GLASS

Glass Bulbs Limited

Glass Tubes and Components Limited

GEC

Cover picture:
Refractor pattern of glass cover
used in airfield runway lighting

1

Glass Bulbs Limited,
Harworth,
Near Doncaster,
Yorkshire,
England DN11 8NF

Tel: Doncaster 742631 (10 lines)
Telex: 547224
Telegrams and cables:
"Glassbulb, Harworth, Doncaster"

2

Glass Tubes & Components Ltd.,
Sheffield Road,
Chesterfield,
Derbyshire,
England S41 8LD

Tel: Chesterfield 77288 (10 lines)
Telex: 54486
Telegrams and cables:
"Glassparts, Chesterfield"

3

Glass Tubes & Components Ltd.,
Lemington,
Newcastle-upon-Tyne 5,
England,
NE15, 8SX

Tel: Lemington 67-4109 (4 lines)
Telex: 53275
Telegrams and cables:
"Glassparts, Newcastle-upon-Tyne"

Introduction

The two companies, Glass Bulbs Limited and Glass Tubes and Components Limited, were originally formed to supply glass components to the lamp, radio valve and electronics industries. The companies operate as a group with the same top management and joint technical, engineering and research services.

Glass Bulbs Limited was formed in 1948 to manufacture lamp bulbs by the latest ribbon machine technique. The factory at Harworth, near Doncaster, is the largest plant of its type outside the United States of America and produces the majority of the lamp bulbs used in Western Europe. The plant also manufactures most of the tubes for fluorescent lamps in Great Britain and all the borosilicate glass pressings for automobile sealed beam headlamps.

Glass Tubes and Components Limited was formed in 1962 by a merger of the glassworks of Osram (G.E.C.) Limited and of A.E.I. Lamp and Lighting Company Limited, to produce the tubing and special glass requirements of the lamp, radio valve and electronics industries.

At Chesterfield the company produces lead and soda glass tubing, the shorter run machine-made soda glass lamp and valve bulbs, vacuum flask blanks, lamp chimneys, lighting shades and large quantities of drinking ware.

Short run hand production of bulbs and pressings in a range of different glasses is carried out at Lemington-upon-Tyne.

This plant is one of the largest hand plant factories in Europe, producing a range of special glasses from fused silica with an expansion of 5×10^{-7} to special copper sealing glasses with an expansion in the region of 150×10^{-7}. This range also includes aluminosilicate, borosilicate and lead glasses in addition to special glasses for the absorption of infra-red and the transmission of ultra-violet wavelengths.

The experience gained in supplying the wide range of components required by the electrical, radio and electronics industries has resulted in the development of a high degree of skill which has been used to extend production into many other fields.

Glass tubing is supplied in very large quantities to pharmaceutical and scientific glassware manufacturers and to other industrial users throughout the world.

Blownware is supplied as tumblers and stemmed glasses, oil heater glasses, lamp chimneys, cathode ray bulbs, milk jars and coffee percolator components, as well as bulbs for flash, automobile, domestic and industrial lamps, vacuum flask blanks, lighting shades and ornaments.

Glass pressings are made for spirit measures, petrol pump glasses, cathode ray tube components, valve bases, beer mugs and various lenses, as well as for clear or coloured glass lamp covers for industrial and airfield use.

Various ancillary processes of glass grinding, polishing, fabrication, crushing, cutting, frosting, enamelling and decorating are carried out within the factories. Glass is produced in the form of rod, pellets, powder and cullet and supplied to other manufacturers, for example, to be made into glass fibre or sintered preforms.

The vast experience of making such a large variety of glasses using the complete range of techniques from the glass industry's most skilled hand craftsmen to the largest volume mechanical processes makes the group one of the most versatile glass manufacturers in Great Britain. Our background and skills in advanced glass technology as well as in routine processes enable us to place at our customers' disposal an unequalled knowledge in glass making. Therefore, whatever your requirements—standard ware, new designs or special glasses—you are cordially invited to discuss your problem with us and to take full advantage of the technical and production facilities offered by Glass Bulbs Limited and Glass Tubes and Components Limited.

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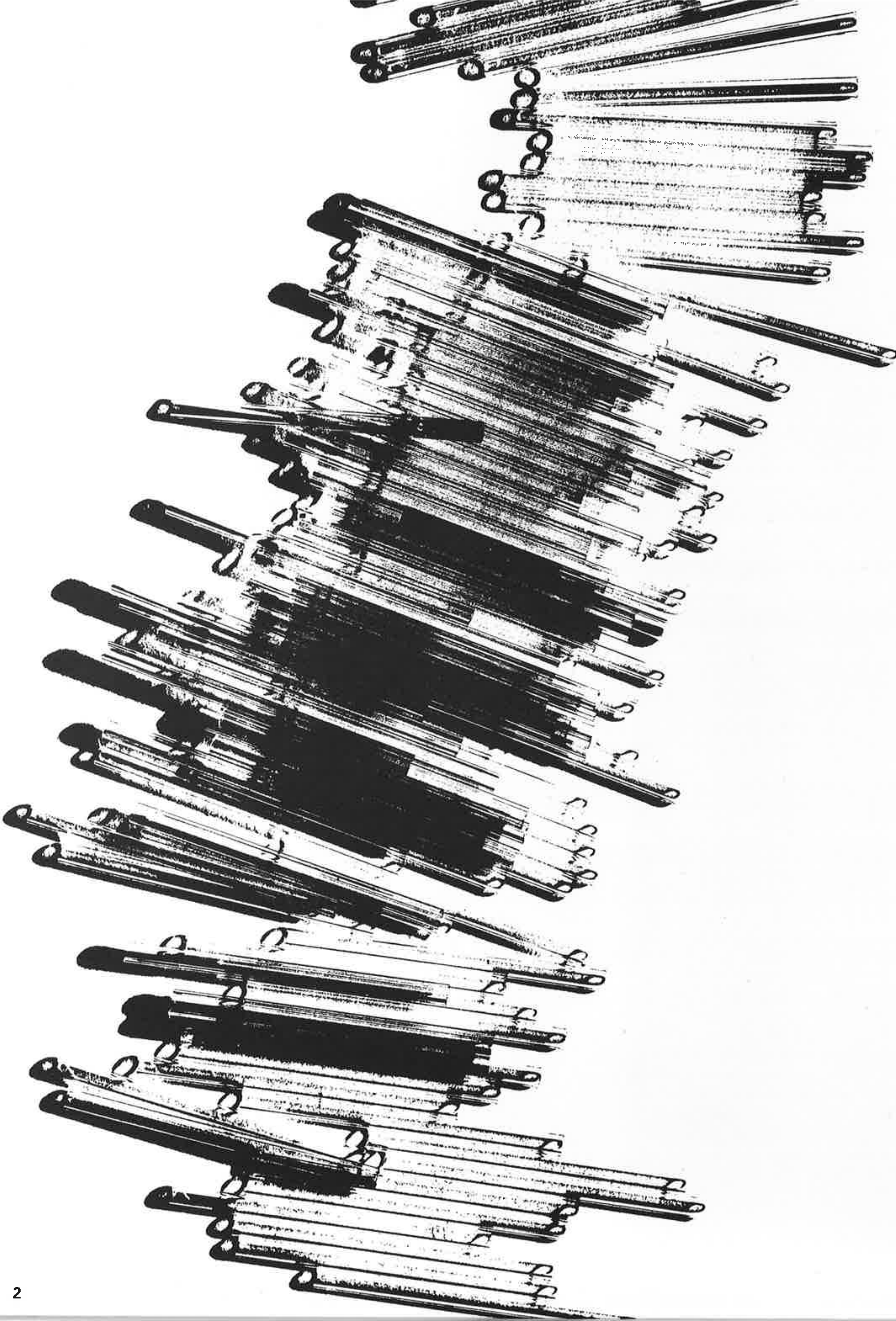


Glass Advisory Services

The many glasses of widely differing characteristics manufactured within the group have been tailor-made for their respective uses. Specialist research and development teams are working constantly to improve manufacturing methods, to solve technological problems arising from the use of glasses, and to advise on the many possible applications.

The introduction of transistorised circuits has enabled us to install temperature, pressure, glass level and other controllers which over a period of years have resulted in improvements in glass quality delivered to the many types of forming machines operated in the various factories.

In our endeavour to provide glass free from defects and of constant composition and properties, modern methods of melting are in use with refractories, including rare metals, of the highest corrosion resistance.

To maintain improvements in the diameter and wall tolerances of glass tubing, equipment is now available which minimises short-term variations in dimensions. Further, sophisticated control equipment has been installed which continuously monitors and corrects the tube diameter and wall thickness within close limits.

In all forming processes, from hand-working to fully automatic machinery, and in after-working processes, too, a knowledge of heat transfer characteristics between glass and other materials is essential, and a team is actively engaged in the study of this problem.

The research and development teams always seek a total solution and their facilities and advice are available to satisfy customers' specific problems and requirements.

Detailed information is available on many major properties of glass and is summarised in data sheets later in the catalogue. An understanding of these properties and of the relationships between them is vital for a precise solution to an application problem. For example, a knowledge of annealing is essential to the successful use of glass. Seals are not usually stress free and often the aim is to produce seals with a moderately high but controlled stress so that stresses introduced later, under working conditions, can be withstood. Whatever the aim, however, the way in which stresses in glass change with time and temperature, in the annealing range, is of fundamental importance.

Annealing schedules can be calculated using a series of curves developed by G. D. Redston and J. E. Stanworth (J. Soc. Glass Tech. 1948, 32, 32), or derived from information in the Glass Engineering Handbook by E. B. Shand, 2nd Edition, page 109.

On all aspects of the choice and application of glass, the Glass Advisory Service is organised to provide a fully comprehensive information and technical service.

Enquiries of this nature should be made directly to:

The Research & Development Manager,
Glass Tubes and Components Limited,
Sheffield Road,
Chesterfield,
Derbyshire S41 8LD.

Product Quality Control

STATEMENT OF QUALITY CONTROL POLICY

The quality of the items sold to our customers is of major concern to us. We have an independent Quality Control Department which uses rigid procedures based on sound statistical principles. This is backed by specialised resources in the Technical Department, to ensure that quality and reliability are built in to our products.

In the manufacture of mass-produced glassware it is important that we and our customers have a close understanding of inspection and quality control methods.

We would, therefore, welcome the opportunity to discuss with our customers, our own methods or any other applications of quality control.

INSPECTION STANDARDS

Glass products sold by the Group are inspected to standards defined in one or more of the following ways:

Inspection criteria

Each set of criteria covers a particular group of products and broadly defines terminology, glass quality limits and special requirements for each group.

Product drawings

These are prepared where required and show article shape and principal dimensions.

Product data sheets

These set out dimensional and other information that cannot conveniently be shown on a product drawing.

Approved samples

Where a written definition is not possible, e.g. some glass quality limits, standards may be agreed with the customer and defined by selected samples.

SAMPLING PLANS

We are anxious to establish with our customers agreed sampling plans which specify for criteria the acceptable quality level (A.Q.L.), the applicable sampling methods and the techniques of inspection.

Use of the U.S. Military Standard 105-D or the equivalent British DEF-131-A procedure is favoured in the interests of standardisation; however, agreed variations are acceptable.

PRODUCT CERTIFICATION

We are prepared to provide our customers with certificates stating that products have been inspected to agreed plans. We will discuss with customers the provision of data for particular products.

ACCEPTANCE SAMPLING PLANS

The following points are suggested as the basis of an Acceptance Sampling Plan procedure which may be used in the event of complaint.

Lot size

According to product this may be defined as that lot which is produced by us in a given period of time or received by the customer in a consignment.

Sample selection

The sample must be obtained at random and be as representative as possible. At least 5% of cartons or 10% of bundles should be the quantity taken from the lot.

Sample size

To be determined by the applicable sampling table required by the U.S. Military Standard 105-D or the equivalent British DEF-131-A.

Classification of defects

There are normally two categories, namely Major and Minor, with sub-divisions which are well established in the general specification data. It is only necessary to criticise one defect in any individual piece of ware.

A.Q.L. limits

These are generally established in the standard Glassworks Quality Control procedures but the value of any particular A.Q.L. is open to negotiation for special attention.

Cracked or broken ware

Cracked or broken ware is not considered as a defect for the purpose of acceptance sampling because of possible transit or handling damage. However, if it is apparent that poor or careless packing has caused a high loss, an adjustment will be discussed on the basis of the individual complaint, apart from the Acceptance Sampling Plan.

Accepted lots

If inspection of the sample results in acceptance of the lot, then the entire lot shall be accepted and no credit will be allowed on the accumulated rejected pieces found in this and other related lots.

Rejected lots

If inspection of the sample shows that the lot of ware is rejected, full information such as carton labels, production date, shift, sample size, number criticised and defects criticised should be forwarded to the factory of origin. This is essential to minimise investigation time and permit early corrective action.

Data Sheets

This catalogue contains data sheets for all our commercial glasses except natural coloured glasses. For ease of reference the sheets have been split into four groups, each of which is printed on paper of a different colour.

Colourless glasses in continuous production
(Green section)
The glasses in this section are melted continuously and standard ware can generally be obtained from stock or current production.

Glasses of limited application
(Yellow section)
These glasses are melted intermittently according to demand.

Graded seal and solder glasses
(Blue section)
These glasses are generally available from stock.

Natural coloured glasses
(Red section)
The glasses in this group are generally melted to order.

The data sheets give details of the major physical properties of the glass together with a typical chemical composition.
Please note that all temperatures quoted are in degrees Celsius.

At the end of the catalogue the first three sections are summarised in a table so that physical properties may be readily compared. In addition, the principal uses and the types of ware available are listed.

Mean coefficient of expansion
The linear thermal expansion coefficient is quoted as 10^{-7} mm/mm/deg. C, and unless otherwise stated, over a temperature range of 50°–300°. Typical expansion curves are shown on the data sheets, with increase in length per unit length ($\frac{\Delta l}{l}$) plotted against temperature.

Specific gravity
This is measured at 20°

Refractive index
All measurements are based on the sodium D-line wavelength (589.3nm), and the refractive index is therefore designated n_D.

Viscosity
Knowledge of the viscosity/temperature relationship of glass is invaluable at all stages of the annealing, working and melting processes. In the various data sheets, temperatures are quoted for the strain point, annealing point and softening point of glass. These correspond to viscosities of $10^{14\cdot6}$, 10^{13} and $10^{7\cdot6}$ poises respectively. The data sheets show typical viscosity/temperature curves in the annealing range with log viscosity (log η) against reciprocal absolute temperature ($\frac{1}{T}$).

Strain point
The strain point is that temperature below which glass can be cooled without the introduction of permanent strain. Cooling may be as rapid as possible provided that the thermal gradients created do not crack the glass.

Annealing point
The annealing point is that temperature at which a sample is generally accepted to become commercially 'strain free' in fifteen minutes. However, slightly higher temperatures may be used without glass deformation, as may lower temperatures, provided sufficient time is allowed for the stress release.

Softening point
The softening point is that temperature at which a 'thread' of standard dimensions lengthens under its own weight at a specified rate and is a guide to the lowest temperature at which fusion takes place.

Direct current resistivity
In the data sheets log resistivities are generally quoted for temperatures of 250° and 350°, and values at other temperatures can be obtained knowing that a graph of log resistivity (log ρ) and reciprocal absolute temperature ($\frac{1}{T}$) is a straight line over a very wide range of temperature.

The temperature corresponding to 10^8 ohm cm (T_K100) has been extracted from these graphs and affords a means of comparing the resistivities of the various glasses.

Dielectric properties
Where applicable, glasses have been measured for dielectric constant (K) and loss angle (tan δ) under standard conditions of frequency (1 MHz) and temperature (20°).

Key to Coding

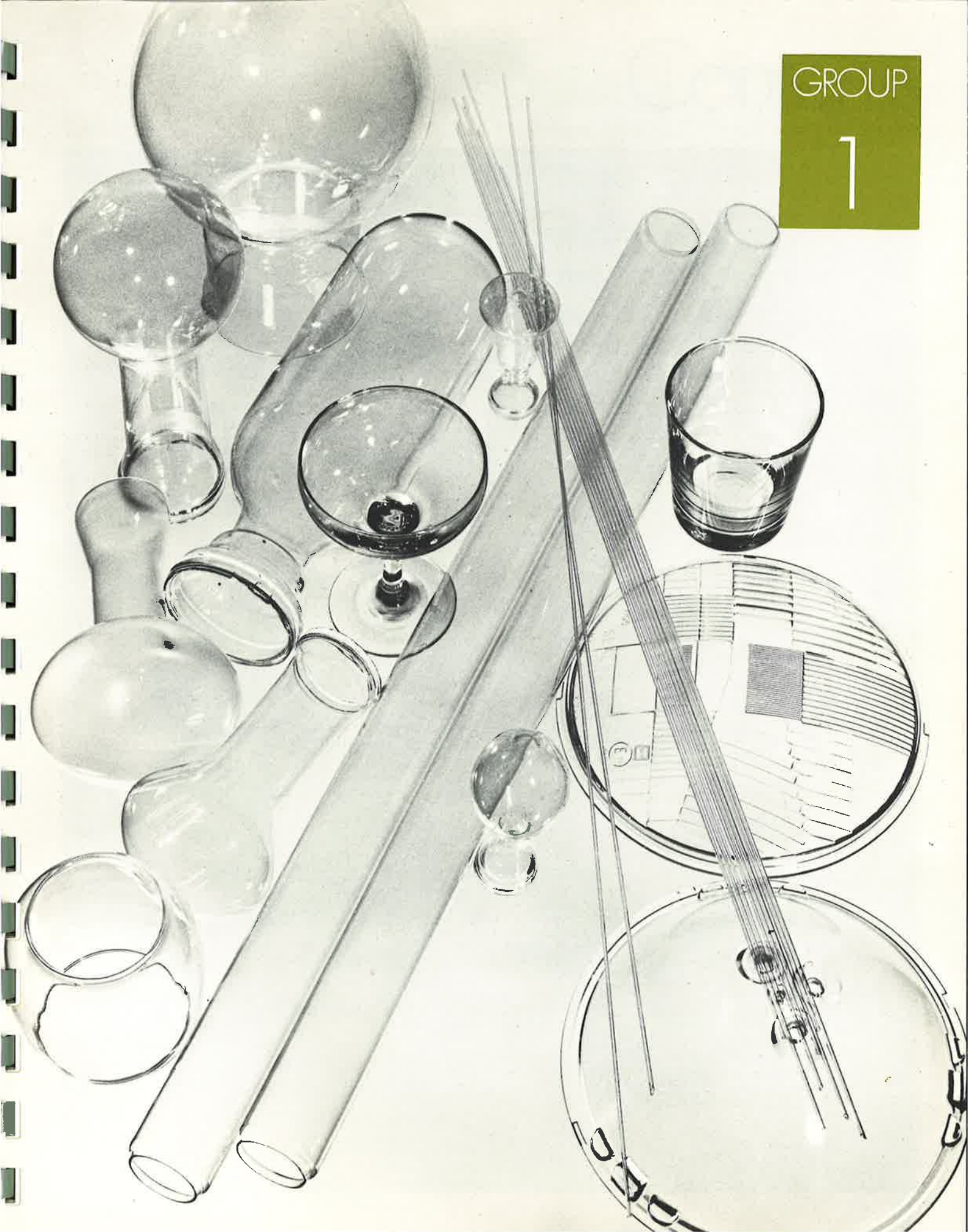
The glasses have been given references made up as follows:

Prefix letters denote the type of glass:
A — Aluminosilicate
B — Borosilicate
GS — Graded seal
L — Lead-alkali-silicate
Q — Quartz
S — Soda-lime-silicate
X — Complex base glass

Numbers indicate the approximate thermal expansion coefficient $\times 10^{7}$.

Suffix letters indicate the glass colour:
A — Amber
B — Blue
BK — Black
BV — Blue ultra-violet transmitting
G — Green
R — Ruby or Red
W — White opal
Y — Yellow

Suffix numbers indicate intensities of glass colour, e.g. L101B1 and L101B5 relate to two different depths of blue colour.


GROUP
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COLOURLESS GLASSES IN CONTINUOUS PRODUCTION

Glass Reference	Main Applications
B36	Pressings for sealed beam headlamps
B37	Tubing, envelopes and pressings for sealing to tungsten
S911	Machine-made domestic ware
L92	Tubing and lamp components where high electrical resistance is required
S95	Fluorescent lamp envelopes, vials and lamp blown scientific ware
S96	Lamp bulbs and fluorescent lamp envelopes
S97	Hand produced envelopes and pressings for special lamps and valves

B36

1st September, 1973

INTRODUCTION
B36 glass is a borosilicate designed to be suitable for the pressing techniques of producing face plates and covers.

APPLICATIONS
The main production consists of pressing face plates and backs or covers for sealed beam headlamps for the automobile industry.

AVAILABILITY
Machine made pressings.

PHYSICAL PROPERTIES

Expansion coefficient	36·5
Specific gravity:	2·25
Refractive index:	1·45
Strain point:	490
Annealing point:	560
Softening point:	790

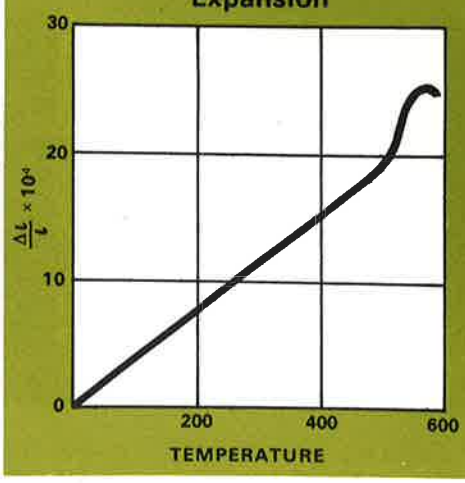
ELECTRICAL PROPERTIES

Log ρ 250°:	7·7
Log ρ 350°:	6·3
T_K 100:	230

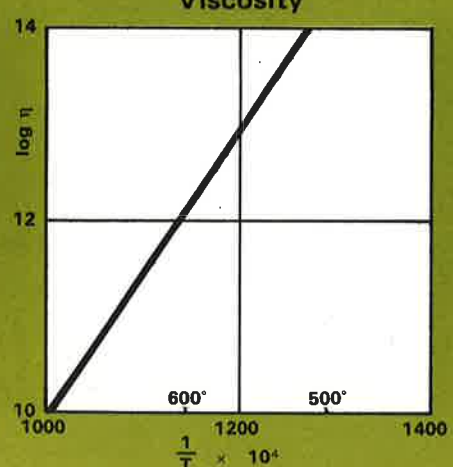
CHEMICAL COMPOSITION

	(Wt. %)
SiO_2	77·6
Al_2O_3	2·3
B_2O_3	14·6
Na_2O }	5·4
K_2O }	

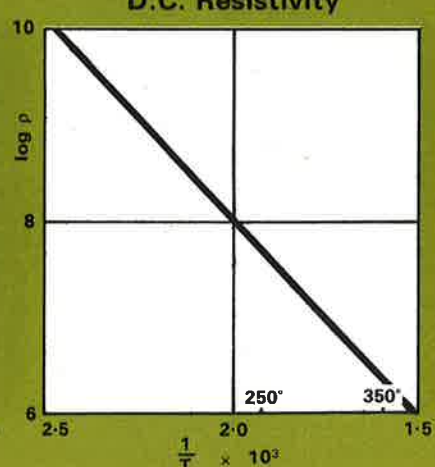
Expansion



Viscosity



D.C. Resistivity



B37

1st November, 1970

INTRODUCTION

B37 is a tungsten-sealing borosilicate glass. The mechanical and thermal properties make the glass suitable for applications which have to withstand both higher operating temperatures and greater thermal shock than soda-lime glass.

APPLICATIONS

Applications include envelopes for high wattage lamps, radio transmitting valves, X-ray tubes and domestic ware. Pressings which have to withstand thermal shock are also produced in a wide range.

AVAILABILITY

Machine made tubing and rod, hand made bulbs, pressings, powders and sinters.

PHYSICAL PROPERTIES

Expansion coefficient:	37·5
Specific gravity:	2·25
Refractive index:	1·478
Strain point:	490
Annealing point:	560
Softening point:	770

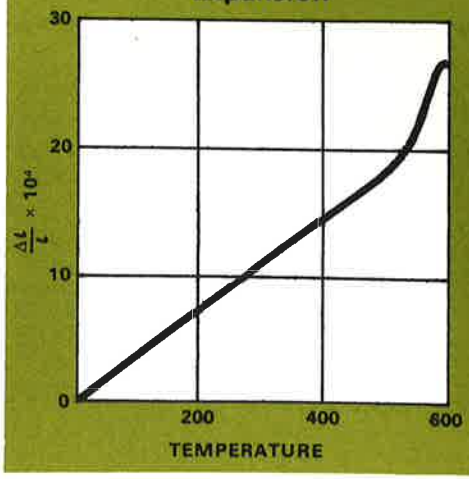
ELECTRICAL PROPERTIES

Log ρ 250°:	8·7
Log ρ 350°:	7·1
T_K 100:	290
K:	4·2
Tan δ:	0·0013

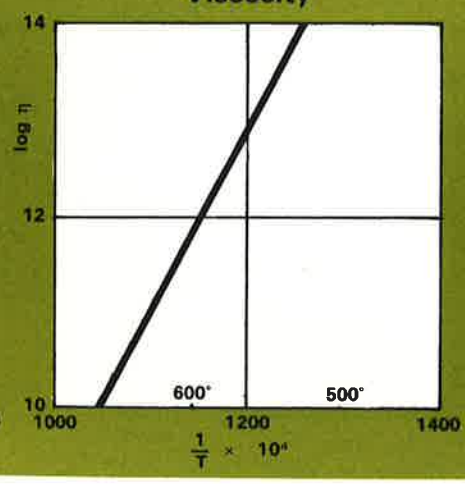
CHEMICAL COMPOSITION

	(Wt. %)
SiO_2	75·5
Al_2O_3	2·6
B_2O_3	16·0
Na_2O	3·7
K_2O	1·7

Expansion



Viscosity



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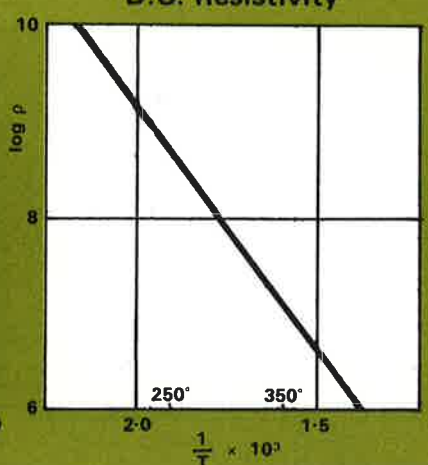


S911

1st November, 1970

INTRODUCTION
S911 glass is a soda-lime-silicate with a slightly faster setting rate than our standard S96 glass.

APPLICATIONS
The glass is used primarily for the production of domestic ware on fully automatic machines.

AVAILABILITY
Domestic drinking glasses, tableware and lamp shades.

PHYSICAL PROPERTIES

Expansion coefficient:	88
Specific gravity:	2·47
Refractive index:	1·513
Strain point:	525
Annealing point:	555
Softening point:	725

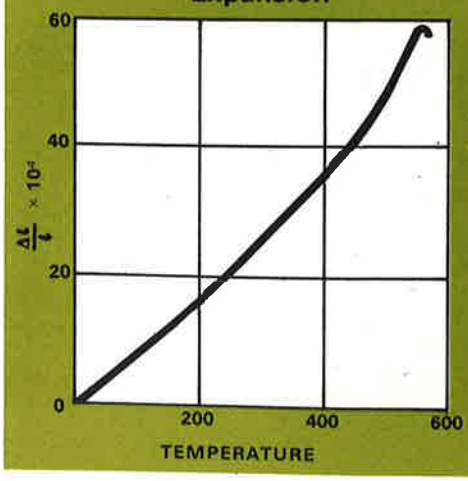
ELECTRICAL PROPERTIES

Log ρ 250°:	6·2
Log ρ 350°:	5·0
T_K 100:	145

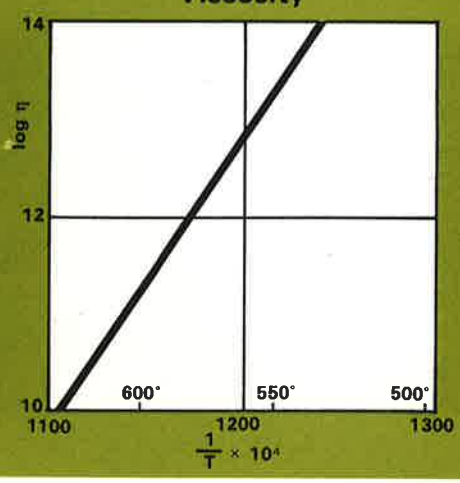
CHEMICAL COMPOSITION

	(Wt. %)
SiO_2	73·8
Al_2O_3	1·3
CaO	7·5
MgO	2·0
Na_2O + K_2O	15·1

Expansion



Viscosity



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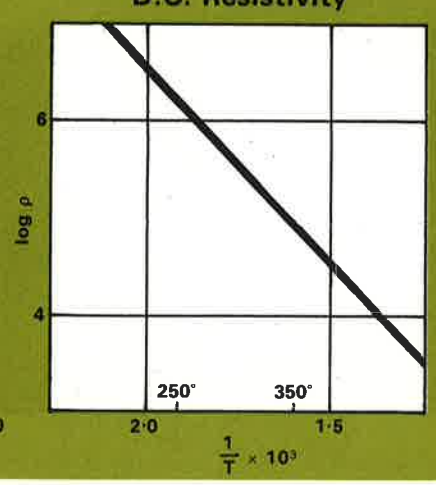


L92

1st November, 1970

INTRODUCTION

L92 glass is an alkali-lead-silicate which is in constant production as machine drawn tubing and rod, hand made bulbs and pressings. It can be sealed directly to our standard soda-lime glasses and other glasses of similar expansion. Seals without intermediate glasses can also be made to platinum, copper clad wire and chrome-iron alloys with similar expansion characteristics.

APPLICATIONS

The glass has excellent flame working and electrical resistance properties essential for lamp and valve manufacture.

AVAILABILITY

Machine made tubing and rod, machine made miniature bulbs and flares. Hand made bulbs, pressings and powders are available in glass with a slightly different chemical composition to improve hand working.

PHYSICAL PROPERTIES

Expansion coefficient:	90
Specific gravity:	3·04
Refractive index:	1·563
Strain point:	390
Annealing point:	435
Softening point:	630

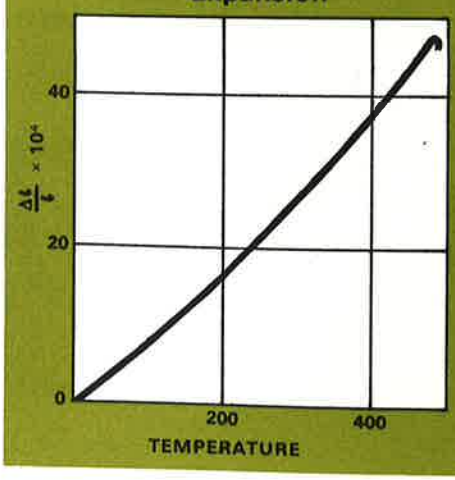
ELECTRICAL PROPERTIES

Log ρ 250°:	9·6
Log ρ 350°:	7·8
T_K 100:	335
K:	6·3
Tan δ:	0·0008

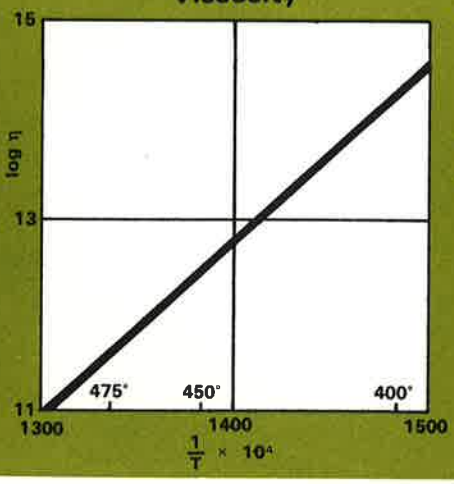
CHEMICAL COMPOSITION

	(Wt. %)
SiO_2	56·5
Al_2O_3	1·4
PbO	29·0
Na_2O	4·25
K_2O	8·25

Expansion



Viscosity



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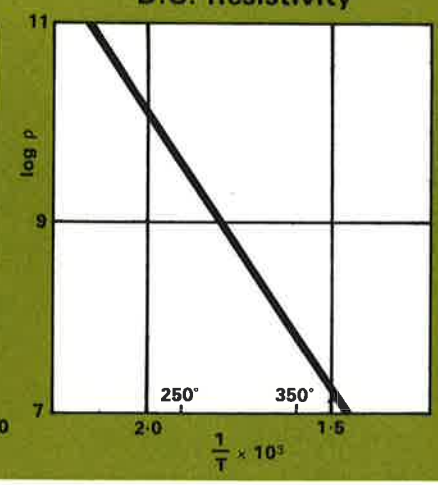


S95

1st September, 1973

INTRODUCTION

S95 glass is a soda-lime-silicate which is continuously available as machine drawn tubing or rod. It can be sealed directly to our standard lead glass (L92), and other glasses with similar expansion characteristics. Seals without intermediate glasses can also be made to chrome-iron alloys, copper clad nickel-iron alloys, or metals of the platinum group.

APPLICATIONS

The glass is eminently suitable for the manufacture of fluorescent tubes, neon signs and other lamp and valve envelopes. Cathode poisoning in lamp or valve manufacture is minimised by the absence of fluorine in the glass. The hydrolytic resistance of the glass is such that it can be used for laboratory glassware and for vials and other pharmaceutical applications where a full neutral glass is not essential. The viscosity/temperature characteristic is suitable for bench working applications.

AVAILABILITY

Machine made tubing and rod.

DURABILITY

German Pharmacopoeia DIN 12.111–Class 3
German Pharmacopoeia DIN 52.322–Class 2
German Pharmacopoeia DIN 12.116–Class 1
European Pharmacopoeia 1971, Vol 1, Page 68-Type III

PHYSICAL PROPERTIES

Expansion coefficient:	92
Specific gravity:	2·50
Refractive index:	1·513
Strain point:	470
Annealing point:	515
Softening point:	710

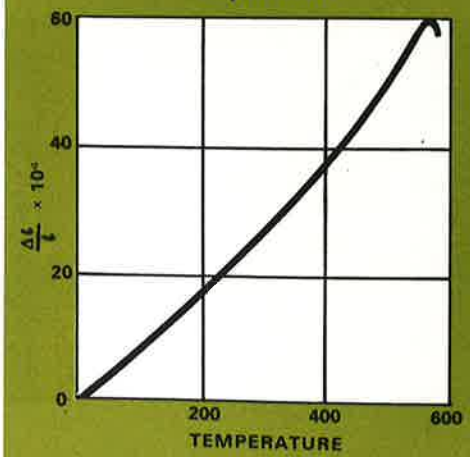
ELECTRICAL PROPERTIES

Log ρ 250°:	6·6
Log ρ 350°:	5·3
T_K 100:	175

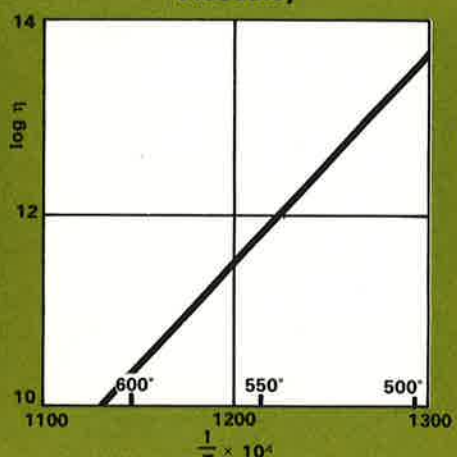
CHEMICAL COMPOSITION

	(Wt. %)
SiO_2	71·0
Al_2O_3	2·4
CaO	5·7
MgO	3·0
BaO	1·7
Na_2O	14·2
K_2O	1·5

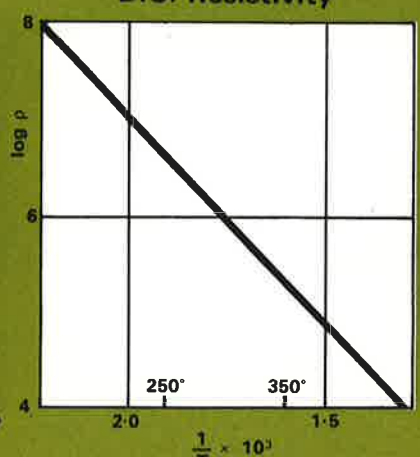
Expansion



Viscosity



D.C. Resistivity



S96

1st November, 1970

INTRODUCTION

S96 glass is a soda-lime-silicate which is readily available as bulbs and valve envelopes made on the ribbon machine and machine made tubing, rod and domestic ware. The glass seals satisfactorily to our standard lead glass L92 and other glasses of similar expansion.

APPLICATIONS

The glass is used extensively for bulbs for the electric lamp industry, blanks for vacuum flasks, bulbs for Christmas tree decorations and fluorescent lamp tubing.

AVAILABILITY

Machine made bulbs and tubing.

PHYSICAL PROPERTIES

Expansion coefficient:	94
Specific gravity:	2·48
Refractive index:	1·512
Strain point:	495
Annealing point:	525
Softening point:	715

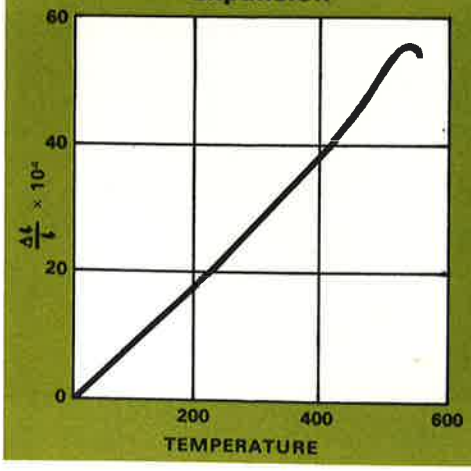
ELECTRICAL PROPERTIES

Log ρ 250°:	6·5
Log ρ 350°:	5·1
T_K 100:	170
K:	6·8
Tan δ:	0·008

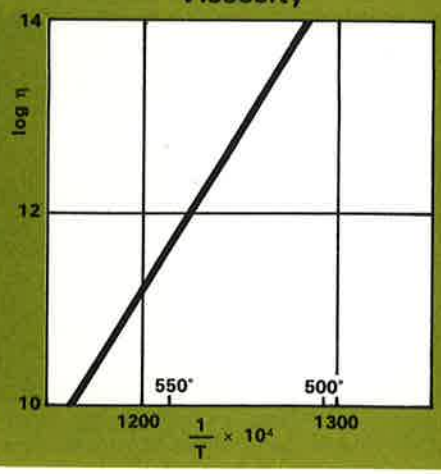
CHEMICAL COMPOSITION

	(Wt. %)
SiO_2	71·5
Al_2O_3	2·0
Na_2O	15·5
K_2O	1·0
CaO	6·6
MgO	2·8

Expansion



Viscosity



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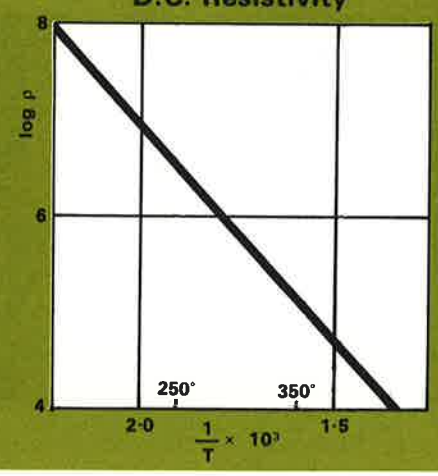


S97

1st November, 1970

INTRODUCTION
S97 glass is a soda-lime-silicate designed for hand made bulbs and special pressings where the quantities are too small for efficient machine production. It can be sealed directly to our standard lead glass (L92) and to other glasses with similar expansion coefficients.

APPLICATIONS
The main application is for special lamp and valve envelopes. It is also used as the base glass for the machine production of two-ply sodium resistant tubing.

AVAILABILITY
Hand made bulbs and pressings.

PHYSICAL PROPERTIES

Expansion coefficient:	95
Specific gravity:	2·47
Refractive index:	1·511
Strain point:	460
Annealing point:	520
Softening point:	710

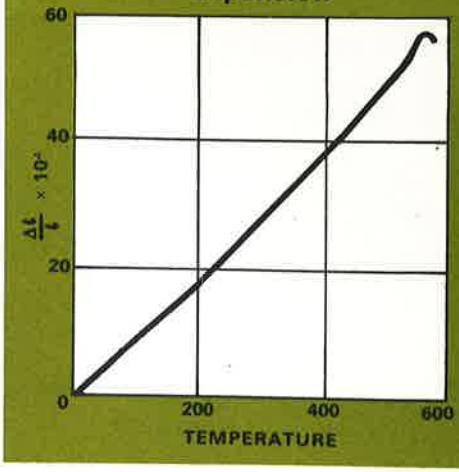
ELECTRICAL PROPERTIES

Log ρ 250°:	6·2
Log ρ 350°:	5·0
T_K 100:	150

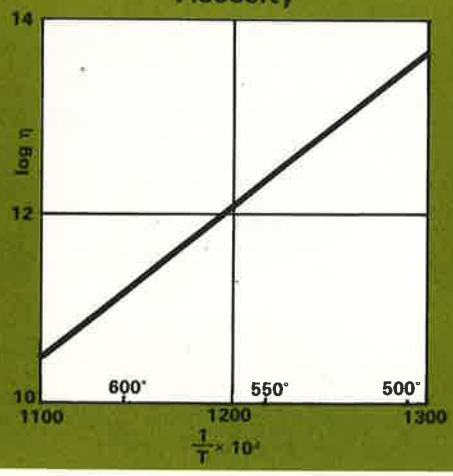
CHEMICAL COMPOSITION

	(Wt. %)
SiO_2	72·5
Al_2O_3	1·3
B_2O_3	1·0
Na_2O	17·8
CaO	4·4
MgO	3·0

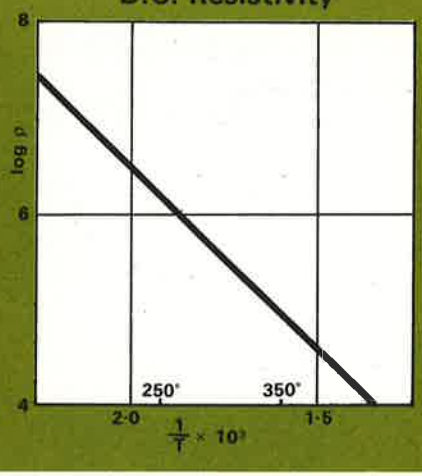
Expansion

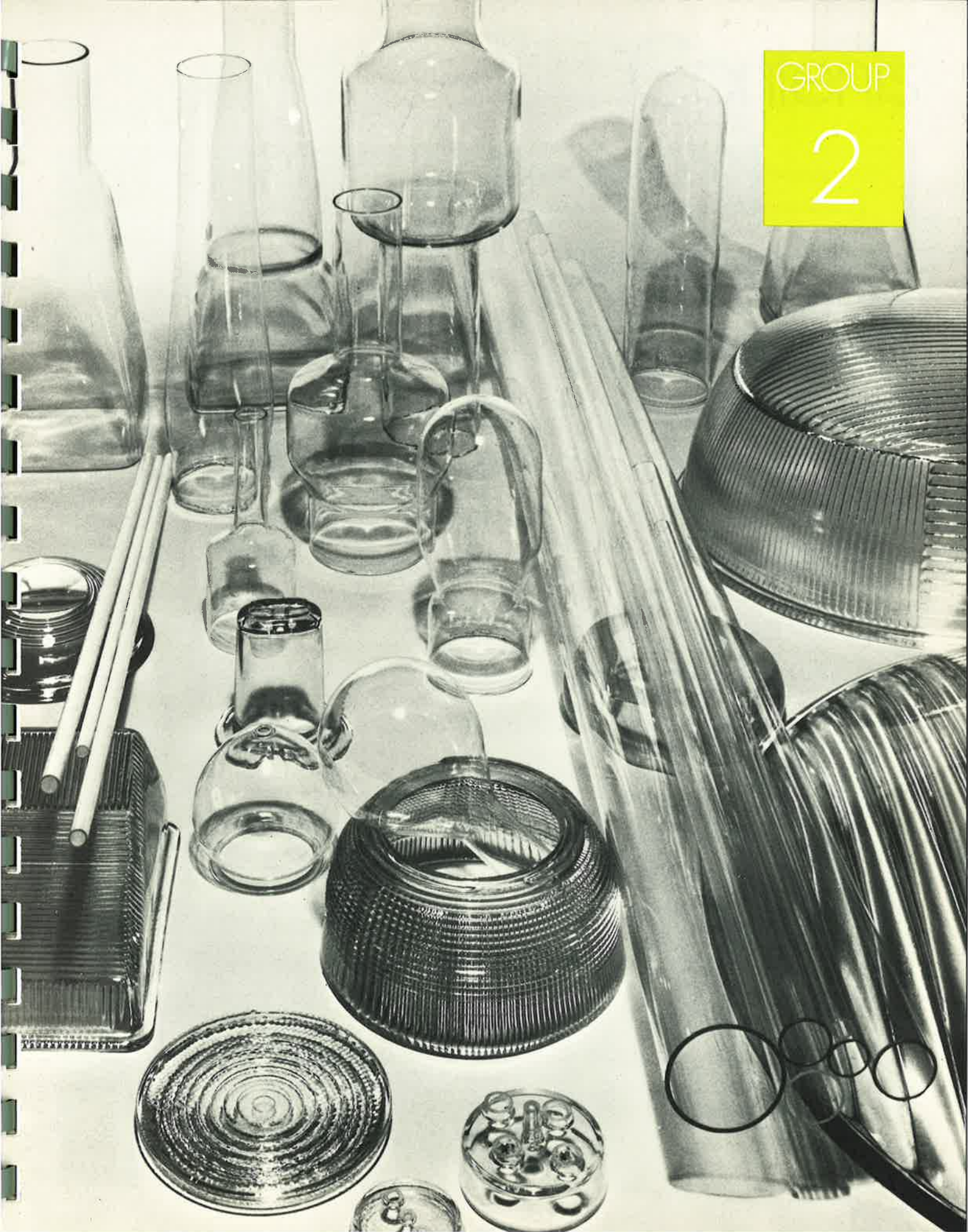


Viscosity



D.C. Resistivity




GROUP
2

Contents

GLASSES OF LIMITED APPLICATIONS

Glass Reference	Main Applications
Q5	Envelopes for high pressure mercury vapour lamps
Q6	Sheaths for electrical heating elements
A41	Envelopes for mercury vapour lamps
B47	Lamp and valve envelopes required to seal to Kovar type alloys
B472	Lamp and valve envelopes required to seal to Kovar type alloys where a radioactive free glass is essential
B53	Lamp and valve envelopes required to seal to Kovar and Nilo-K type alloys where the highest durability is required
X90	Composite tubing for sodium vapour lamps
X91	Composite tubing for sodium vapour lamps
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X951	Powders for sintered bases
S972	Tubing for reed relays
S100	Envelopes for cathode ray tubes
X150	Copper sealing glass

Q5

1st November, 1970

INTRODUCTION
Q5 tubing is made by a continuous process of melting pure Brazilian quartz and is readily available from stock.

APPLICATIONS
The clear vitreous silica tubing is used mainly for the manufacture of high pressure mercury vapour lamps.

AVAILABILITY
Machine made tubing.

PHYSICAL PROPERTIES

Expansion coefficient:	5·5
Specific gravity:	2·20
Refractive index:	1·458
Strain point:	1060
Annealing point:	1190
Softening point:	1630

ELECTRICAL PROPERTIES

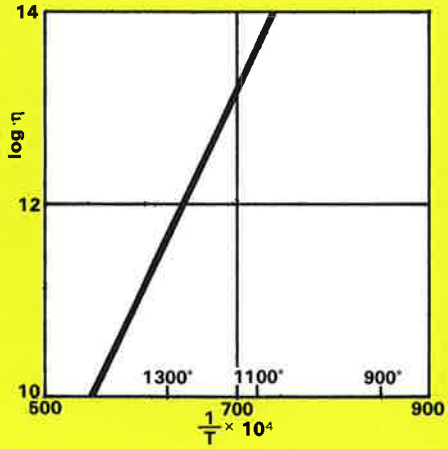
Log ρ 250°:	11·7
Log ρ 350°:	9·6
T_K 100:	465
K:	3·75
Tan δ:	>0·0004

CHEMICAL COMPOSITION

(Wt. %)

SiO_2	99·9 minimum

Viscosity



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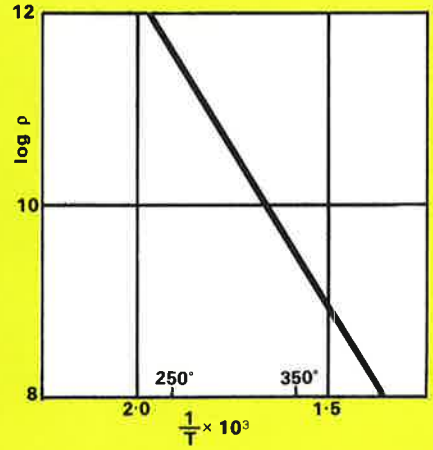


Q6

1st November, 1970

INTRODUCTION
Translucent fused silica is produced by melting high quality sand in a continuous process.

APPLICATIONS
The main use is for the sheaths of electrical heating elements.

AVAILABILITY
Machine made tubing.

PHYSICAL PROPERTIES

Expansion coefficient:	6
Specific gravity:	2·02
Refractive index:	—
Strain point:	1040
Annealing point:	1170
Softening point:	1620

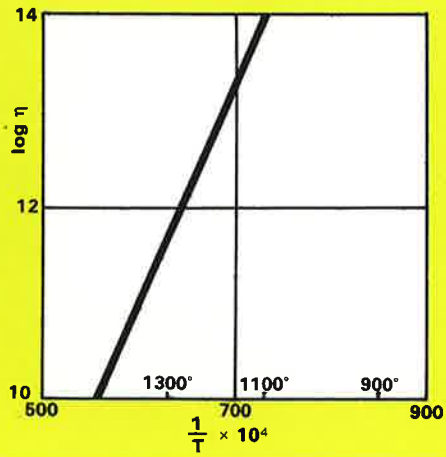
ELECTRICAL PROPERTIES

Log ρ 250°:	12·3
Log ρ 350°:	10·2
T_K 100:	510

CHEMICAL COMPOSITION

	(Wt. %)
SiO_2	>99·5

Viscosity



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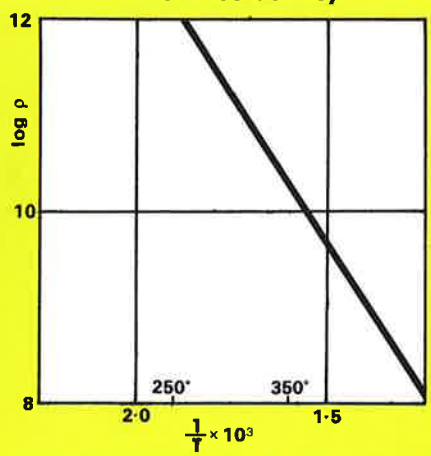


A41

1st September, 1973

INTRODUCTION
A41 glass is an alkali-free aluminosilicate with a high softening temperature. It seals to molybdenum and is highly resistant to electrical and thermal shock.

APPLICATIONS
The glass is used for the envelopes of high pressure mercury vapour lamps where its high softening temperature safeguards the lamp against collapse. It is also used for certain types of projector lamps.

AVAILABILITY
Hand made bulbs, tubing and pressings.

PHYSICAL PROPERTIES

Expansion coefficient:	43
Specific gravity:	2·65
Refractive index:	1·541
Strain point:	735
Annealing point:	760
Softening point:	970

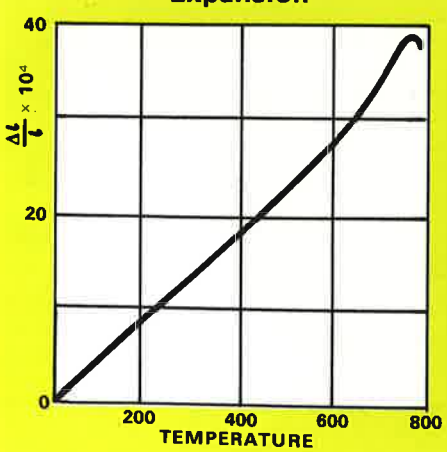
ELECTRICAL PROPERTIES

Log ρ 250°:	14·1
Log ρ 350°:	11·8
T_K 100:	645

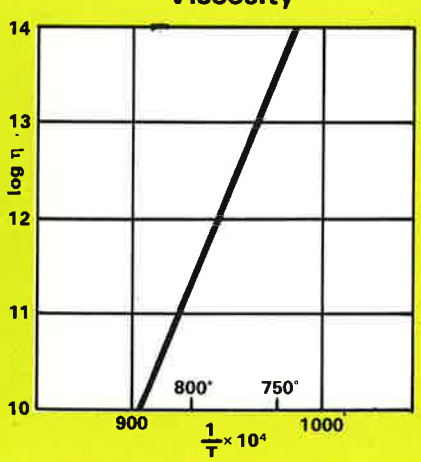
CHEMICAL COMPOSITION

	(Wt. %)
SiO_2	51·2
P_2O_5	4·5
B_2O_3	1·5
Al_2O_3	22·6
MgO	5·4
CaO	9·0
BaO	5·3

Expansion



Viscosity



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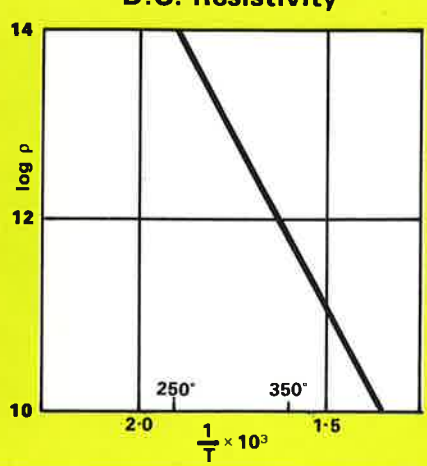


B47

1st November, 1970

INTRODUCTION
B47 glass is a borosilicate designed to seal satisfactorily to iron-nickel-cobalt alloys of the Kovar type.

APPLICATIONS
The glass is primarily used for the production of lamp and valve envelopes which are required to seal to Kovar type alloys.

AVAILABILITY
Hand made bulbs, tubing, pressings and granular powder.

PHYSICAL PROPERTIES

Expansion coefficient:	47
Specific gravity:	2·25
Refractive index:	1·485
Strain point:	435
Annealing point:	490
Softening point:	715

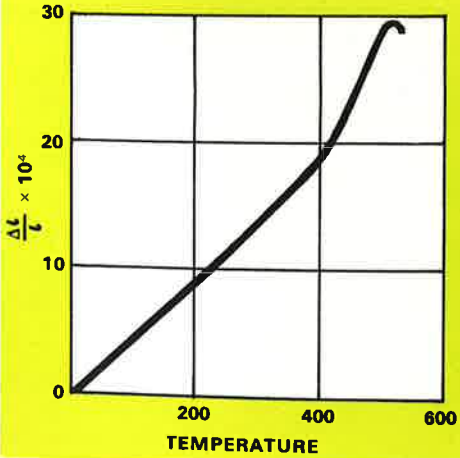
ELECTRICAL PROPERTIES

Log ρ 250°:	9·4
Log ρ 350°:	7·6
T_K 100:	320

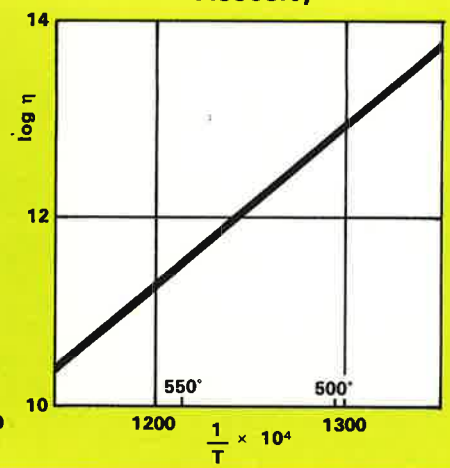
CHEMICAL COMPOSITION

	(Wt. %)
SiO_2	67·5
Al_2O_3	2·5
B_2O_3	21·7
Na_2O	3·2
K_2O	4·2
Li_2O	0·2
PbO	0·2
F_2	0·2

Expansion



Viscosity



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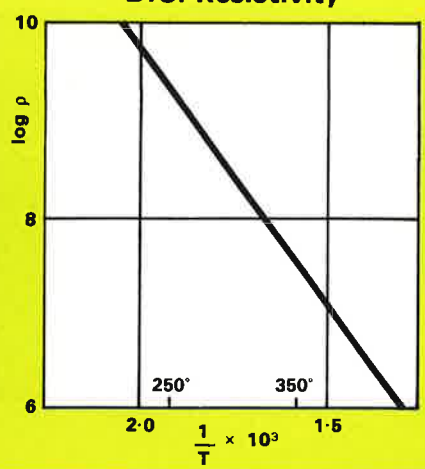


B472

1st September, 1973

INTRODUCTION
B472 glass is a borosilicate designed to seal satisfactorily to iron-nickel-cobalt alloys of the Kovar type.

APPLICATIONS
The glass is used for the production of lamp and valve envelopes which are required to seal to Kovar type alloys, and where it is essential for a radioactive free glass to be employed.

AVAILABILITY
Hand made bulbs, tubing pressings and granular powder.

PHYSICAL PROPERTIES

Expansion coefficient	47·5
Specific gravity	2·26
Strain point	455
Annealing point	525
Softening point	700

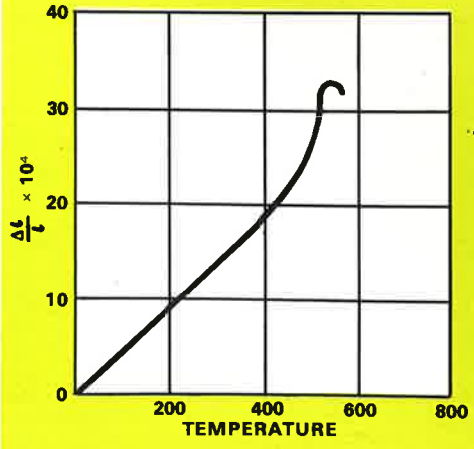
ELECTRICAL PROPERTIES

Log ρ 250°	7·6
Log ρ 350°	6·0
T_k 100	230

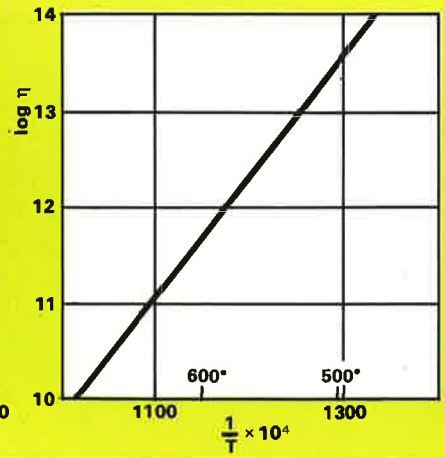
CHEMICAL COMPOSITION

	(Wt.%)
SiO_2	66·0
B_2O_3	22·7
Al_2O_3	4·5
Na_2O	6·8

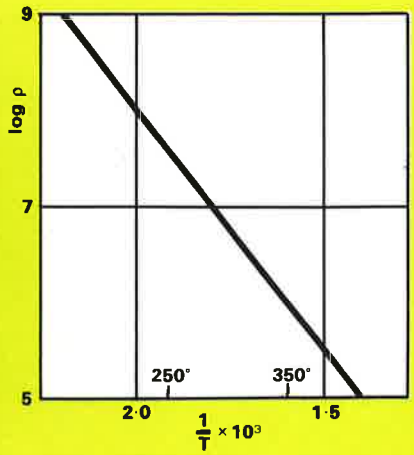
Expansion



Viscosity



D.C. Resistivity



B53

1st November, 1970

INTRODUCTION
B53 glass is a borosilicate designed to seal to iron-nickel-cobalt alloys.

APPLICATIONS
The main application is for lamp and valve envelopes required by the electronics industry for sealing to special alloys of the Kovar and Nilo K type and where the highest durability is required.

AVAILABILITY
Hand made bulbs, tubing, pressings and granular powder.

PHYSICAL PROPERTIES

Expansion coefficient:	51
Specific gravity:	2·35
Refractive index:	1·492
Strain point:	490
Annealing point:	530
Softening point:	740

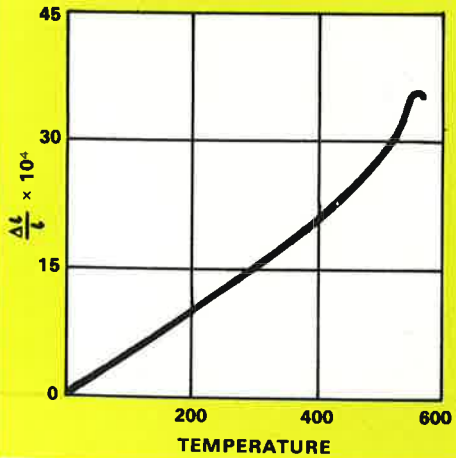
ELECTRICAL PROPERTIES

Log ρ 250°:	8·8
Log ρ 350°:	7·2
T_K 100:	300
K:	5·2
Tan δ:	0·0024

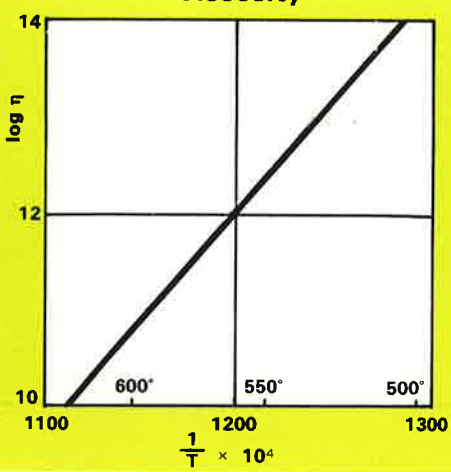
CHEMICAL COMPOSITION

	(Wt. %)
SiO_2	65·5
Al_2O_3	6·2
B_2O_3	15·0
Na_2O	4·7
K_2O	3·0
BaO	2·5
CaO	0·5
ZnO	2·0
F_2	0·3

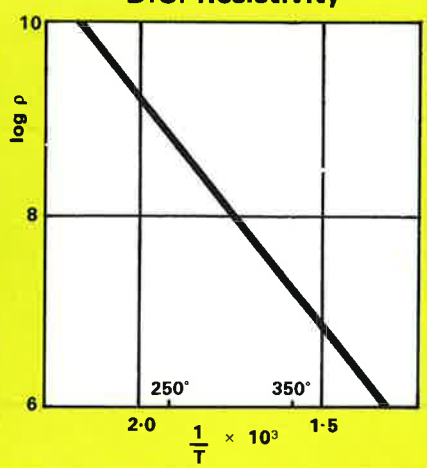
Expansion



Viscosity



D.C. Resistivity



X90

1st November, 1970

INTRODUCTION
X90 glass is a barium-alumino-borate with a low silica and iron oxide content. It is melted in platinum using especially pure raw materials in order to avoid impurity contamination and is used as the internal flashing glass on S97 glass tubing to resist the attack of sodium vapour.

APPLICATION
It is used in composite tubing for the manufacture of sodium vapour discharge lamps.

AVAILABILITY
Machine drawn two-ply sodium vapour lamp tubing.

PHYSICAL PROPERTIES

Expansion coefficient:	97

CHEMICAL COMPOSITION

	(Wt. %)
SiO_2	5·0
Al_2O_3	17·5
B_2O_3	16·0
BaO	52·0
CaO	9·5

X91

1st November, 1970

INTRODUCTION
X91 is a sodium-alumino-borate with a low silica and iron oxide content. It is melted in platinum using very pure raw materials in order to avoid impurity contamination. It is used as the internal flashing glass for S97 glass tubing and has been designed specifically for use in sodium vapour lamps.

APPLICATION
The glass is used in composite tubing for sodium vapour discharge lamps.

AVAILABILITY
Machine drawn two-ply sodium vapour lamp tubing.

PHYSICAL PROPERTIES

Expansion coefficient:	83·0

CHEMICAL COMPOSITION

	(Wt. %)
SiO_2	7·5
Al_2O_3	24·5
B_2O_3	48·0
CaO	7·0
Na_2O	13·0

X94

1st September, 1973

INTRODUCTION
X94 glass is an alkali-barium-silicate with high electrical resistivity which prevents electrolysis at the pinch seal in sodium vapour lamps.

APPLICATION
The glass is used for sheathing the copper clad lead-in wires of sodium vapour lamps.

AVAILABILITY
Hand drawn tubing.

PHYSICAL PROPERTIES

Expansion coefficient:	92
Specific gravity:	2·68
Strain point	490
Annealing point	525
Softening point	700

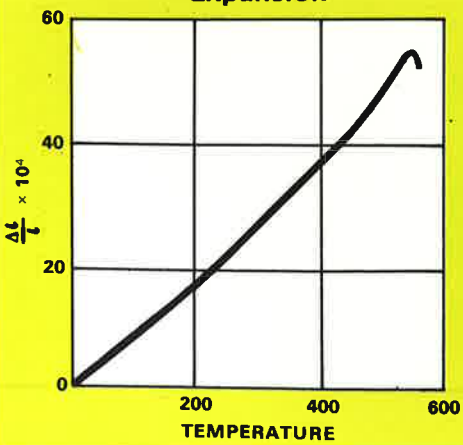
ELECTRICAL PROPERTIES

Log ρ 250°	9·5
Log ρ 350°	7·6
T_k 100	325

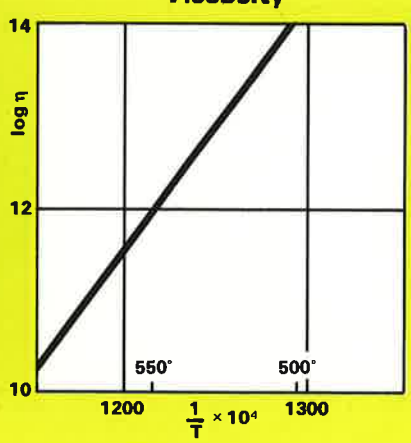
CHEMICAL COMPOSITION

	(Wt. %)
SiO_2	67·0
Al_2O_3	0·5
B_2O_3	2·7
BaO	15·2
CaO	0·5
Na_2O	6·7
K_2O	7·0

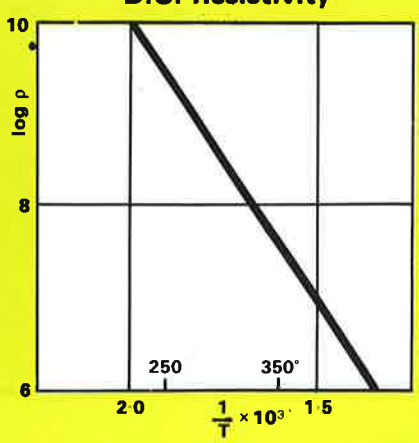
Expansion



Viscosity



D.C. Resistivity



X951

1st November, 1970

INTRODUCTION

X951 glass is an alkali-barium-silicate with a similar thermal expansion coefficient to soda-lime glass yet with a higher electrical resistivity.

APPLICATIONS

The glass is mainly used in the manufacture of sintered bases for special valves and other electrical devices.

AVAILABILITY

Powders for sinters.

PHYSICAL PROPERTIES

Expansion coefficient:	91
Specific gravity:	2·59
Strain point:	425
Annealing point:	470

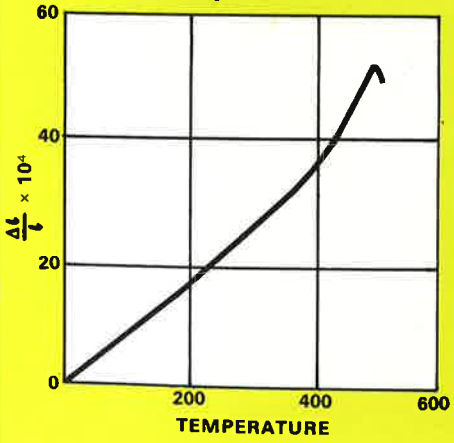
ELECTRICAL PROPERTIES

Log ρ 250°:	8·2
Log ρ 350°:	6·5
T_K 100:	255

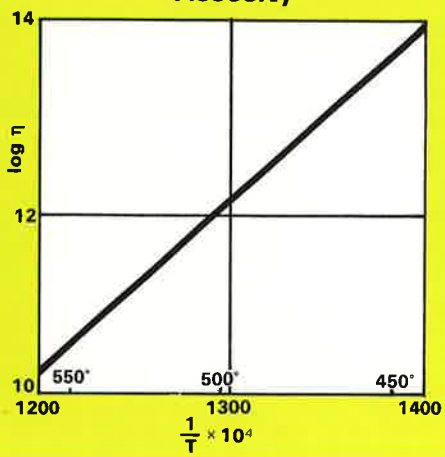
CHEMICAL COMPOSITION

	(Wt. %)
SiO_2	66·5
Al_2O_3	4·9
B_2O_3	1·0
BaO	11·2
Na_2O	8·3
K_2O	6·7
F_2	1·7

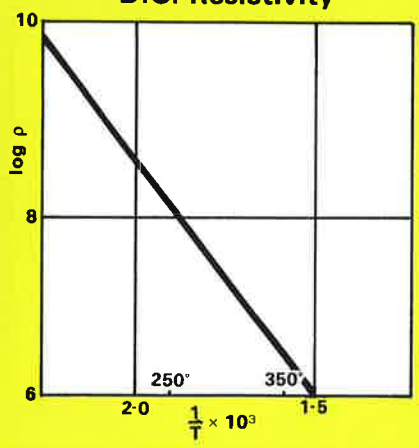
Expansion



Viscosity



D.C. Resistivity



S972

1st September, 1973

INTRODUCTION

S972 glass is a soda-lime-silicate designed for the development of solid state devices in which radiant heat is used for sealing such devices rather than flame sealing. The energy of the sources used for sealing is mainly in the longer wavelength range of the spectrum and this inevitably requires a greater heat absorption of the glass in these wavelengths in order to assist the sealing process. Glasses suitable for this application require, in general, the addition of small amounts of iron oxide in the ferrous state. To assist observation during sealing and in the finished article it is desirable that glass transparency is retained. The glass must also seal satisfactorily to metals or material of similar expansion coefficients.

APPLICATIONS

Mainly used for the construction of dry reed switches and diodes. Its use with radiant heating permits gains of five times in sealing rates enabling the devices to be more easily encapsulated. The use in sealing of radiant heat systems permits seals to be made in controlled atmosphere.

The infra-red transmission is maintained within limits to enable the customer to work the glass under controlled conditions of temperature and time, the time being much less than for conventional glasses.

Further information may be obtained on application.

AVAILABILITY

Machine drawn tubing.

CHEMICAL COMPOSITION

	(Wt. %)
SiO_2	71·0
Al_2O_3	2·2
CaO	3·0
MgO	2·3
B_2O_3	1·0
Na_2O	16·8
K_2O	0·7
Total iron as Fe_2O_3*	3·0

*The ratio of ferrous to ferric iron shall be such as to give an acceptable infra-red absorption.

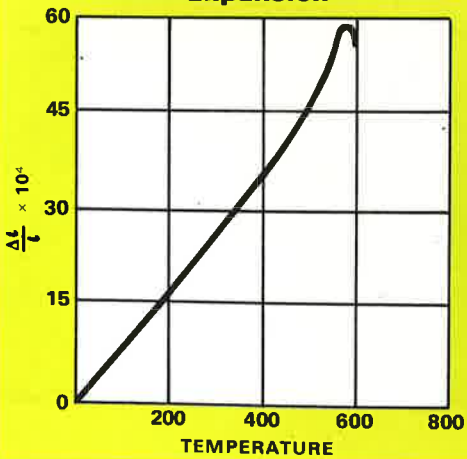
PHYSICAL PROPERTIES

Expansion coefficient:	93
Specific gravity:	2·5
Strain point:	450
Annealing point:	510
Softening point:	700

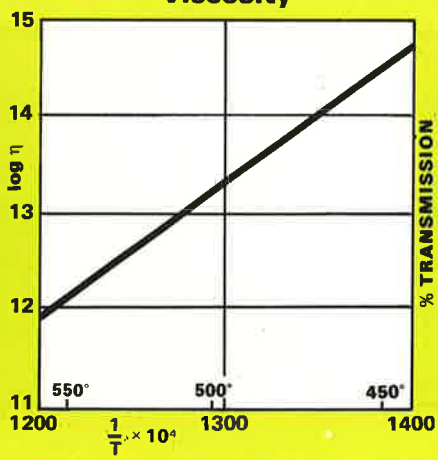
ELECTRICAL PROPERTIES

Log ρ 250°	6·2
Log ρ 350°	5·0
T_k 100	150

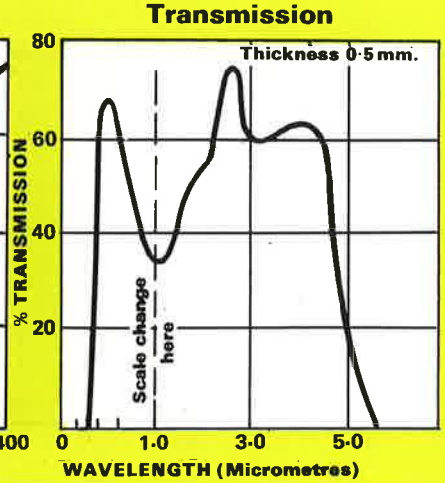
Expansion



Viscosity



Transmission



S100

1st September, 1973

INTRODUCTION
S100 glass is a lead free alkali-silicate with a higher electrical resistivity than our standard soda-lime glass.

APPLICATIONS
It is principally used for special cathode ray tube envelopes.

AVAILABILITY
Hand made bulbs and pressings.

PHYSICAL PROPERTIES

Expansion coefficient:	96
Specific gravity:	2·53
Refractive index:	1·508
Strain point:	535
Annealing point:	570
Softening point:	725

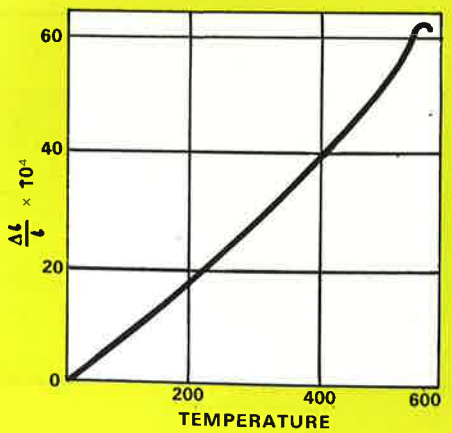
ELECTRICAL PROPERTIES

Log ρ 250°:	8·3
Log ρ 350°:	6·5
T_K 100:	260

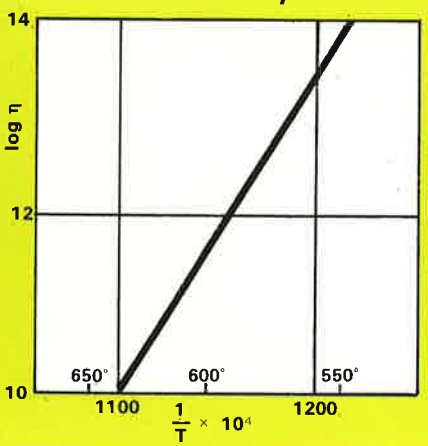
CHEMICAL COMPOSITION

	(Wt. %)
SiO_2	71·0
Al_2O_3	1·6
B_2O_3	1·0
CaO	4·6
MgO	3·1
Na_2O	8·5
K_2O	9·8

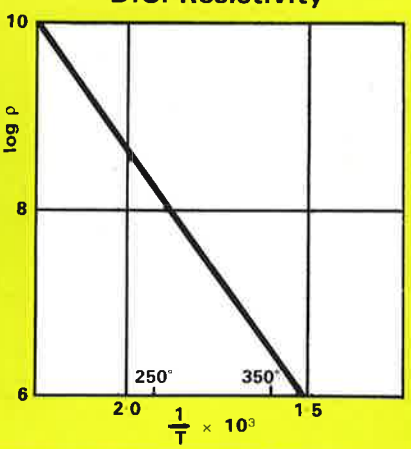
Expansion



Viscosity



D.C. Resistivity



X150

1st November, 1970

INTRODUCTION
X150 glass provides matched seals to copper. It has good electrical and flame working properties but can prove more sensitive to thermal shock than glasses such as S95 or L92. Care should, therefore, be taken to transfer the seals quickly to the annealing ovens.

APPLICATION
The glass is used mainly for sealing to copper, alloys or high expansion steels with similar expansion coefficients.

AVAILABILITY
Hand made rod.

PHYSICAL PROPERTIES

Expansion coefficient:	148
Specific gravity:	2·78
Refractive index:	1·616
Strain point:	390
Annealing point:	450
Softening point:	570

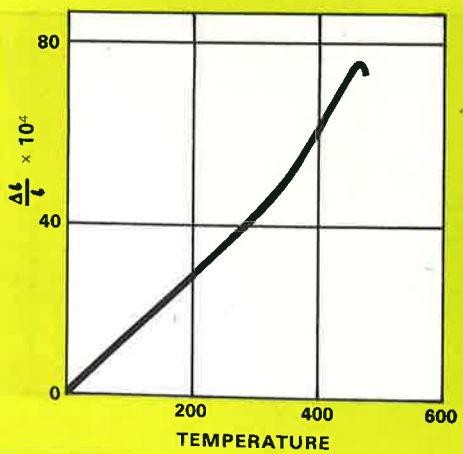
ELECTRICAL PROPERTIES

Log ρ 250°:	6·9
Log ρ 350°:	5·1
T_K 100:	200
K:	9·5
Tan δ:	0·0020

CHEMICAL COMPOSITION

	(Wt. %)
SiO_2	42·0
BaO	3·0
SrO	4·0
TiO_2	20·0
Na_2O	17·1
K_2O	13·8

Expansion



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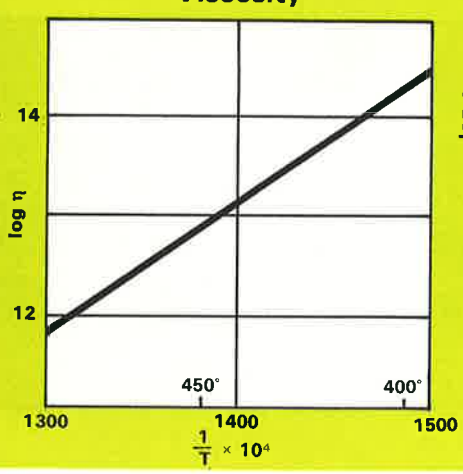
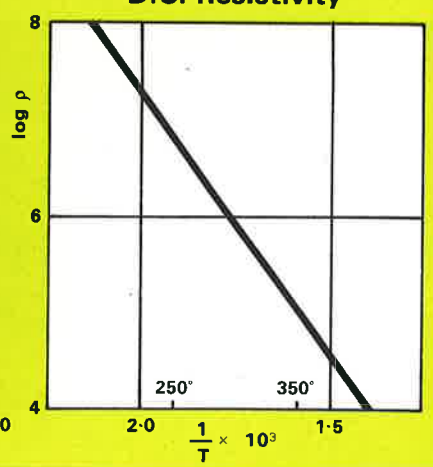
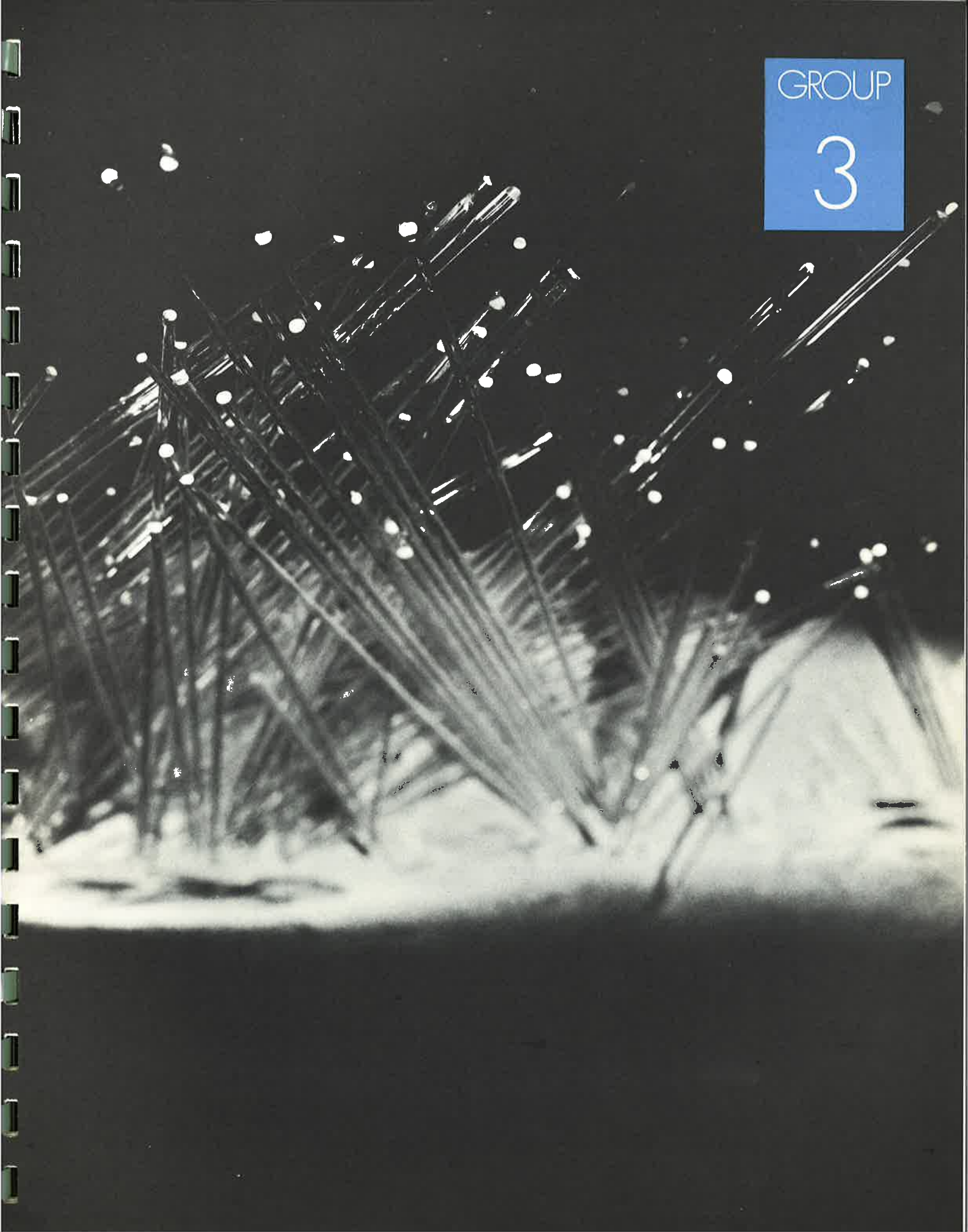


D.C. Resistivity




GROUP
3

Graded Seal Glasses

1st September, 1973

Many technical applications and scientific apparatus require a seal between fused silica and a borosilicate glass, a soda-lime or a lead glass. However the wide difference in thermal expansion coefficients between these glasses makes it impossible to seal them directly to each other without cracking and a 'graded seal' is necessary.

A seal is made to the fused silica with a small quantity of glass of a slightly higher thermal expansion coefficient, viz. GS10. In turn, a small quantity of a second glass with a slightly higher expansion than GS10, viz. GS20, is joined to it and by repeating the process with glasses of successively higher expansion coefficients, the final join can be made to either L92 or S95 glass.

In this technique, the stresses in the seal are distributed throughout the whole seal and at no point should the stress level fracture the seal.

A number of graded seal glasses covering a range of thermal expansion coefficients are available.

SEALING GLASS	MEAN EXPANSION COEFFICIENT
Fused silica	5
GS10	12
GS20	19
GS25	26
GS30	30

The graded seal may then be made successively to Chemical Pyrex, B37, followed by:

GS44	43
GS50	49
GS65	62
GS77	75
GS85	83
L92 or S95	90 – 92

*All GS glasses can only be supplied as rod.

Graded Seal Glasses (Contd)

1st September, 1973

Typical Chemical Compositions (Wt. %)

	GS10	GS20	GS25	GS30	GS44	GS50	GS65	GS77	GS85
SiO_2	83·5	80·2	77·6	77·6	70·0	62·0	59·7	57·4	55·2
Al_2O_3	4·8	5·2	5·4	5·5	1·4	—	—	—	—
B_2O_3	11·3	11·6	11·5	11·0	21·7	19·8	16·4	13·0	9·6
BaO	0·4	1·9	2·2	1·9	—	6·4	8·4	10·4	12·4
CaO	—	1·0	1·0	1·0	0·2	—	—	—	—
ZnO	—	—	—	—	—	3·6	4·8	6·0	7·2
Na_2O	—	—	—	—	3·5	2·0	2·6	3·2	3·8
K_2O	—	—	2·3	3·0	3·2	4·6	6·0	7·4	8·8
CaF_2	—	—	—	—	—	1·7	2·2	2·7	3·2

Physical and Electrical Properties

	GS10	GS20	GS25	GS30	GS44	GS50	GS65	GS77	GS85
Expansion coefficient:	12	19	26	30	43	49	62	75	83
Specific gravity:	—	—	—	—	2·24	2·45	2·58	2·68	2·73
Strain point:	625	645	615	545	510	460	490	510	490
Annealing point:	750	730	690	640	550	520	535	550	540
Softening point:	1210	1190	1150	1075	790	770	745	720	710
Log ρ 250°:	9·5	10·1	10·7	10·7	9·1	10·6	10·0	10·0	10·2
Log ρ 350°:	7·9	8·5	9·1	9·1	7·3	8·7	8·2	8·2	8·3
T_K 100:	345	385	435	435	305	400	360	360	365

Solder Glasses X49BK X76 X88

1st September, 1973

INTRODUCTION

Three solder glasses have been specially developed for sealing together glass of similar expansion coefficients, or glass to mica, without fusion and deformation of the components.

APPLICATIONS

X49BK, a zinc-vanadium-borate glass, is supplied in granular form for making seals at approximately 610° between glasses with an expansion coefficient of approximately 50, e.g. B47 glass and/or metals or alloys with similar expansion, e.g. nickel-iron-cobalt alloys.

X76 is a lead-zinc-borate glass, available in either granular form or as a powder. It enables seals to be made satisfactorily between glasses with an expansion coefficient of approximately 90, e.g. between S95, and/or L92 glasses at a temperature of 550°.

X88 is a lead-zinc-borate glass available in either granular form or as a powder. It enables seals to be made between S95 and mica at approximately 550°.

PHYSICAL PROPERTIES	**X49BK**	**X76**	**X88**
Expansion coefficient:	47×10^{-7}	76×10^{-7} (50°-200°C)	88×10^{-7} (50°-200°C)
Specific gravity:	—	5·45	—
Strain point:	495	—	—
Annealing point:	520	—	—
ELECTRICAL PROPERTIES			
Log ρ 250°:	12·6	12·8 (at 150°C)	—
Log ρ 350°:	10·4	8·9 (at 300°C)	—
T_K 100:	520		
CHEMICAL COMPOSITION (Wt. %)			
SiO_2	4·7	5·0	2·4
Al_2O_3	4·7	—	—
B_2O_3	27·0	17·0	15·0
PbO	—	64·0	70·4
ZnO	54·4	14·0	12·2
V_2O_5	9·2	—	—


GROUP
4

Coloured Glasses

1st September, 1973

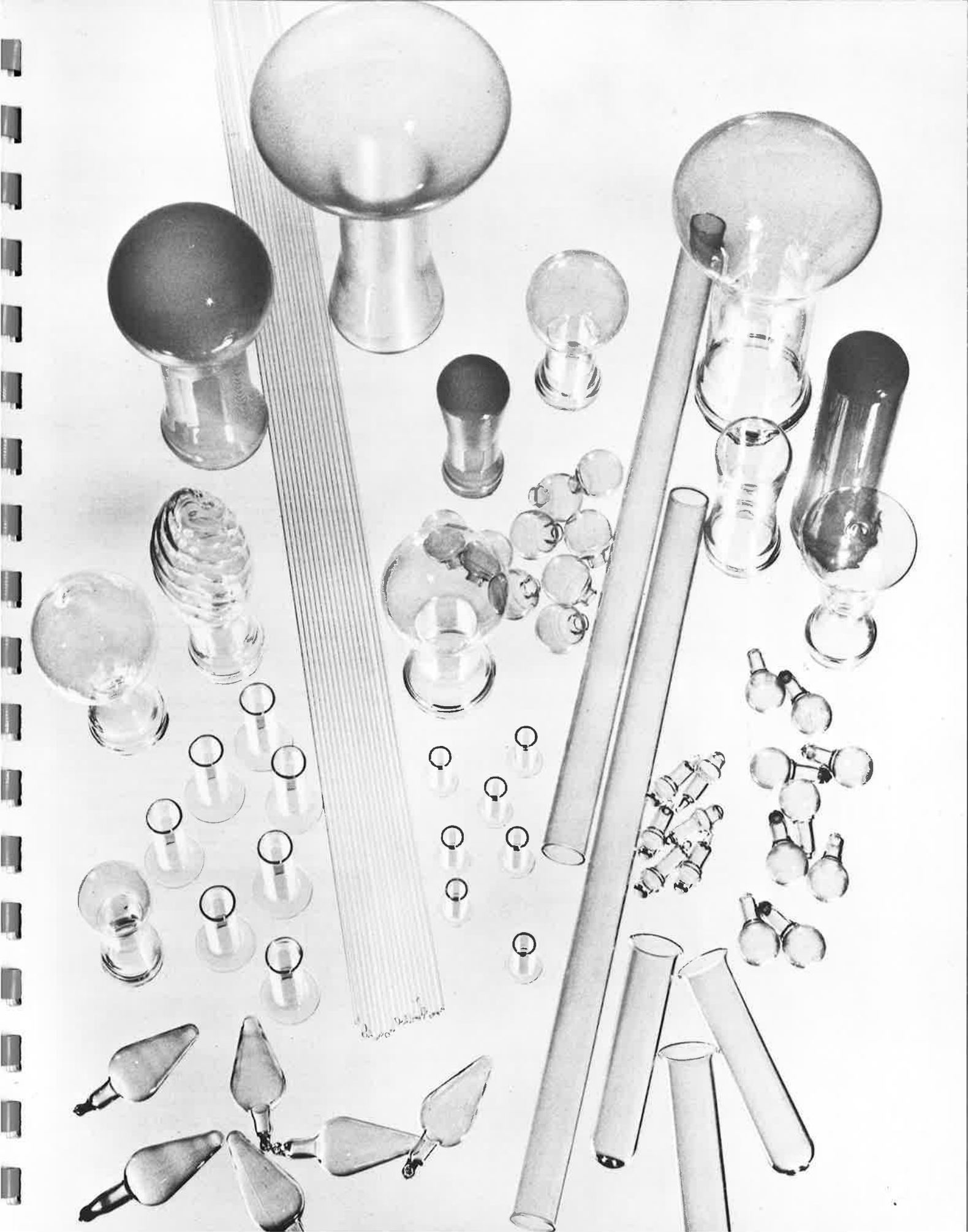
A wide range of coloured glasses is manufactured for decorative lighting ware, automobile fog lamps, airfield landing lights, indicator lamps, lamps for electric fires and forecourt lighting. The glasses are melted as required and are available as hand made bulbs, hand drawn tubing and pressings.

The coloured glasses are normally produced to specifications defining the light transmitting properties according to British Standard 1376 (1953).

Consideration will be given to the production of coloured glasses for a variety of applications.

COLOURED GLASSES

Glass Reference	Colour	Classification	Application
B48R	Red	BS1376 (1953) Class T	Airfield landing lights
B48Y1	Yellow	BS1376 (1953) Class B1	Airfield landing lights
B48Y2	Yellow	BS1376 (1953) Class T	Airfield landing lights
X60B	Blue	BS1376 (1953) Class A	Airfield landing lights
X60G	Green	BS1376 (1953) Class T	Airfield landing lights
X101A	Amber		Lamps for electric fires
X101A2	Orange-ruby		Indicator lamps
L101B1	Blue		Daylight blue lamps
L101B5	Blue	BS1376 (1953) Class A	Airfield landing lights
L101B6	Blue		Decorative lamps
L101G	Green		Decorative lamps
L101G1	Green	BS1376 (1953) Class T	Airfield landing lights
X101R	Ruby		Decorative lamps
X101R1	Ruby		Admiralty ruby lamps
X101R2	Red	BS1376 (1953) Class A	Airfield landing lights
X101R3	Red	BS1376 (1953) Class T	Airfield landing lights
X101R4	Ruby		Decorative cylinders
X101Y	Yellow		Automobile fog lamps
X101Y1	Yellow	BS1376 (1953) Class B1	Airfield landing lights
X101Y2	Yellow	BS1376 (1953) Class T	Airfield landing lights
X101Y3	Yellow		Forecourt lighting
S101BV	Black		U.V. lamps max. transmittancy at 365 nm
L101W1	White		Beads for miniature lamp assembly



Technical Data

GLASS REFERENCE	TYPE	PRINCIPAL USE	AVAILABILITY	EXPANSION COEFFICIENT (mm/mm/deg C) x 10^7 50°–300°C	VISCOSITY			VOLUME RES log ρ
					STRAIN POINT $10^{14\cdot6}$ poise °C	ANNEALING POINT 10^{13} poise °C	SOFTENING POINT $10^{7\cdot6}$ poise °C	250°C
Q5	Clear fused silica	Quartz lamps	T	5.5	1060	1190	1630	11.7
Q6	Translucent fused silica	Heating elements	T	6	1040	1170	1620	12.3
B36	Borosilicate	Sealed beam lamps	P	36.5	490	560	790	7.7
B37	Borosilicate	Tungsten sealing	B.T.R.P.G.S.	37.5	490	560	770	8.7
A41	Aluminosilicate	Mercury vapour lamps	B.T.P.	43	735	760	970	14·1
B47	Borosilicate	Fe-Ni-Co seals	B.T.P.G.	47	435	490	715	9.4
B472	Borosilicate	Fe-Ni-Co seals	B.T.P.G.	47·5	455	525	700	7·6
B53	Borosilicate	Fe-Ni-Co seals	B.T.P.G.S.	51	490	530	740	8.8
X90	Barium-alumino-borate	Sodium vapour lamps	Two-ply tubing	97				
X91	Sodium-alumino-borate	Sodium vapour lamps	Two-ply tubing	83				
S911	Soda-lime-silicate	Domestic ware	Tumblers, lamp shades	88	525	555	725	6.2
L92	Alkali-lead-silicate	Lamp tubing	B.T.R.P.G.S.	90	390	435	630	9.6
X94	Alkali-barium-silicate	Sheathing copper clad wire	T	92	490	525	700	9·5
S95	Soda-lime-silicate	Fluorescent lamp tubing, vials, bench working	T.R.	92	470	515	710	6.6
X951	Alkali-barium-silicate	Sintered bases	G	91	425	470		8.2
S96	Soda-lime-silicate	Bulbs, fluorescent lamp tubing	B.T.R.	94	495	525	715	6.5
S97	Soda-lime-silicate	Lamp and valve bulbs	B.T.P.	95	460	520	710	6.2
S972	Soda-lime-silicate	Reed relays	T	93	450	510	700	6·2
S100	Alkali-silicate	Cathode ray tubes	B.P.	96	535	570	725	8·3
X150	Alkali-silicate	Copper sealing	R	145	390	450	570	6.9
GS10	High silica	Graded seals	R	12	625	750	1210	9.5
GS20	High silica	Graded seals	R	19	645	730	1190	10.1
GS25	High silica	Graded seals	R	26	615	690	1150	10.7
GS30	High silica	Graded seals	R	30	545	640	1075	10.7
GS44	Borosilicate	Graded seals	R	43	510	550	790	9.1
GS50	Borosilicate	Graded seals	R	49	460	520	770	10.6
GS65	Borosilicate	Graded seals	R	62	490	535	745	10.0
GS77	Borosilicate	Graded seals	R	75	510	550	720	10.0
GS85	Borosilicate	Graded seals	R	83	490	540	710	10.2
X49BK	Zinc-vanadium-borate	Solder seals to B47	G	47	495	520		12·6
X76	Lead-zinc-borate	Solder seals	G	76 (50°—200°C)				12.8 (at 150°C)
X88	Lead-zinc-borate	Solder seals to mica	G	88 (50°—200°C)				

Summary sheet

ELECTRICAL ISTIVITY (ohm cm.)	DIELECTRIC PROPERTIES at 1 MHz and 20°C		SPECIFIC GRAVITY 20°C	TECHNICAL DATA	
350°C	K	tan δ		REFRACTIVE INDEX n_D	GLASS REFERENCE
9.6	3.75	0.0004	2.20	1.458	Q5
10.2			2.02	—	Q6
6.3			2.25	1.45	B36
7.1	4.2	0.0013	2.25	1.478	B37
11·8			2·65	1·541	A41
7.6			2.25	1.485	B47
6·0			2·26		B472
7.2	5.2	0.0024	2.35	1.492	B53
					X90
					X91
5.0			2.47	1.513	S911
7.8	6.3	0.0008	3.04	1.563	L92
7·6			2.68		X94
5.3			2.50	1.513	S95
6.5			2.59		X951
5.1	6.8	0.008	2.48	1.512	S96
5.0			2.47	1.511	S97
5·0			2·50		S972
6.5			2.53	1.508	S100
5.1	9.5	0.002	2.78	1.616	X150
7.9					GS10
8.5					GS20
9.1					GS25
9.1					GS30
7.3			2.24		GS44
8.7			2.45		GS50
8.2			2.58		GS65
8.2			2.68		GS77
8.3			2.73		GS85
10·4			3.48		X49BK
8.9 (at 300°C)			5.45		X76
					X88

B—Bulbs P—Pressings T—Tubing G—Granular powder R—Rod S—Sinters

Table 1

APPROXIMATE FEET PER LB. OF S95 TUBING AND ROD

MEAN O.D. MM	WALL MM													
	.20/.30	.30/.40	.40/.50	.50/.60	.60/.70	.70/.80	.80/.90	.90/1.0	1.05/1.15	1.25/1.40	1.50/1.75	1.75/2.0	2.0/2.5	ROD
2	433	328	272	238										190
3		204	165	141										84.2
4			119	99.8	87.0	77.7	70.8	65.4	59.4					47.4
5			92.5	77.4	67.0	59.4	53.7	49.2	44.2					30.3
6			75.9	63.2	54.5	48.1	43.3	39.5	35.2	30.6	26.7	24.5		21.1
7			64.3	53.4	45.9	40.4	36.2	33.0	29.2	25.2	21.7	19.7		15.5
8			55.8	46.2	39.7	34.8	31.2	28.3	25.0	21.4	18.3	16.5		11.8
9			49.2	40.8	34.9	30.6	27.4	24.8	21.8	18.6	15.8	14.2	12.5	9.36
10			44.1	36.5	31.2	27.3	24.4	22.0	19.4	16.5	13.9	12.4	10.9	7.58
11			39.9	33.0	28.2	24.6	22.0	19.8	17.4	14.8	12.4	11.1	9.63	6.26
12			36.5	30.1	25.7	22.5	20.0	18.1	15.8	13.4	11.2	9.98	8.64	5.26
13				27.7	23.6	20.6	18.3	16.6	14.5	12.3	10.3	9.08	7.83	4.48
14				25.6	21.8	19.1	17.0	15.3	13.4	11.3	9.42	8.34	7.17	3.87
15				23.8	20.3	17.7	15.8	14.2	12.4	10.5	8.72	7.70	6.61	3.37
16				22.3	19.0	16.6	14.7	13.3	11.6	9.75	8.11	7.16	6.13	2.96
17				20.9	17.8	15.5	13.8	12.4	10.8	9.12	7.58	6.68	5.71	2.62
18				19.7	16.8	14.6	13.0	11.7	10.2	8.58	7.12		5.35	2.34
19				18.7	15.9	13.8	12.3	11.1	9.62	8.09	6.71		5.03	
20					15.1	13.1	11.6	10.5	9.11	7.66	6.35		4.74	
21					14.3	12.5	11.1	9.95	8.66	7.27	6.02		4.49	
22					13.7	11.9	10.5	9.48	8.24	6.92	5.72		4.26	
23					13.0	11.4	10.1	9.05	7.87	6.60	5.46		4.06	
24					12.5	10.9	9.63	8.65	7.52	6.31	5.21		3.87	
25					12.0	10.4	9.23	8.29	7.21	6.04	4.99		3.70	
26					11.5	10.0	8.86	7.96	6.92	5.80	4.78		3.55	
27							8.53	7.66	6.65	5.57	4.60		3.40	
28							8.21	7.37	6.40	5.36	4.42		3.27	
29							7.92	7.11	6.17	5.17	4.26		3.15	
30							7.65	6.87	5.96	4.99	4.11		3.04	
31							7.39	6.64	5.76	4.82	3.97		2.93	
32							7.16	6.42	5.58	4.66	3.84		2.83	
33							6.93	6.22	5.40	4.52	3.72			
34									5.24	4.38	3.60			
35									5.08	4.25	3.49			
36									4.94	4.12	3.39			
37									4.80	4.01	3.30			
38									4.67	3.90	3.21			
39									4.55	3.80	3.12			
40									4.43	3.70	3.04			
45									3.92	3.16				
50									3.52	2.83				
55									3.20	2.66				
60									2.92	2.44				
65									2.70	2.25				

These figures have been calculated using the following formulae:

	Tubing	*Rod*
Ft/lb. =	$\frac{189.5}{W(D-W)}$	$\frac{757.9}{D^2}$

Where D = mean diameter in mm

W = mean wall in mm

Table 2

APPROXIMATE METRES PER KILOGRAMME OF S95 TUBING AND ROD

MEAN O.D. MM	WALL MM													
	.20/.30	.30/.40	.40/.50	.50/.60	.60/.70	.70/.80	.80/.90	.90/1.0	1.05/1.15	1.25/1.40	1.50/1.75	1.75/2.0	2.0/2.5	ROD
2	291	220	182	160										127
3		137	111	94.4										56.6
4			79.7	67.1	58.4	52.2	47.5	43.9	39.9					31.8
5			62.2	52.0	45.0	39.9	36.1	33.1	29.7					20.4
6			51.0	42.5	36.6	32.3	29.1	26.5	23.6	20.6	17.9	16.5		14.1
7			43.2	35.9	30.8	27.2	24.3	22.1	19.6	16.9	14.6	13.2		10.4
8			37.5	31.1	26.6	23.4	20.9	19.0	16.8	14.4	12.3	11.1		7.96
9			33.1	27.4	23.5	20.6	18.4	16.6	14.6	12.5	10.6	9.53	8.38	6.29
10			29.6	24.5	20.9	18.3	16.4	14.8	13.0	11.1	9.35	8.36	7.30	5.09
11			26.8	22.1	18.9	16.6	14.8	13.3	11.7	9.93	8.35	7.44	6.47	4.21
12			24.5	20.2	17.3	15.1	13.4	12.1	10.6	9.00	7.55	6.71	5.80	3.54
13				18.6	15.9	13.9	12.3	11.1	9.72	8.23	6.89	6.10	5.26	3.01
14				17.2	14.7	12.8	11.4	10.3	8.97	7.58	6.33	5.60	4.82	2.60
15				16.0	13.6	11.9	10.6	9.54	8.33	7.03	5.86	5.17	4.44	2.26
16				15.0	12.8	11.1	9.89	8.90	7.77	6.55	5.45	4.81	4.11	1.99
17				14.1	12.0	10.4	9.27	8.35	7.28	6.13	5.10	4.49	3.84	1.76
18				13.3	11.3	9.84	8.73	7.86	6.85	5.76	4.78		3.59	1.57
19				12.5	10.7	9.30	8.25	7.42	6.47	5.44	4.51		3.38	
20					10.1	8.82	7.82	7.03	6.12	5.14	4.26		3.19	
21					9.62	8.38	7.43	6.40	5.82	4.88	4.04		3.02	
22					9.17	7.99	7.08	6.37	5.54	4.65	3.84		2.86	
23					8.76	7.63	6.76	6.08	5.28	4.43	3.66		2.73	
24					8.39	7.30	6.47	5.81	5.05	4.24	3.50		2.60	
25					8.04	7.00	6.20	5.57	4.84	4.06	3.35		2.49	
26					7.73	6.72	5.95	5.35	4.65	3.89	3.21		2.38	
27							5.73	5.14	4.47	3.74	3.09		2.29	
28							5.52	4.95	4.30	3.60	2.97		2.20	
29							5.32	4.78	4.15	3.47	2.86		2.12	
30							5.14	4.61	4.00	3.35	2.76		2.04	
31							4.97	4.46	3.87	3.24	2.67		1.97	
32							4.81	4.32	3.75	3.13	2.58		1.90	
33							4.66	4.18	3.63	3.03	2.50			
34									3.52	2.94	2.42			
35									3.41	2.85	2.35			
36									3.32	2.77	2.28			
37									3.22	2.69	2.21			
38									3.14	2.62	2.15			
39									3.05	2.55	2.10			
40									2.97	2.48	2.04			
45									2.64	2.20				
50									2.37	1.97				
55									2.15	1.79				
60									1.96	1.64				
65									1.81	1.51				

These figures have been calculated using the following formulae:

	Tubing	*Rod*
M/Kg =	$\frac{127.3}{W(D-W)}$	$\frac{509.3}{D^2}$

Where D = mean diameter in mm

W = mean wall in mm

APPROXIMATE FEET PER LB. OF L92 TUBING AND ROD

Table 3

MEAN O.D. MM	WALL MM														
	.30/.40	.40/.50	.50/.60	.60/.75	.70/.80	.80/.90	.90/1.0	1.05/1.15	1.15/1.25	1.25/1.35	1.35/1.50	1.50/1.75	1.75/2.25	2.0/2.50	ROD
2	270	223	195												156
3	168	136	116	99.3											69.3
4	122	97.5	82.1	69.4											39.0
5		76.1	63.6	53.4	48.9	44.2									24.9
6			52.0	43.4	39.6	35.6	32.5	28.9							17.3
7			43.9	36.5	33.2	29.8	27.1	24.0							12.7
8			38.0	31.5	28.7	25.6	23.3	20.5	19.1						9.74
9			33.5	27.7	25.2	22.5	20.4	17.9	16.6						7.70
10			30.0	24.8	22.5	20.0	18.1	15.9	14.8						6.23
11			27.1	22.4	20.3	18.1	16.3	14.3	13.2						5.15
12			24.7	20.4	18.5	16.4	14.8	13.0	12.0	11.2					4.33
13			22.8	18.7	17.0	15.1	13.6	11.9	11.0	10.2					3.69
14			21.1	17.3	15.7	13.9	12.6	11.0	10.1	9.44					
15				16.1	14.6	13.0	11.7	10.2	9.41	8.75					
16						12.1	10.9	9.51	8.77	8.15	7.50				
17						11.3	10.2	8.91	8.22	7.63	7.02				
18						10.7	9.62	8.38	7.73	7.18	6.60	5.86			
19						10.1	9.09	7.91	7.29	6.77	6.22	5.52			
20							8.61	7.49	6.91	6.41	5.89	5.22			
21							8.18	7.12	6.56	6.08	5.59	4.95			
22							7.79	6.78	6.24	5.79	5.31	4.71			
23											5.07	4.49			
24											4.84	4.29	3.54	3.18	
25											4.64	4.10	3.39	3.04	
26											4.45	3.93	3.25	2.92	
27											4.28	3.78	3.12	2.80	
28												3.64	3.00	2.69	
29												3.50	2.89	2.59	
30												3.38	2.78	2.50	
31												3.26	2.69	2.41	
32												3.16	2.60	2.33	
33												3.06	2.51	2.25	
34												2.96	2.43	2.18	
35												2.87	2.36	2.11	
36												2.79	2.29	2.05	

These figures have been calculated using the following formulae:

	Tubing	*Rod*
Ft./lb. =	$\frac{155.8}{W(D-W)}$	$\frac{623.3}{D^2}$

Where D = mean diameter in mm

W = mean wall in mm

APPROXIMATE METRES PER KILOGRAMME OF L92 TUBING AND ROD

Table 4

MEAN O.D. MM	WALL MM														ROD
	.30/.40	.40/.50	.50/.60	.60/.75	.70/.80	.80/.90	.90/1.0	1.05/1.15	1.15/1.25	1.25/1.35	1.35/1.50	1.50/1.75	1.75/2.25	2.0/2.50	
2	181	150	131												105
3	113	91.2	77.7	66.7											46.5
4	81.9	65.5	55.2	46.7											26.2
5		51.1	42.8	35.9	32.8	29.7									16.7
6			34.9	29.1	26.6	23.9	21.8	19.4							11.6
7			29.5	24.5	22.3	20.0	18.2	16.1							8.54
8			25.5	21.2	19.3	17.2	15.6	13.8	12.8						6.54
9			22.5	18.6	16.9	15.1	13.7	12.0	11.2						5.17
10			20.1	16.6	15.1	13.5	12.2	10.7	9.91						4.19
11			18.2	15.0	13.6	12.1	11.0	9.61	8.90						3.46
12			16.6	13.7	12.4	11.0	9.97	8.73	8.08	7.53					2.91
13			15.3	12.6	11.4	10.1	9.15	8.00	7.39	6.88					2.48
14			14.2	11.6	10.5	9.37	8.44	7.38	6.82	6.34					
15				10.8	9.80	8.70	7.84	6.85	6.32	5.88					
16						8.13	7.32	6.39	5.90	5.48	5.04				
17						7.63	6.87	5.99	5.52	5.13	4.72				
18						7.18	6.46	5.63	5.19	4.82	4.43	3.93			
19						6.79	6.11	5.32	4.90	4.55	4.18	3.71			
20							5.79	5.04	4.64	4.31	3.96	3.51			
21							5.50	4.78	4.41	4.09	3.75	3.33			
22							5.24	4.55	4.19	3.89	3.57	3.15			
23											3.41	3.01			
24											3.25	2.88	2.38	2.21	
25											3.12	2.76	2.28	2.05	
26											2.99	2.64	2.18	1.96	
27											2.87	2.54	2.09	1.88	
28												2.44	2.01	1.81	
29												2.35	1.94	1.74	
30												2.27	1.87	1.68	
31												2.19	1.81	1.62	
32												2.12	1.75	1.56	
33												2.05	1.69	1.51	
34												1.99	1.64	1.47	
35												1.93	1.59	1.42	
36												1.87	1.54	1.38	

These figures have been calculated using the following formulae:

$$M/Kg = \frac{104.7}{W(D - W)} \quad \text{(Tubing)} \qquad \frac{418.7}{D^2} \quad \text{(Rod)}$$

Where D = mean diameter in mm

W = mean wall in mm

APPROXIMATE FEET PER LB. OF B37 TUBING AND ROD

This table also applies to Q5, B46, B47 and B53 glasses.
For other hard glasses the lengths shown should be multiplied by the factors given below:

Q 6	1·1
A 43	0·9
A 45	0·9

MEAN O.D. MM	MEAN WALL MM									ROD
	.625	.875	1.00	1.25	1.50	1.75	2.25	3.75	4.25	
2	245									
3	142	113.2	105.3	96.2						93.6
4	99.8	77.0	70.2	61.2						52.6
5	77.0	58.3	52.6	44.9	40.1	37.0				33.7
6	62.7	46.9	42.1	35.5	31.2	28.3				23.4
7	52.8	39.3	35.1	29.3	25.5	22.9	19.7			17.2
8	45.7	33.8	30.1	25.0	21.6	19.3	16.3			13.2
9	40.2	29.6	26.3	21.7	18.7	16.6	13.9			10.4
10	35.9	26.4	23.4	19.3	16.5	14.6	12.1			8.42
11		23.8	21.1	17.3	14.8	13.0	10.7			6.96
12		21.6	19.1	15.7	13.4	11.7	9.60			5.85
13		19.8	17.5	14.3	12.2	10.7	8.70			4.98
14		18.3	16.2	13.2	11.2	9.82	7.96			4.30
15		17.0	15.0	12.3	10.4	9.08	7.34			3.74
16				11.4	9.68	8.44	6.80			3.29
17				10.7	9.05	7.89	6.34			2.91
18				10.1	8.51	7.40	5.94			2.60
19				9.49	8.02	6.97	5.59			2.33
20				8.98	7.59	6.59	5.27	3.45	3.14	2.10
21				8.53	7.20	6.25	4.99	3.25	2.96	1.91
22				8.12	6.85	5.94	4.74	3.08	2.79	
23				7.74	6.53	5.66	4.51	2.92	2.64	
24				7.40	6.24	5.41	4.30	2.77	2.51	
25				7.09	5.97	5.17	4.11	2.64	2.39	
26				6.80	5.73	4.96	3.94	2.52	2.28	
27				6.54	5.50	4.76	3.78	2.41	2.18	
28				6.30	5.30	4.58	3.63	2.31	2.09	
29				6.07	5.10	4.41	3.50	2.22	2.00	
30				5.86	4.92	4.26	3.37	2.14	1.92	
32				5.48	4.60	3.98	3.14	1.99	1.79	
34				5.14	4.32	3.73	2.95	1.86	1.67	
36				4.85	4.07	3.51	2.77	1.74	1.56	
38				4.58	3.84	3.32	2.61	1.64	1.47	
40				4.35	3.65	3.14	2.48	1.55	1.39	
42				4.13	3.47	2.99	2.35	1.47	1.31	
44				3.94	3.30	2.85	2.24	1.40	1.25	
46				3.76	3.15	2.72	2.14	1.33	1.19	
48				3.60	3.02	2.60	2.05	1.27	1.13	
50				3.45	2.89	2.49	1.96	1.21	1.08	

These figures have been calculated using the following formulae:

Rod $\frac{842.1}{D^2}$

Tubing Ft./lb. = $\frac{210.5}{W(D-W)}$

Where D = mean diameter in mm

W = mean wall in mm

APPROXIMATE METRES PER KILOGRAMME OF B37 TUBING AND ROD

Table 6

This table also applies to Q5, B46, B47 and B53 glasses.
For other hard glasses the lengths shown should be multiplied by the factors given below:

Q 6	1·1
A 43	0·9
A 45	0·9

MM	MEAN WALL MM									ROD
	.625	.875	1.00	1.25	1.50	1.75	2.25	3.75	4.25	
2	165									
3	95.3	76.1	70.7	64.6						62.9
4	67.0	51.7	47.1	41.1						35.4
5	51.7	39.2	35.4	30.2	26.9	24.9				22.6
6	42.1	31.5	28.3	23.8	21.0	19.0				15.7
7	35.5	26.4	23.6	19.7	17.1	15.4	13.2			11.5
8	30.7	22.7	20.2	16.8	14.5	12.9	10.9			8.84
9	27.0	19.9	17.7	14.6	12.6	11.1	9.31			6.99
10	24.1	17.7	15.7	12.9	11.1	9.79	8.11			5.66
11		16.0	14.1	11.6	9.92	8.74	7.18			4.68
12		14.5	12.9	10.5	9.00	7.88	6.45			3.93
13		13.3	11.8	9.63	8.20	7.18	5.85			3.35
14		12.3	10.9	8.87	7.54	6.60	5.35			2.89
15		11.4	10.1	8.23	6.98	6.10	4.93			2.52
16				7.67	6.50	5.67	4.57			2.21
17				7.18	6.08	5.30	4.26			1.96
18				6.75	5.71	5.00	4.00			1.75
19				6.37	5.39	4.68	3.75			1.57
20				6.03	5.10	4.43	3.54	2.32	2.11	1.41
21				5.73	4.83	4.20	3.35	2.19	1.99	1.28
22				5.45	4.60	4.00	3.18	2.07	1.87	
23				5.20	4.38	3.80	3.03	2.00	1.77	
24				4.97	4.19	3.63	2.89	1.86	1.68	
25				4.76	4.01	3.48	2.76	1.77	1.60	
26				4.57	3.85	3.33	2.65	1.69	1.53	
27				4.39	3.70	3.20	2.54	1.62	1.46	
28				4.23	3.60	3.08	2.44	1.55	1.40	
29				4.08	3.43	2.97	2.35	1.49	1.34	
30				3.94	3.31	2.86	2.26	1.44	1.29	
32				3.68	3.10	2.67	2.11	1.33	1.20	
34				3.45	2.90	2.51	2.00	1.25	1.12	
36				3.26	2.73	2.36	1.86	1.17	1.05	
38				3.08	2.58	2.23	1.76	1.10	.986	
40				2.92	2.45	2.11	1.66	1.04	.931	
42				2.78	2.33	2.00	1.58	.986	.881	
44				2.65	2.22	1.91	1.51	.937	.837	
46				2.53	2.12	1.83	1.44	.892	.797	
48				2.42	2.03	1.75	1.37	.852	.761	
50				2.32	1.94	1.67	1.32	.815	.727	

These figures have been calculated using the following formulae:

Rod M/Kg $= \frac{565.9}{D^2}$

Tubing M/Kg $= \frac{141.4}{W(D-W)}$

Where D = mean diameter in mm

W = mean wall in mm

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