

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



Goodfellow Cambridge Limited

Ermine Business Park
HUNTINGDON
PE29 6WR
England

Tel: +44 1480 424 800
or +44 1480 424 800
Fax: +44 1480 424 900
or +44 1480 424 900

Goodfellow Corporation

125 Hookstown Grade Road
Coraopolis, PA 15108-9302
USA

Tel: 1-800-821-2870 (USA and Canada)
or +1 724 695 7060
Fax: 1-800-283-2020 (USA and Canada)
or +1 724 695 7063

Goodfellow SARL

229, rue Solférino
F-59000 Lille
France

Tel : 0800 917 241 (numéro vert)
or +44 1480 424 813
Fax : 0800 917 313 (numéro vert)
or +44 1480 424 900

Goodfellow GmbH

Am Edelspfad 4
D-61169 Friedberg
Germany

Tel: 0800 1000 579 (freecall)
or +44 1480 424 810
Fax: 0800 1000 580 (freecall)
or +44 1480 424 900

Goodfellow (Shanghai) Trading Co., Ltd

Room 803, Centro Build, No. 568 Hengfeng Road
SHANGHAI
200070

The People's Republic of China
Tel: 00 86 21 6112 1560

Standard Price List for All Bars

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Introduction

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

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

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

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

Materials

Metals and Alloys

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

Ceramics

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

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

Polymers

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

Compounds & Intermetallics

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

Composites

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

Glasses

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

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

Product Descriptions



Bar

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

Tolerances

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



Bolt

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

Tolerances

Ceramics: ANSI B18.6.7M-1985



Chopped Fibre

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

Tolerances

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



Crucible

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

Tolerances

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



Fabric

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

Tolerances

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



Fibre

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

Tolerances

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



Film

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

Tolerances

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



Flake

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

Tolerances

Dimensions shown are nominal

Product Descriptions



Foam

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



Foil

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

Tolerances

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



Granule

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

Tolerances

Dimensions shown are nominal



Honeycomb

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

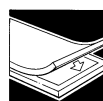


Insulated Wire

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

Tolerances

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



Laminate

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

Tolerances

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

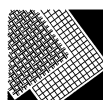


Lump

A solid piece of material with no defined shape.

Tolerances

Dimensions shown are nominal



Mesh

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

Tolerances

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

Product Descriptions



Metallised Film

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

Tolerances

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



Microfoil

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

Tolerances

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



Microleaf

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

Tolerances

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



Monofilament

A single strand of a non-metallic material.

Tolerances

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



Non-Woven Fabric

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

Tolerances

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



Nut

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

Tolerances

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



Powder

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

Tolerances

Dimensions shown are nominal

Product Descriptions



Rod

A straight length of circular section material.

Tolerances

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



Sheet

Flat material with a thickness > 0.5mm.

Tolerances

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



Single Crystal

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

Tolerances

Orientation:	± 3°
Size:	Sizes shown are nominal



Sphere

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

Tolerances

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



Sputtering Target

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

Tolerances

Thickness:	± 0.5mm
Size:	± 0.5mm



Tube

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

Tolerances

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



Washer

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

Tolerances

Ceramics:	see item
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Product Descriptions



Wire

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

Tolerances

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

Hazards Information

HAZARDS

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

HAZARD SYMBOLS



C

Corrosive

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



D

Dangerous when wet

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



E

Explosive

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



F+

Extremely flammable

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



Xn

Harmful

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



F

Highly flammable

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



Xi

Irritant

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



R

Radioactive

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



T

Toxic

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



T+

Very Toxic

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

General Information

Analyses

Typical Analysis :

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

Purity

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

High Purity

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

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

Supports

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

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

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

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

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

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

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

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

Vacuum tight

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

Continuous Lengths

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

Technical Data and Information

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

Tolerances

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

Order information

General Information

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

Prices

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

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

Transport Restriction

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

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

Delivery

Split shipment

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

Special Analysis, Supports or Tolerances

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

Cancellations

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

Express Service

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

Shipment

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

Despatch

Orders will normally be despatched within 48 hours of receipt.

Non delivery

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

Insurance

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

Export Restrictions

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

Materials Handling

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

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

Terms of payment

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

Order information

Credit account

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

Credit card payments

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

Mastercard, VISA, American Express, DELTA and Switch.

VAT

VAT number: GB 212 8527 79

UK

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

EU

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

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

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

Export

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

Return of goods

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

Claims

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

Goods ordered in error

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

Conditions of sale

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

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

Exclusions

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

Law

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

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

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

Order information

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

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

Company Details

Company Structure

The Goodfellow Group consists of five companies:

Goodfellow Cambridge Limited

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

Goodfellow Corporation

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

Goodfellow GmbH

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

Goodfellow SARL

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

Goodfellow (Shanghai) Trading Co., Ltd

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

COMPANY DETAILS

Goodfellow Cambridge Limited

Ermine Business Park
HUNTINGDON
PE29 6WR
England
Registered in England and Wales no. 1188162
VAT registration GB 212 8527 79

Goodfellow Corporation

125 Hookstown Grade Road
Coraopolis, PA 15108-9302
USA
A Pennsylvania corporation
EIN 23-2557381

Goodfellow SARL

229, rue Solférino
F-59000 Lille
France
Registered in Lille : RCS : B 381 486 836
Siren : 381486836
Numéro de TVA Intracommunitaire :
FR 06 381 486 836

Goodfellow GmbH

Am Edelspfad 4
D-61169 Friedberg
Germany
Registered in Friedberg (Hessen) No. HRB 1309
Import VAT number DE112610478

Goodfellow (Shanghai) Trading Co., Ltd

Room 803, Centro Build, No. 568 Hengfeng Road
SHANGHAI
200070
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,

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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

Conditions of Sale

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

Chromium

Cr

Discovered in 1780 by N.L. Vanquelin in Paris, France.

Chromium is a bright, blue/white metal with excellent corrosion resistance. It is obtained by the aluminium reduction of Cr_2O_3 , the source of which is chromite, a double oxide of chromium and iron which generally also contains magnesium. It has an abundance within the earth's crust of approximately 100 ppm. Chromium is soluble in HCl and H_2SO_4 , but not in H_3PO_4 , HNO_3 or $HClO_4$ due to the formation of a stable and insoluble oxide layer on its surface; this, along with its hardness, has been used to advantage in the chromium plating of steel which has good corrosion resistance. Chromium is alloyed with nickel in the manufacture of heat resisting alloys, and with iron, or nickel and iron, to produce stainless and heat resistant steels.

Chromium is an important trace element for humans as it assists in the manufacture of glucose.

Atomic Properties

Atomic number	24
Atomic radius - Goldschmidt	0.128 nm
Atomic weight	51.996 amu
Crystal structure	Body centred cubic
Electronic structure	Ar $3d^5 4s^1$
Photo-electric work function	4.4 eV
Thermal neutron absorption cross-section	3.1 Barns
Valences shown	2, 3, 6

Physical Properties

Boiling point	2672 C
Density @20C	7.1 g cm ⁻³
Melting point	1857 C

Electrical Properties

Electrical resistivity @20C	13.2 μ Ohmcm
Temperature coefficient @0-100C	0.00214 K ⁻¹

Thermal Properties

Coefficient of thermal expansion @0-100C	6.5 x10 ⁻⁶ K ⁻¹
Latent heat of evaporation	6580 J g ⁻¹
Latent heat of fusion	260 J g ⁻¹
Specific heat @25C	518 J K ⁻¹ kg ⁻¹
Thermal conductivity @0-100C	94 W m ⁻¹ K ⁻¹

Natural isotope distribution

Mass No.	%
50	4.35
52	83.79
53	9.50
54	2.36

Mechanical Properties

Material condition	Soft	Hard	Polycrystalline
Bulk modulus			160.2 GPa
Hardness - Vickers	130	220	
Poisson's ratio			0.21
Tensile modulus			279 GPa
Tensile strength	103	689	MPa

Ionisation potential

No.	eV
1	6.77
2	16.5
3	31.0
4	49.1
5	69.3
6	90.6



Bar

CR008010

Side Length 2mm
 Purity..... 99.7+ %

Side Length (of longer side)2mm



Size
Web Code
 994-548-988

		Quantity	
Length		1pc	2pcs
100 mm		USD 356.00	USD 603.00

Typical Analysis : Al 10, C 40, Ca 20, Cu 5, Fe 2000, K <5, Mg <5, Mo 50, Na 10, P 5, Pb 5, S 5, Si 80, W 100.

Copper

Cu

Known to ancient civilisations.

Copper is a reddish coloured metal which is malleable and ductile. It has excellent thermal and electrical conductivities and good corrosion resistance. It is found in sulphide ores and as carbonate, arsenide and chloride (abundance in the Earth's crust is 50 ppm). Extraction of the metal involves roasting the ore to produce the oxide, followed by reduction and purification by electrolysis. The element is inert to non-oxidising acids but reacts with oxidising agents. In air, it will weather to produce the characteristic green patina of the carbonate. Copper will combine with oxygen on heating to produce CuO at red heat, and Cu₂O at elevated temperatures.

Pure copper has an electrical conductivity second only to that of silver and hence its main application is in the electrical industry. Copper is also the basis of many important alloys (e.g. brass, bronze and aluminium bronze) and has been traditionally considered to be one of the coinage metals, along with silver and gold, but being more common, is the least valued. It is one of the first metals ever to have been worked by man and is thought to have been mined for more than 5000 years.

Atomic Properties

Atomic number	29
Atomic radius - Goldschmidt	0.128 nm
Atomic weight	63.546 amu
Crystal structure	Face centred cubic
Electronic structure	Ar 3d ¹⁰ 4s ¹
Photo-electric work function	4.5 eV
Thermal neutron absorption cross-section	3.8 Barns
Valences shown	1, 2

Physical Properties

Boiling point	2567 C
Density @20C	8.96 g cm ⁻³
Melting point	1083 C

Electrical Properties

Electrical resistivity @20C	1.69 µOhmcm
Temperature coefficient @0-100C	0.0043 K ⁻¹
Thermal emf against Pt (cold 0C - hot 100C)	+0.76 mV

Natural isotope distribution

Mass No.	%
63	69.2
65	30.8

Thermal Properties

Coefficient of thermal expansion @0-100C	17.0 x10 ⁻⁶ K ⁻¹
Latent heat of evaporation	4796 J g ⁻¹
Latent heat of fusion	205 J g ⁻¹
Specific heat @25C	385 J K ⁻¹ kg ⁻¹
Thermal conductivity @0-100C	401 W m ⁻¹ K ⁻¹

Ionisation potential

No.	eV
1	7.73
2	20.29
3	36.8
4	55.2
5	79.9
6	103

Mechanical Properties

Material condition	Soft	Hard	Polycrystalline	
Bulk modulus			137.8	GPa
Hardness - Vickers	49	87		
Izod toughness	58	68		
Poisson's ratio			0.343	
Tensile modulus			129.8	GPa
Tensile strength	224	314		MPa
Yield strength	54	270		MPa



Bar

CU008021 Side Length **8.0mm**
 High Purity **99.995%**

Side Length (of longer side)**52mm**

Size

Web Code
 721-181-558
 528-161-256
 632-956-560

Length	Quantity		
	1pc	2pcs	5pcs
50 mm	USD 365.00	USD 603.00	USD 1292.00
100 mm	USD 582.00	USD 1037.00	
200 mm	USD 1016.00		

Typical Analysis : Ag 10, Fe 5, Pb 2, Sb 2, Sn 2.

Copper - O.F.H.C.

Cu - OFHC



Bar

CV008120 Side Length **20mm**
 Purity..... **99.95 + %**

Side Length (of longer side)**20mm**
 Condition..... **Machining feedstock**

Size

Web Code
 358-185-220
 906-206-250
 587-258-498

Length	Quantity		
	1pc	2pcs	5pcs
100 mm	USD 217.00	USD 310.00	USD 574.00
200 mm	USD 286.00	USD 460.00	
500 mm	USD 512.00		

Typical Analysis : Ag 100, Al 1, Bi 1, Ca 3, Cd 1, Fe 2, Mg 1, Pb 3, Si 2, Sn 2.

Indium

In

Discovered in 1863 by F. Reich and H. Richter in Freiberg, Germany.

Indium derives its name from the characteristic indigo line in its spectrum. It is a soft, malleable and ductile metal which is generally unaffected by air or water but is soluble in acids. It is found only in the form of minor components of various minerals (as are gallium and thallium, other members of the boron group of elements in the periodic table) and the pure element is produced by electrolytic reduction in aqueous solution. It has an abundance in the earth's crust of 0.049 ppm.

Indium has a large cross-section for slow neutrons and is, therefore, readily activated. Indium is used in the forms of InAs and InSb within the semiconductor industry in thermistors and transistors. As a result of its physical properties, it is particularly suited to being used as a sealing material in vacuum systems and also as bonding material in acoustic transducers. Indium is also widely used in the manufacture of "fusible" materials, a range of alloys which have low melting points and can be used as thermal fuses and solders.

Atomic Properties

Atomic number	49
Atomic radius - Goldschmidt	0.157 nm
Atomic weight	114.82 amu
Crystal structure	Face centred tetragonal
Electronic structure	Kr 4d ¹⁰ 5s ² 5p ¹
Photo-electric work function	4.12 eV
Thermal neutron absorption cross-section	194 Barns
Valences shown	1, 2, 3

Natural isotope distribution	Mass No.	%
	113	4.3
	115	95.7

Ionisation potential	No.	eV
	1	5.79
	2	18.9
	3	28.0
	4	54

Physical Properties

Boiling point	2080 C
Density @20C	7.3 g cm ⁻³
Melting point	156.6 C

Electrical Properties

Electrical resistivity @20C	8.8 μOhmcm
Temperature coefficient @0-100C	0.0052 K ⁻¹
Superconductivity critical temperature	3.41 K
Thermal emf against Pt (cold 0C - hot 100C)	+ 0.69 mV

Thermal Properties

Coefficient of thermal expansion @0-100C	24.8 x10 ⁻⁶ K ⁻¹
Latent heat of evaporation	2024 J g ⁻¹
Latent heat of fusion	28.5 J g ⁻¹
Specific heat @25C	234 J K ⁻¹ kg ⁻¹
Thermal conductivity @0-100C	81.8 W m ⁻¹ K ⁻¹

Mechanical Properties

Material condition	Soft	Polycrystalline
Bulk modulus		35.3 GPa
Hardness - Vickers	< 10	
Poisson's ratio		0.45
Tensile modulus		10.6 GPa
Tensile strength	2.6-4.5 MPa	



Bar

IN008010

Side Length 27mm
 High Purity 99.999%

Side Length (of longer side)35mm

Size

Web Code
 971-289-514

Quantity

Length	150 mm
Quantity	1pc POA

Typical Analysis : Ag <1, Cd <1, Fe <1, Pb 4, Sn 3, Tl 1.

Lead

Pb

Lead has been known of and used since prehistoric times.

Lead is a soft, malleable and ductile metal. It has an abundance in the earth's crust of 14 ppm., the main source of the metal being the ore "galena", lead (II) sulphide (PbS) which occurs as grey cubic crystals, often in conjunction with "sphalerite", the equivalent sulphide of zinc.

Lead oxidises readily in moist air, is stable to oxygen and water, but dissolves in nitric acid. It is a poor electrical and thermal conductor but has reasonable corrosion resistance. Applications for this metal are wide and varied; for example, its relative imperviousness to radiation makes it ideal as radiation shielding material for use with X-ray equipment. Lead is also used in ceramic glazes, batteries, paints, as a fuel additive in petrol (lead tetraethyl) and as a prime constituent of soft solders. However, its use is now being discouraged as lead is now known to be detrimental to health, particularly to that of children.

Atomic Properties

Atomic number	82
Atomic radius - Goldschmidt	0.175 nm
Atomic weight	207.2 amu
Crystal structure	Face centred cubic
Electronic structure	Xe 4f ¹⁴ 5d ¹⁰ 6s ² 6p ²
Photo-electric work function	4.0 eV
Thermal neutron absorption cross-section	0.18 Barns
Valences shown	2, 4

Natural isotope distribution	Mass No.	%
	204	1.4
	206	24.1
	207	22.1
	208	52.4

Ionisation potential	No.	eV
	1	7.42
	2	15.03
	3	31.9
	4	42.3
	5	68.8

Physical Properties

Boiling point	1740 C
Density @20C	11.35 g cm ⁻³
Melting point	327.5 C

Electrical Properties

Electrical resistivity @20C	20.6 μOhmcm
Temperature coefficient @0-100C	0.0042 K ⁻¹
Superconductivity critical temperature	7.196 K
Thermal emf against Pt (cold 0C - hot 100C)	+0.44 mV

Thermal Properties

Coefficient of thermal expansion @0-100C	29.0 x10 ⁻⁶ K ⁻¹
Latent heat of evaporation	862 J g ⁻¹
Latent heat of fusion	23.2 J g ⁻¹
Specific heat @25C	159 J K ⁻¹ kg ⁻¹
Thermal conductivity @0-100C	35.3 W m ⁻¹ K ⁻¹

Mechanical Properties

Material condition	Sand cast Polycrystalline
Bulk modulus	45.8 GPa
Hardness - Mohs	1.5
Poisson's ratio	0.44
Tensile modulus	16.1 GPa
Tensile strength	12 MPa
Yield strength	5.5 MPa



Bar

PB008010

Side Length **20mm**
 High Purity **99.999+%**

Side Length (of longer side) **40mm**
 Condition **Semicircular cross section, rounded ends**

Size

Web Code
 663-973-822

Length	1pc
175 mm	POA

Typical Analysis : Ag 1, Bi 1, Cd <1, Cu 1, Fe <1, Ni <1, Sn <1.
 Nominal ingot weight : 1000g.

Metal - Lead

Ruthenium

Ru

Ruthenium was initially discovered in 1808 by J.A. Sniadecki at the University of Vilno, Poland and then again by G.W. Osnann in 1828 at the University of Tartu, Russia.

Ruthenium is a rare member of the platinum group of metals (abundance 0.001 ppm in the earth's crust). It is a lustrous, silvery coloured metal which is unaffected by air, water and acids, but is soluble in fused alkalis. Extraction of the metal is achieved by several techniques; for example, extraction of the mixed platinum group metals by dissolution in aqua regia, followed by treatment of the various soluble and insoluble fractions.

Applications of the metal are limited; as a pure metal, ruthenium is extremely hard and brittle and, consequently, difficult to machine. It is relatively unreactive, and is used as an alloying element with platinum and palladium to produce alloys which have improved wear resistance, and with titanium to improve the material's corrosion resistance. In all cases, the ruthenium addition has to be less than 15%, otherwise the resultant alloy is too hard to work.

Atomic Properties

Atomic number	44
Atomic radius - Goldschmidt	0.134 nm
Atomic weight	101.07 amu
Crystal structure	Hexagonal close packed
Electronic structure	Kr 4d ⁷ 5s ¹
Photo-electric work function	4.71 eV
Thermal neutron absorption cross-section	3.0 Barns
Valences shown	0, 1, 2, 3, 4, 5, 6, 7, 8

Physical Properties

Boiling point	3900 C
Density @20C	12.2 g cm ⁻³
Melting point	2310 C

Electrical Properties

Electrical resistivity @20C	7.7 µOhmcm
Temperature coefficient @0-100C	0.0041 K ⁻¹
Superconductivity critical temperature	0.49 K

Natural isotope distribution

Mass No.	%
96	5.5
98	1.9
99	12.7
100	12.6
101	17.1
102	31.6
104	18.6

Thermal Properties

Coefficient of thermal expansion @0-100C	9.6 x10 ⁻⁶ K ⁻¹
Latent heat of evaporation	5610 J g ⁻¹
Latent heat of fusion	252 J g ⁻¹
Specific heat @25C	238 J K ⁻¹ kg ⁻¹
Thermal conductivity @0-100C	117 W m ⁻¹ K ⁻¹

Ionisation potential

No.	eV
1	7.36
2	16.8
3	28.5

Mechanical Properties

Material condition	Soft	Hard	Polycrystalline
Bulk modulus			286 GPa
Hardness - Vickers	350	750	
Poisson's ratio			0.25
Tensile modulus			432 GPa
Tensile strength	495 MPa		
Yield strength	372 MPa		



Bar

RU008010

Side Length **2mm**
 Purity **99.9%**

Side Length (of longer side)**2mm**

Size

Web Code
 835-251-939
 508-169-988

Quantity

Length	1pc	2pcs
25 mm	USD 600.00	USD 1083.00
50 mm	USD 1040.00	

Typical Analysis : Ag <1, Au 3, Ca 30, Cr 3, Cu 2, Fe 30, Ir 50, Mg 3, Mn <1, Os 300, Pb 3, Pd 10, Pt 50, Rh 50, Si 20.

Tin Sn

Tin was known and used by ancient civilisations.

Tin is a silvery white metal which is soft and pliable, and which emits the characteristic sound of "tin cry" when bent. It is a relatively common element, its abundance being 2.2 ppm in the earth's crust. Its principal ore is cassiterite, SnO₂, from which the metal is obtained by reduction. Tin forms a stable oxide coating on its surface which makes it unreactive in water; however, it is soluble in both acids and alkalis, and reacts readily with halogens.

As tin has good chemical resistance, it is used as a coating of other metals to prevent corrosion, the coating of steel to produce tin plate being an important example of this application. Tin is widely used in the manufacture of soft solders where it is alloyed with other elements to produce a wide range of alloys with different characteristics. Tin is also a constituent of bronzes, pewter, certain bearing materials and fusible alloys.

Atomic Properties

Atomic number	50
Atomic radius - Goldschmidt	0.158 nm
Atomic weight	118.69 amu
Crystal structure	Tetragonal
Electronic structure	Kr 4d ¹⁰ 5s ² 5p ²
Photo-electric work function	4.3 eV
Thermal neutron absorption cross-section	0.63 Barns
Valences shown	2, 4

Natural isotope distribution

Mass No.	%
112	1.0
114	0.7
115	0.4
116	14.7
117	7.7
118	24.3
119	8.6
120	32.4
122	4.6
124	5.6

Ionisation potential

No.	eV
1	7.34
2	14.63
3	30.5
4	40.7
5	72.3

Physical Properties

Boiling point	2270 C
Density @20C	7.28 g cm ⁻³
Melting point	231.9 C

Electrical Properties

Electrical resistivity @20C	12.6 μOhmcm
Temperature coefficient @0-100C	0.0046 K ⁻¹
Superconductivity critical temperature	3.722 K
Thermal emf against Pt (cold 0C - hot 100C)	+0.42 mV

Thermal Properties

Coefficient of thermal expansion @0-100C	23.5 x10 ⁻⁶ K ⁻¹
Latent heat of evaporation	2497 J g ⁻¹
Latent heat of fusion	59.6 J g ⁻¹
Specific heat @25C	213 J K ⁻¹ kg ⁻¹
Thermal conductivity @0-100C	66.8 W m ⁻¹ K ⁻¹

Mechanical Properties

Material condition	Polycrystalline
Bulk modulus	58.2 GPa
Hardness - Mohs	1.5-1.8
Poisson's ratio	0.357
Tensile modulus	49.9 GPa



Bar

SN008100

Side Length **7mm**
 High Purity **99.9999%**

Side Length (of longer side)**12mm**

Size

Web Code
991-297-309
136-975-904
019-205-308
846-449-947
400-666-135
083-273-697

Length	Quantity			
	1pc	2pcs	5pcs	10pcs
12 mm	USD 262.00	USD 318.00	USD 548.00	USD 932.00
22 mm	USD 303.00			
25 mm	USD 322.00	USD 479.00	USD 952.00	
28 mm	USD 340.00			
50 mm	USD 477.00	USD 790.00	USD 1729.00	
75 mm	USD 632.00	USD 1101.00	USD 2506.00	

Typical Analysis : Ag 0.3, Ca 0.2, Mg 0.1, Si 0.1.

SN008150

Side Length **25mm**
 Purity **99.99+%**

Side Length (of longer side)**30mm**

Size

Web Code
093-130-064

Length	Quantity
	1pc
290 mm	POA

Typical Analysis : Ag <1, Al <1, Au 1, Bi 2, Cd 1, Cu <1, Fe 2, In <1, Mg 1, Ni 1, Pb 10, Si 5, Ti 1.
 Nominal ingot weight : 1000g.

Titanium

Ti

Titanium was discovered by Rev. William Gregor in 1791 in Creed, Cornwall, England and, independently, by M.H. Klaproth in 1795 in Berlin, Germany.

Titanium is a hard, lustrous, silvery metal which is obtained by magnesium or calcium reduction of the tetrachloride. It is a relatively abundant element, there being 5600 ppm in the earth's crust. It forms a protective oxide coating and, hence, resists corrosion, although powdered metal burns in air. Titanium tends to be inert at low temperatures but will combine with a variety of reagents at elevated temperatures.

Titanium and its alloys are characterised by their lightness, strength and corrosion resistance and are used widely in aerospace applications. In addition, these properties also make the material suitable for medical applications (e.g. replacement hip joints). Titanium dioxide, TiO₂ is used as a white pigment in paints and plastics as it provides great opacity. The same material is also used in the manufacture of heat resisting and durable glass, the TiO₂ replacing certain proportions of the soda. Titanium carbide is used to manufacture cemented carbides.

Atomic Properties

Atomic number	22
Atomic radius - Goldschmidt	0.147 nm
Atomic weight	47.88 amu
Crystal structure	Hexagonal close packed
Electronic structure	Ar 3d ² 4s ²
Photo-electric work function	4.1 eV
Thermal neutron absorption cross-section	6.1 Barns
Valences shown	2, 3, 4

Physical Properties

Boiling point	3287 C
Density @20C	4.5 g cm ⁻³
Melting point	1660 C

Electrical Properties

Electrical resistivity @20C	54 μOhmcm
Temperature coefficient @0-100C	0.0038 K ⁻¹
Superconductivity critical temperature	0.40 K

Natural isotope distribution

Mass No.	%
46	8.0
47	7.5
48	73.7
49	5.5
50	5.3

Thermal Properties

Coefficient of thermal expansion @0-100C	8.9 x10 ⁻⁶ K ⁻¹
Latent heat of evaporation	8893 J g ⁻¹
Latent heat of fusion	365 J g ⁻¹
Specific heat @25C	523 J K ⁻¹ kg ⁻¹
Thermal conductivity @0-100C	21.9 W m ⁻¹ K ⁻¹

Ionisation potential

No.	eV
1	6.82
2	13.6
3	27.5
4	43.3
5	99.2
6	119

Mechanical Properties

Material condition	Annealed	Polycrystalline
Bulk modulus	60	108.4 GPa
Hardness - Vickers	61 J m ⁻¹	
Izod toughness		
Poisson's ratio	0.361	
Tensile modulus	120.2	GPa
Tensile strength	230-460 MPa	
Yield strength	140-250 MPa	



Bar

TI008003

Side Length 10mm
 Purity..... 99.6+ %

Side Length (of longer side)12mm

Size

Web Code
 024-847-271
 871-756-044
 655-568-722
 289-180-194

Length	Quantity			
	1pc	2pcs	5pcs	10pcs
100 mm	USD 116.00	USD 140.00	USD 193.00	USD 322.00
200 mm	USD 138.00	USD 171.00	USD 318.00	
500 mm	USD 188.00	USD 316.00		
1000 mm	USD 313.00	USD 566.00		

Typical Analysis : Al 500, Co 2, Cr 500, Cu 200, Fe 300, Mg 20, Mn 500, Ni 500, Si 200, Sn 200, Ta 10, V 500.

TI008010

Side Length 50mm
 Purity..... 99.6+ %

Side Length (of longer side)50mm

Size

Web Code
 943-781-460

Length	Quantity
	1pc
100 mm	POA

Typical Analysis : Al 500, Co 2, Cr 500, Cu 200, Fe 300, Mg 20, Mn 500, Ni 500, Si 200, Sn 200, Ta 10, V 500.

Brass

Cu63/Zn37

Common Brand Names : Boltomet L[®], IMI 237[®], MS 63

Good machineability, excellent for hot working, forming and brazing. Uses include architectural grillwork, reflectors, chain, fasteners, rivets and screws.

Physical Properties

Density 8.45 g cm⁻³
 Melting point 900-920 C

Thermal Properties

Coefficient of thermal expansion @20-100C 19.0-20.5 x10⁻⁶ K⁻¹
 Thermal conductivity @23C 125 W m⁻¹ K⁻¹

Electrical Properties

Electrical resistivity 6.2-6.6 μOhmcm
 Temperature coefficient 0.0016-0.0017 K⁻¹

Mechanical Properties

Elongation at break < 55 %
 Hardness - Brinell 65-136
 Modulus of elasticity 95-110 GPa
 Shear strength 280-310 MPa
 Tensile strength 330-500 MPa



Bar

CU028020 Side Length 6.35mm

Side Length (of longer side)12.7mm

Size Web Code	Length	Quantity			
		1pc	2pcs	5pcs	10pcs
404-394-041	100 mm	USD 158.00	USD 183.00	USD 240.00	USD 319.00
790-271-627	200 mm	USD 174.00	USD 206.00	USD 276.00	
519-497-492	500 mm	USD 206.00	USD 251.00		
988-588-951	1000 mm	USD 243.00			

Magnetic Shape Memory Alloy

Ni50/Mn28/Ga22 (Atomic %)

Physical Properties

Density 8 g cm⁻³
 Melting point 1130 C

Electrical Properties

Electrical resistivity 70 μOhmcm
 Temperature coefficient 0.003 K⁻¹

Magnetic Properties

Coercivity (Hc) 4000 Am⁻¹
 Curie temperature 95 - 105 C
 Initial permeability 2
 Maximum permeability 90
 Remanence from saturation (Brem) 0.02 T
 Saturation flux density 0.6 T

Thermal Properties

Coefficient of thermal expansion @°C 20 x10⁻⁶ K⁻¹
 Crystallisation temperature 1090 C
 Maximum use temperature in air 45 C
 Temperature - Austenitic 50 C
 Temperature - Martensitic 45 C
 Thermal conductivity @°C 16 W m⁻¹ K⁻¹

Mechanical Properties

Hardness - Vickers 130 kgf mm⁻²
 Modulus of elasticity 8 - 20 GPa



Bar

MA048010 Side Length 1mm
 Condition..... Shape-Memory Alloy

Side Length (of longer side)2.5mm

Size Web Code	Length	Quantity	
		1pc	2pcs
606-453-592	20 mm	POA	POA

MA048015 Side Length 2mm
 Condition..... Shape-Memory Alloy

Side Length (of longer side)3mm

Size Web Code	Length	Quantity	
		1pc	2pcs
666-887-346	15 mm	POA	POA

MA048020 Side Length 3mm
 Condition..... Shape-Memory Alloy

Side Length (of longer side)5mm

Size Web Code	Length	Quantity	
		1pc	2pcs
457-498-858	20 mm	POA	POA

Alloy – Brass

Tungsten/Copper

W 72/Cu28

Common Brand Names : Copelmet[®]

Developed as an electrode material, this alloy is used for spark erosion electrodes and contacts giving excellent resistance to mechanical wear and electrical erosion.

Physical Properties

Density 14.4 g cm⁻³

Thermal Properties

Coefficient of thermal expansion @20C 10.5 x10⁻⁶ K⁻¹

Specific heat @25C 210 J K⁻¹ kg⁻¹

Thermal conductivity @23C 198 W m⁻¹ K⁻¹

Mechanical Properties

Hardness - Rockwell 92

Tensile strength 600 MPa



Bar

W 118100 Side Length 25mm

Side Length (of longer side)25mm

Size

Web Code

603-324-979

415-617-158

018-406-324

Quantity

Length	1pc	2pcs
50 mm	USD 355.00	USD 506.00
100 mm	USD 482.00	USD 798.00
200 mm	USD 773.00	

Alloy – Tungsten/Copper

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 ⁻³
Water absorption - saturation	0 %

Electrical Properties

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

Thermal Properties

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

Mechanical Properties

Compressive strength	2200-2600 MPa
Hardness - Knoop	2100 kgf mm ⁻²
Hardness - Vickers	1500-1650 kgf mm ⁻²
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



Bar

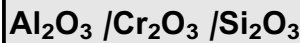
AL608025 Side Length 20mm

Side Length (of longer side)25mm

Size
Web Code
 362-882-764

Quantity	
Length	1pc
736 mm	USD 1245.00

Ruby



Ruby exhibits identical properties to those of Sapphire. Small amounts of impurities give Ruby a red colouration.

Physical Properties

Apparent porosity	0 %
Density	3.98 g cm ⁻³
Useful optical transmission range	150-5500nm
Water absorption - saturation	0 %

Electrical Properties

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

Thermal Properties

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

Mechanical Properties

Compressive strength	2100 MPa
Hardness - Knoop	2000 kgf mm ⁻²
Hardness - Vickers	2500-3000 kgf mm ⁻²
Tensile modulus	350-390 GPa
Tensile strength	250-400 MPa

Chemical Resistance

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



Bar

AJ608020 Side Length 2mm

Side Length (of longer side)2mm

Size
Web Code
 526-447-089

Quantity			
Length	1pc	2pcs	3pcs
12 mm	USD 425.00	USD 558.00	USD 738.00

Ceramic - Alumina

MACOR[®] Machinable Glass Ceramic
SiO₂ 46/Al₂O₃ 16/MgO 17/K₂O 10/B₂O₃ 7

Common Brand Names : MACOR[®]

This Machineable Ceramic is a white ceramic which can be machined with ordinary steel or carbide tools. It has been used extensively in the Space Shuttle Orbiter. It can be used continuously up to 800C and is a good electrical and thermal insulator. Outgassing in ultra-high vacuum environments can be eliminated, if degassed before use. MACOR[®] is non-wetting and can be bonded to itself as well as to various metals, if the MACOR[®] surfaces are first metallised.

Physical Properties

Apparent porosity 0 %
 Density 2.52 g cm⁻³

Magnetic Properties

Curie temperature 40 C
 Saturation flux density 5.9 T

Electrical Properties

Volume resistivity @25C > 10¹⁴ Ohmcm

Thermal Properties

Coefficient of thermal expansion @20-1000C 13 x10⁻⁶ K⁻¹
 Specific heat @25C 790 J K⁻¹ kg⁻¹
 Thermal conductivity @20C 1.5 W m⁻¹ K⁻¹
 Upper continuous use temperature 800-1000 C

Mechanical Properties

Compressive strength 345 MPa
 Hardness - Vickers 400 kgf mm⁻²
 Tensile modulus 67 GPa

Chemical Resistance

Acids - concentrated Poor
 Acids - dilute Fair
 Alkalis Fair



Bar

MA808110 Side Length 10mm

Side Length (of longer side)10mm

Size

Web Code
 379-013-692
 642-393-966

Length	Quantity		
	5pcs	10pcs	20pcs
50 mm	USD 216.00	POA	POA
100 mm	USD 266.00	POA	POA

Typical Analysis : Not applicable

MA808115 Side Length 15mm

Side Length (of longer side)15mm

Size

Web Code
 505-549-530

Length	Quantity		
	1pc	2pcs	5pcs
100 mm	USD 131.00	POA	POA

Typical Analysis : Not applicable

MA808120 Side Length 20mm

Side Length (of longer side)20mm

Size

Web Code
 677-226-999

Length	Quantity		
	1pc	2pcs	5pcs
100 mm	USD 229.00	POA	POA

Typical Analysis : Not applicable

MA808125 Side Length 25.4mm

Side Length (of longer side)25.4mm

Size

Web Code
 305-178-158
 147-266-171
 408-266-401

Length	Quantity		
	1pc	2pcs	5pcs
25 mm	USD 249.00	POA	POA
50 mm	USD 290.00	POA	POA
100 mm	USD 349.00	POA	POA

Typical Analysis : Not applicable

MA808250 Side Length 50.8mm

Side Length (of longer side)50.8mm

Size

Web Code
 499-361-023
 420-137-297

Length	Quantity			
	1pc	2pcs	3pcs	5pcs
25 mm	USD 359.00	POA	POA	POA
50 mm	USD 542.00	POA	POA	POA

Typical Analysis : Not applicable

Glass – MACOR[®] Machinable Glass Ceramic

INDEX

A

Alumina (Al₂O₃) 29

B

Bar

.. Alumina 29

.. Brass 27

.. Chromium 20

.. Copper 21

.. Copper - O.F.H.C. 21

.. Indium 22

.. Lead 23

.. MACOR[®] Machinable Glass Ceramic 30

.. Magnetic Shape Memory Alloy 27

.. Ruby 29

.. Ruthenium 24

.. Tin 25

.. Titanium 26

.. Tungsten/Copper 28

Boltomet L[®] 27

Brass (Cu63/Zn37) 27

C

Chromium (Cr) 20

Copelmet[®] 28

Copper (Cu) 21

Copper - O.F.H.C. (Cu - OFHC) 21

I

IMI 237[®] 27

Indium (In) 22

L

Lead (Pb) 23

M

MACOR[®] 30

MACOR[®] Machinable Glass Ceramic (SiO₂ 46/Al₂O₃ 16/

MgO 17/K₂O 10/B₂O₃ 7) 30

Magnetic Shape Memory Alloy (Ni50/Mn28/Ga22 (Atomic

%) 27

MS 63 27

R

Ruby (Al₂O₃ /Cr₂O₃ /Si₂O₃) 29

Ruthenium (Ru) 24

T

Tin (Sn) 25

Titanium (Ti) 26

Tungsten/Copper (W 72/Cu28) 28