup> Ohmcm

**Thermal Properties**

Coefficient of thermal expansion	100-160 x10 <sup>-6</sup> K <sup>-1</sup>
Heat-deflection temperature - 0.45MPa	120 C
Heat-deflection temperature - 1.8MPa	54 C
Lower working temperature	-260 C
Specific heat	1000 J K <sup>-1</sup> kg <sup>-1</sup>
Thermal conductivity @23C	0.25 W m <sup>-1</sup> K <sup>-1</sup>
Upper working temperature	180-260 C

**Mechanical Properties**

Coefficient of friction	0.05-0.2
Elongation at break	400 %
Hardness - Rockwell	D50-55 - Shore
Izod impact strength	160 J m <sup>-1</sup>
Poisson's ratio	0.46
Tensile modulus	0.3-0.8 GPa
Tensile strength	10-40 MPa

**Chemical Resistance**

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



### Fibre

**FP305722**

Tex Number ..... **22**  
 Number of filaments ..... **30**

Filament diameter ..... **0.0211mm**  
 Colour ..... **Brown**



Xi

**Length**

**Web Code**  
 811-351-325  
 418-915-208  
 364-402-763  
 550-340-963

**Quantity**

Length	1 Reel
100 m	GBP 101.00
200 m	GBP 120.00
500 m	GBP 165.00
1000 m	GBP 252.00

**FP305744**

Tex Number ..... **44**  
 Number of filaments ..... **60**

Filament diameter ..... **0.0211mm**  
 Colour ..... **Brown**



Xi

**Length**

**Web Code**  
 792-618-032  
 077-257-640  
 657-202-911  
 150-374-990  
 796-873-889

**Quantity**

Length	1 Reel
100 m	GBP 107.00
200 m	GBP 127.00
500 m	GBP 180.00
1000 m	GBP 267.00
2000 m	GBP 442.00

## Vectra<sup>®</sup> A - Liquid Crystal Polyester

### Vectra<sup>®</sup> A

**Common Brand Names :** Vectra<sup>®</sup> A, Xydar

**Physical Properties**

Density	1.40 g cm <sup>-3</sup>
Flammability	V0 @ 0.8mm
Limiting oxygen index	35 %
Radiation resistance	Good
Resistance to Ultra-violet	Good
Water absorption - equilibrium	0.03 %
Water absorption - over 24 hours	0.02 %

**Electrical Properties**

Dielectric constant @1MHz	3.0
Dielectric strength	47 @ 1.5mm kV mm <sup>-1</sup>
Dissipation factor @ 1MHz	0.02
Surface resistivity	4x10 <sup>13</sup> Ohm/sq
Volume resistivity	10 <sup>16</sup> Ohmcm

**Thermal Properties**

Coefficient of thermal expansion	-5 to +75 x10 <sup>-6</sup> K <sup>-1</sup>
Heat-deflection temperature - 0.45MPa	220 C
Heat-deflection temperature - 1.8MPa	180 C
Lower working temperature	~ -200 C
Specific heat	1000 J K <sup>-1</sup> kg <sup>-1</sup>
Thermal conductivity @23C	0.18 W m <sup>-1</sup> K <sup>-1</sup>
Upper working temperature	200-220 C

**Mechanical Properties**

Abrasive resistance - ASTM D1044	56 mg/1000 cycles
Coefficient of friction	0.12-0.14
Compressive strength	70 MPa
Elongation at break	3 %
Hardness - Rockwell	M60
Izod impact strength	520 J m <sup>-1</sup>
Tensile modulus	2-10 GPa
Tensile strength	55-165 MPa

**Chemical Resistance**

Acids - concentrated	Good-Poor
Acids - dilute	Good
Alcohols	Good
Alkalies	Good-Fair
Aromatic hydrocarbons	Good
Greases and Oils	Good
Halogenated Hydrocarbons	Good(?)
Halogens	Good
Ketones	Good

## Vectra<sup>®</sup> A - Liquid Crystal Polyester

### Vectra<sup>®</sup> A

The colour of this material may vary significantly between batches.



### Fibre

Material		Vectran HS
Coefficient of thermal expansion	$\times 10^{-6} \text{ K}^{-1}$	-ve.
Density	$\text{g cm}^{-3}$	1.4
Extension to break	%	3.3
Modulus	GPa	65
Specific Modulus	cN/tex	4800
Shrinkage @100C	%	= < 0.5
Specific Tenacity	cN/tex	210

**ES315717** Tex Number ..... 167  
 Number of filaments ..... 300

Filament diameter ..... 0.023mm

#### Length

**Web Code**  
 050-226-618  
 278-335-204  
 791-912-435  
 989-057-649  
 632-207-667  
 025-959-448

#### Quantity

Length	1 Reel
10 m	GBP 74.50
20 m	GBP 88.00
50 m	GBP 124.00
100 m	GBP 177.00
200 m	GBP 256.00
500 m	GBP 478.00

Polymer – Vectra<sup>®</sup> A - Liquid Crystal Polyester

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