PHILIPS

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Glass Components for lighting Industry

GLASS

1

Lighting and Industrial Glass.

GLASS

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(leadglass)

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Thermal properties

Thermal expansion:
The thermal expansion of most glasses is practically linear from room temperature up to the transformation range.
Generally the average coefficient of thermal expansion is given for the temperature range 25°C - 300 °C.
Graphs are usually shown as elongation $\Delta l/l$ (change in length / unit of length in ppm) as a function of the temperature.
Measurement according to DIN 52328.

Transformation temperature:
In the transformation range of a glass a drastic change in the thermal and electrical properties manifests itself. The transformation range is generally characterised by the transformation temperature. For most glasses this temperature is 5 - 20°C below annealing point.
Measurement according to DIN 52324.

Thermal conductivity:
The thermal conductivity is a measure of the ability of a material to transmit heat through the body of this material in a certain period of time. The thermal conductivity of glasses is highly dependent on the temperature level.
Its value is mostly given at 20°C.
Measurement according to DIN 52612, volumes 1, 2 and 3.

Viscosity:
The plastic behaviour of glasses at higher temperatures – above the transformation range – can be characterised by the relation between viscosity and temperature. The viscosity of a glass at a certain temperature is a measure of the flow under the influence of shear stress. The viscosity is generally defined by reference temperatures corresponding to typical viscosity values.

- Strain point: The temperature at which internal stresses are relieved in a few hours. At this temperature the viscosity is $10^{14.5}$dPa.s.
- Annealing point: The temperature at which internal stresses are relieved after some 15 minutes. At this temperature the viscosity is 10^{13}dPa.s.
- Softening point: The temperature at which glass is deformed under its own weight in a few minutes. At this temperature the viscosity is $10^{7.6}$dPa.s.
- Working temperature: The temperature at which the glass is soft enough for the most common hot glass-working processes. At this temperature the viscosity is 10^{4}dPa.s.
- Melting temperature: The temperature at which most glasses can be melted and refined. At this temperature the viscosity of the glass is 10^{2}dPa.s.

Measurement according to DIN 52312, volumes 1, 2 and 3.

Mechanical properties

Density:
Density is defined as the mass per unit of volume at the given temperature.
Measurement according to ASTM C 693.

Young's modulus (modulus of elasticity):
At room temperature most glasses behave as a perfectly elastic material until fracture occurs. Elastic behaviour can be characterised by Young's modulus, which is the ratio between applied stress and strain caused by this stress.
Measurement according to ASTM C 623.

Poisson's ratio:
Longitudinal stretching of an elastic material is accompanied with lateral contraction. The ratio between contraction and stretching is defined as Poisson's ratio.

Electrical properties

Volume resistivity:
The volume resistivity of a material is its resistance to the flow of an electric current through its bulk, under the influence of a different DC potential.
At room temperature glass is known as a good insulating material. Volume resistivity is a function of its chemical composition. It is strongly influenced by temperature, with a considerable drop above the transformation temperature.
The $^{10}\log$ of the resistivity is usually given at 250° and 350 °C, and the resistivity is also characterised by the temperature at which its value is equal to $10^8\ \Omega \cdot cm$ (t_K 100).
Measurement according to DIN 52326.

Dielectric constant:
The dielectric constant ε of a material used as a dielectric medium in a capacitor, is the ratio between the amount of electric energy stored in this material and the amount set up in vacuum.
Measurement according to ASTM D 150.

Loss tangent:
If glass is used as a dielectric medium in alternating current, some electric energy is converted into heat. The loss in energy is proportional to ε tg δ (loss factor). The loss tangent tg δ refers to the loss angle δ, which shows how much the phase shift between current and applied voltage differs from $\pi/2$.
Measurement according to ASTM D 150.

Optical properties

Index of refraction:
The index of refraction at a certain wavelength is the ratio between the velocity of monochromatic light in vacuum, and the velocity of light in the relevant material. The index of refraction is measured with a refractometer.

Transmittance:
The ratio between the intensity of an emerging beam and that of an incident beam is called transmittance. The transmittance is the residue after reflection losses and absorption losses.
Transmittance is measured on a spectrophotometer.

4/84
Printed in the Netherlands

Introduction

Philips 01 glass is an alkali-lead-silicate glass, available as clear machine-drawn tubing and rod.
The thermal expansion properties allow direct sealing to copper-clad wire (dumet), chromium-nickel-iron alloys and platinum.
Main application areas are:
- neck tubing for black-and-white TV, oscilloscopes, etc.
- stem and exhaust tubing for cathode ray tubes.
- tubing for other electronic applications.

Technical data of Philips 01 glass

Thermal properties

Coefficient of expansion	25-300°C	$°C^{-1}$ (x 10^{-6})	9,2
Transformation temperature		°C	425
Conductivity	20°C	$W \cdot m^{-1} \cdot °C^{-1}$	81
Viscosity data			
Strain point	$10^{14,5}$dPa.s	°C	405
Annealing point	10^{13} dPa.s	°C	445
Softening point	$10^{7,6}$dPa.s	°C	625
Working temperature	10^{4} dPa.s	°C	965

Mechanical properties

Density	20°C	$kg \cdot m^{-3}$($x10^3$)	3,05
Young's modulus		GPa	63
Poisson's ratio			0,22

Electrical properties

Volume resistivity	$^{10}\log \rho$ 250°C	$\Omega \cdot cm$	8,6
	$^{10}\log \rho$ 350°C	$\Omega \cdot cm$	6,8
^{t}k 100	10^8 $\Omega \cdot cm$	°C	280
Dielectric constant	at 20°C and 1 MHz		7,2
Loss tangent	at 20°C and 1 MHz	(x 10^{-4})	16

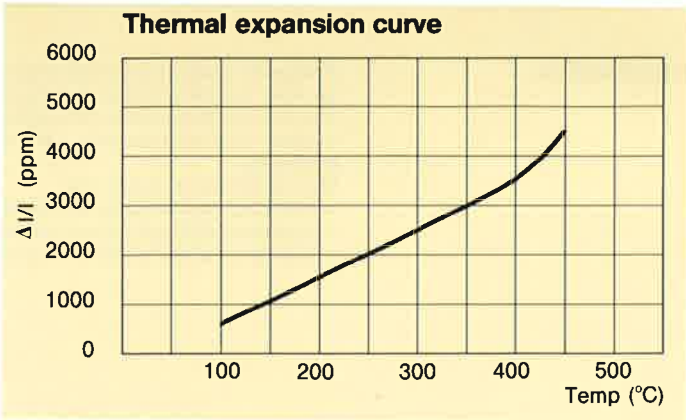
Röntgen absorption

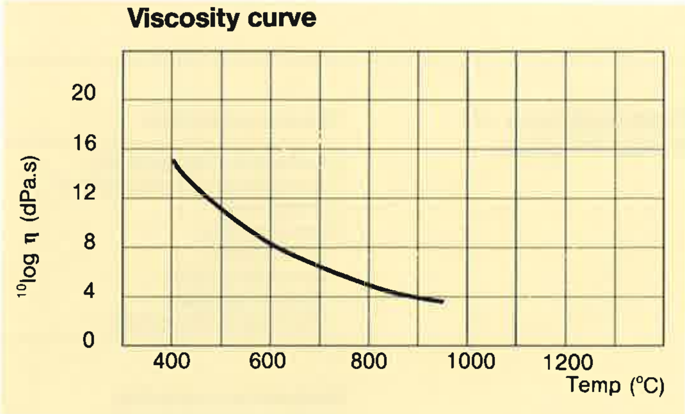
Lin. coeff. of Rö-absorption	20,6 KV;0,6 A		75

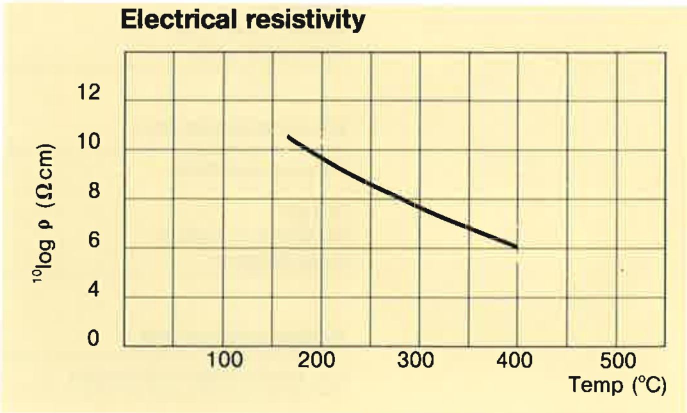
Optical properties

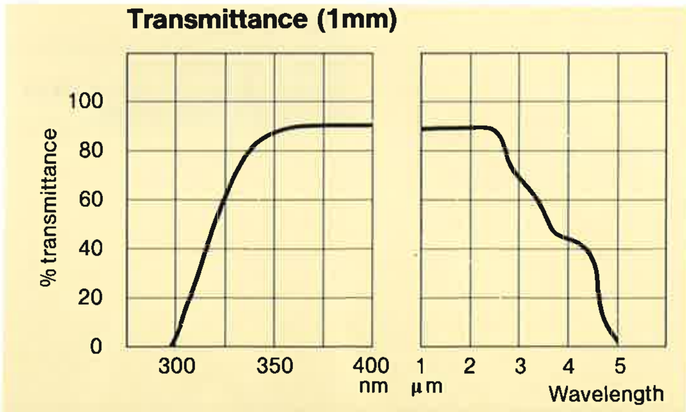
Index of refraction n_D.	at $\lambda = 589{,}3$ nm		1,560
Transmittance (thickness 1 mm) including surface losses			See graph

Philips 01 glass









Technical information

Address: Philips Lighting Division
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The Netherlands

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Data subject to change without notice

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Printed in the Netherlands

PHILIPS

Lighting

Glass

Introduction

Philips 51 glass is an alumino-borosilicate glass, available as drawn rod glass.
It is an intermediate glass for sealing quartz to tungsten.
Main application areas are:
– lead-through constructions in lamps with tungsten lead-in wires and quartz envelopes (e.g. high-pressure mercury vapour compact source lamps).

Technical data of Philips 51 glass

Thermal properties

Coefficient of expansion	25-300°C	$°C^{-1}$ (x 10^{-6})	1,35
Transformation temperature		°C	730
Conductivity	20°C	$W \cdot m^{-1} \cdot °C^{-1}$	–
Viscosity data			
Strain point	$10^{14,5}$ dPa.s	°C	735
Annealing point	10^{13} dPa.s	°C	795
Softening point	$10^{7,6}$ dPa.s	°C	1200
Working temperature	10^{4} dPa.s	°C	–

Mechanical properties

Density	20°C	$kg \cdot m^{-3}$ (x10^3)	2,15
Young's modulus		GPa	–
Poisson's ratio			–

Electrical properties

Volume resistivity	$^{10}\log\ \rho$ 250°C	$\Omega \cdot cm$	9,1
	$^{10}\log\ \rho$ 350°C	$\Omega \cdot cm$	7,5
^{t}k 100	10^8 $\Omega \cdot cm$	°C	310
Dielectric constant	at 20°C and 1 MHz		–
Loss tangent	at 20°C and 1 MHz	(x 10^{-4})	–

Optical properties

Index of refraction n_D.	at $\lambda = 589{,}3$ nm		–
Transmittance (thickness 1 mm) including surface losses			

Lighting & Industrial Glass

GLASS

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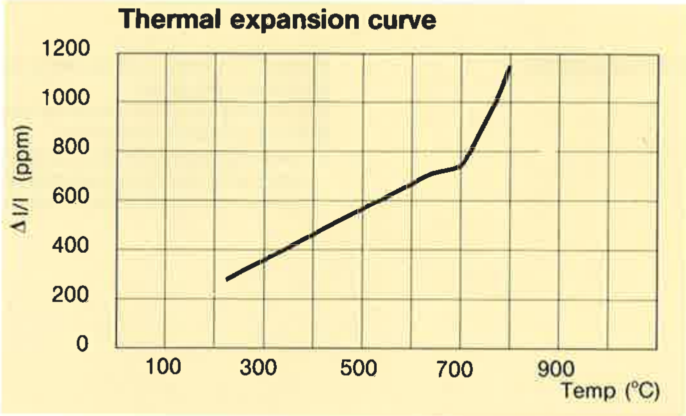
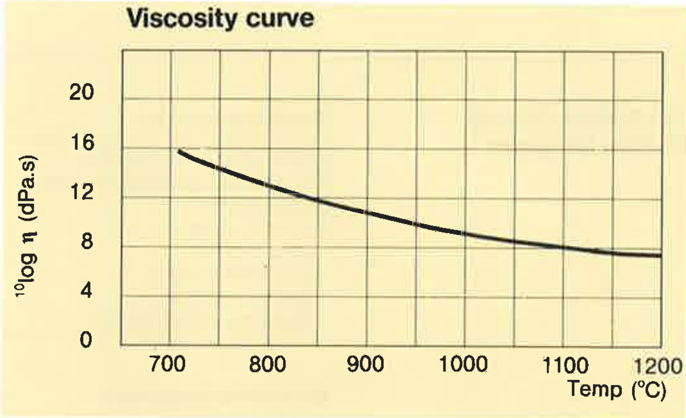
Philips 51 glass





Technical information

Address: Philips Lighting Division
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1013 010 00441
Lighting Division

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Lighting

Glass

Introduction

Philips 78 glass is an alkali-lead-silicate glass, available as clear machine-drawn tubing.
Because of its physical and electrical properties, 78 glass is a good construction material for colour TV stem making and neck production. It can be directly sealed to copper-clad wire (dumet) and chromium-nickel-iron alloys.
Main application areas are:
- colour television necks
- stems for colour television guns
- stems for heavy-loaded special lamps.

Technical data of Philips 78 glass

Thermal properties

Coefficient of expansion	25-300°C	°C^{-1} (x 10^{-6})	9,65
Transformation temperature		°C	465
Conductivity	20°C	W·m^{-1}·°C^{-1}	–
Viscosity data			
Strain point	$10^{14,5}$dPa.s	°C	450
Annealing point	10^{13} dPa.s	°C	485
Softening point	$10^{7,6}$dPa.s	°C	660
Working temperature	10^{4} dPa.s	°C	965

Mechanical properties

Density	20°C	kg·m·$^{-3}$(x10^3)	3,3
Young's modulus		GPa	59
Poisson's ratio			0,24

Electrical properties

Volume resistivity	^{10}log ρ 250°C	Ω·cm	10,6
	^{10}log ρ 350°C	Ω·cm	8,5
^{t}k 100	10^8 Ω·cm	°C	380
Dielectric constant	at 20°C and 1 MHz		8,1
Loss tangent	at 20°C and 1 MHz	(x 10^{-4})	16,4

Röntgen absorption

Lin. coeff. of Rö-absorption	20,6 KV;0,6 A		98

Optical properties

Index of refraction n_D.	at λ = 589,3 nm		1,591
Transmittance (thickness 1 mm) including surface losses			See graph

Lighting & Industrial Glass

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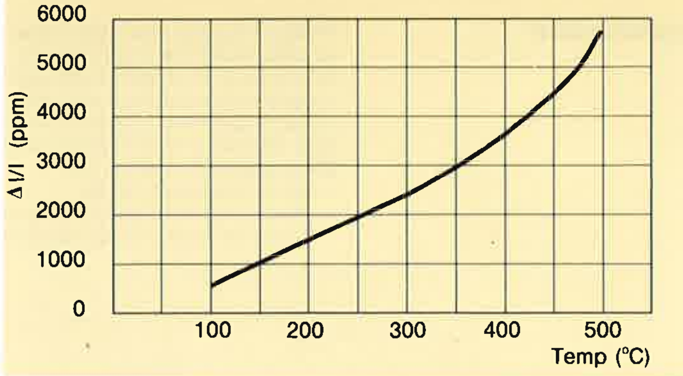
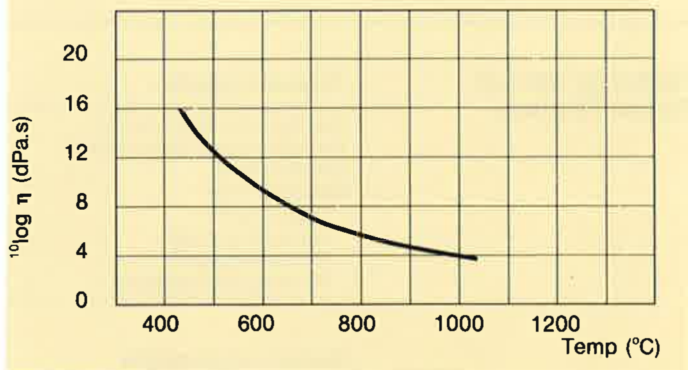
Philips 78 glass

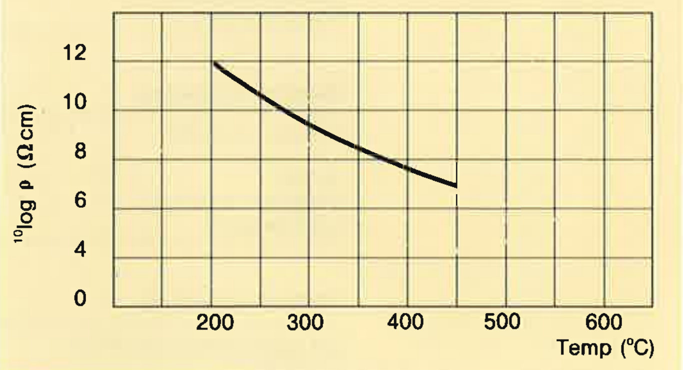
Thermal expansion curve



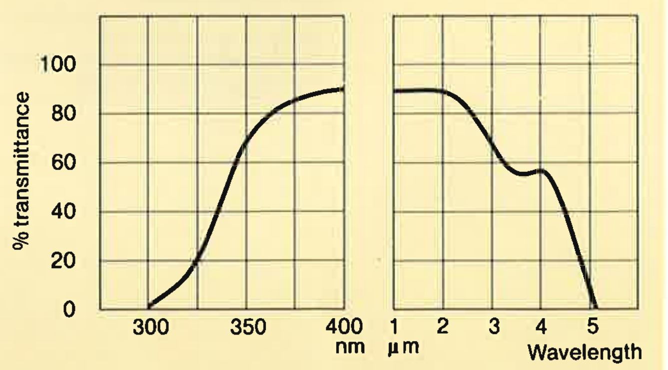
Viscosity curve



Electrical resistivity



Transmittance (1 mm)



Technical information

Address: Philips Lighting Division
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Data subject to change without notice

1013 010 00411
Lighting Division

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PHILIPS

Introduction

Philips 160 glass is a sodium-barium-silicate glass, available as clear machine-drawn tubing.
It has a high transmittance in the short UV region of the spectrum. At a wavelength of 253,7nm (mercury vapour spectral line), the typical transmittance is 65% at a wall thickness of 1 mm.
The thermal expansion properties are matched to seal to Philips 291 glass stem tubing.
Main application area is:
— envelopes for low-pressure mercury vapour germicidal lamps.

Technical data of Philips 160 glass

Thermal properties

Coefficient of expansion	25-300°C	$°C^{-1}$ (x 10^{-6})	9,9
Transformation temperature		°C	470
Conductivity	20°C	$W \cdot m^{-1} \cdot °C^{-1}$	0,95
Viscosity data			
Strain point	$10^{14,5}$ dPa.s	°C	460
Annealing point	10^{13} dPa.s	°C	490
Softening point	$10^{7,6}$ dPa.s	°C	670
Working temperature	10^{4} dPa.s	°C	1000

Mechanical properties

Density	20°C	$kg \cdot m^{-3}$ (x10^3)	2,53
Young's modulus		GPa	65
Poisson's ratio			0,25

Electrical properties

Volume resistivity	$^{10}\log \rho$ 250°C	$\Omega \cdot cm$	8,0
	$^{10}\log \rho$ 350°C	$\Omega \cdot cm$	6,3
tk 100	10^8 $\Omega \cdot cm$	°C	250
Dielectric constant	at 20°C and 1 MHz		–
Loss tangent	at 20°C and 1 MHz	(x 10^{-4})	–

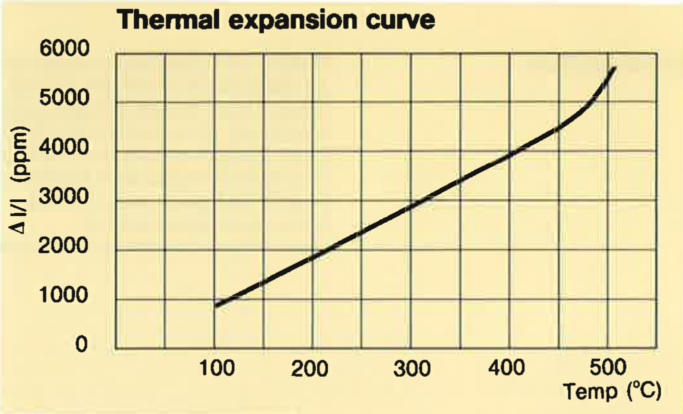
Optical properties

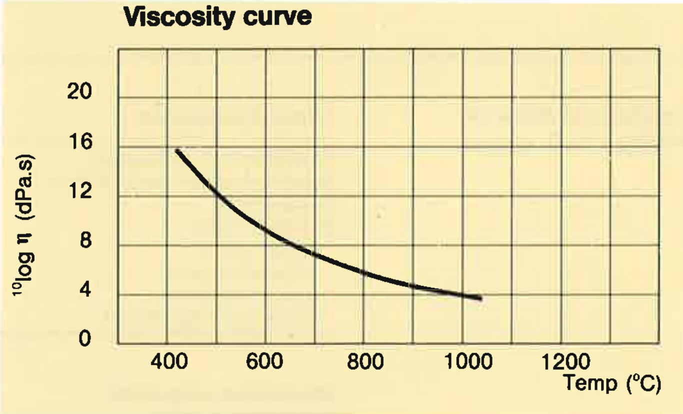
Index of refraction n_D.	at λ = 589,3 nm		1,508
Transmittance (thickness 1 mm) including surface losses			See graph

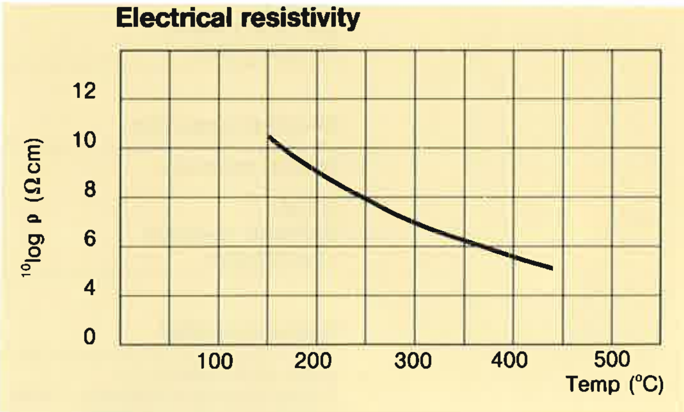
Lighting & Industrial Glass GLASS

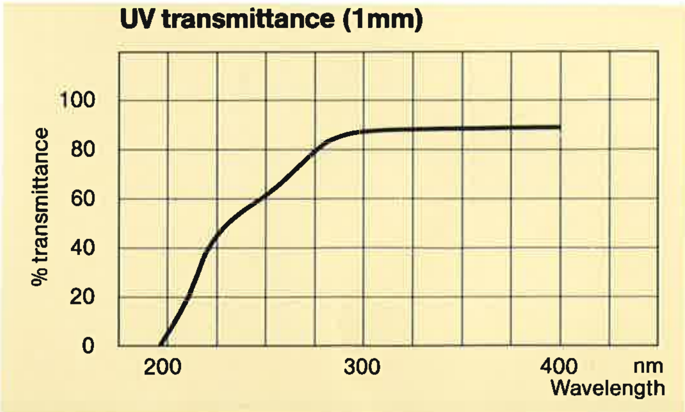
PHILIPS

Philips 160 glass









Technical information

Address: Philips Lighting Division
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Data subject to change without notice

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PHILIPS

Lighting

Glass

Introduction

Philips 175 glass is a dark-blue alkali-lead glass, available as machine-drawn tubing.
It has high transmittance characteristics in the near UV-A region of the spectrum. At a wavelength of 365nm the typical transmittance is 80% at a thickness of 1mm. The transmittance is negligible in the visible region of the spectrum.
The thermal expansion is adapted to Philips 291 stem tubing.
Main application area is:
– envelopes for low-pressure mercury vapour 'black light blue' lamps.

Technical data of Philips 175 glass

Thermal properties

Coefficient of expansion	25-300°C	$°C^{-1}$ (x 10^{-6})	10,0
Transformation temperature		°C	435
Conductivity	20°C	$W \cdot m^{-1} \cdot °C^{-1}$	–
Viscosity data			
Strain point	$10^{14,5}$ dPa.s	°C	415
Annealing point	10^{13} dPa.s	°C	445
Softening point	$10^{7,6}$ dPa.s	°C	615
Working temperature	10^{4} dPa.s	°C	950

Mechanical properties

Density	20°C	$kg \cdot m^{-3}$ ($x10^3$)	2,87
Young's modulus		GPa	63
Poisson's ratio			0,22

Electrical properties

Volume resistivity	$^{10}\log \rho$ 250°C	$\Omega \cdot cm$	8,2
	$^{10}\log \rho$ 350°C	$\Omega \cdot cm$	6,4
t_k 100	10^8 $\Omega \cdot cm$	°C	260
Dielectric constant	at 20°C and 1 MHz		–
Loss tangent	at 20°C and 1 MHz	(x 10^{-4})	–

Optical properties

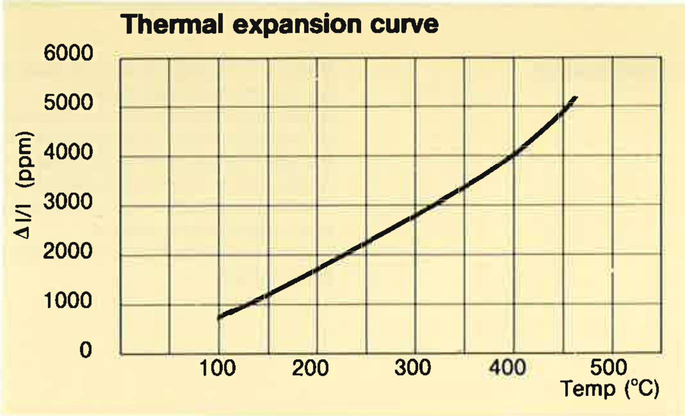
Index of refraction n_D.	at $\lambda = 589,3$ nm		–
Transmittance (thickness 1 mm) including surface losses			See graph

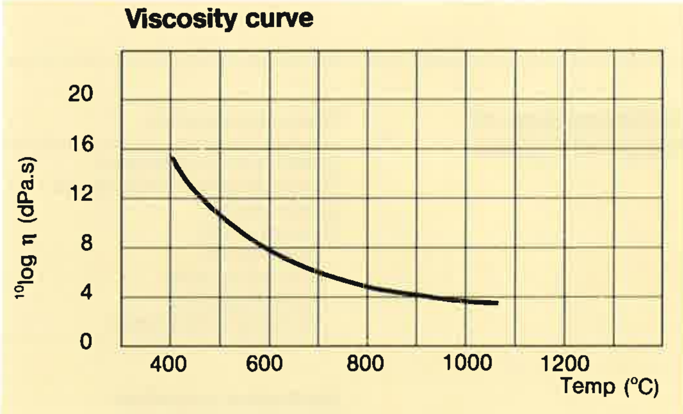
Lighting & Industrial Glass

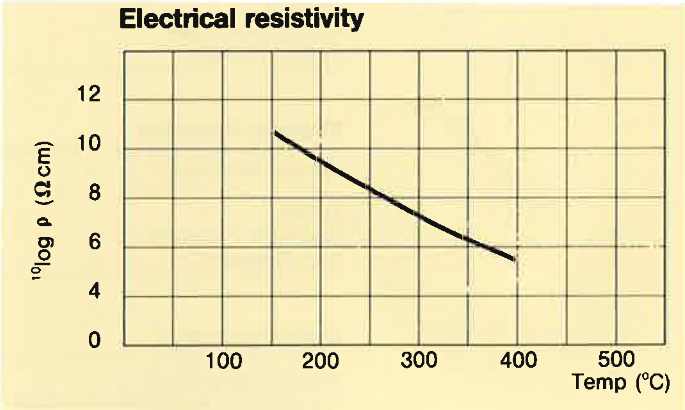
GLASS

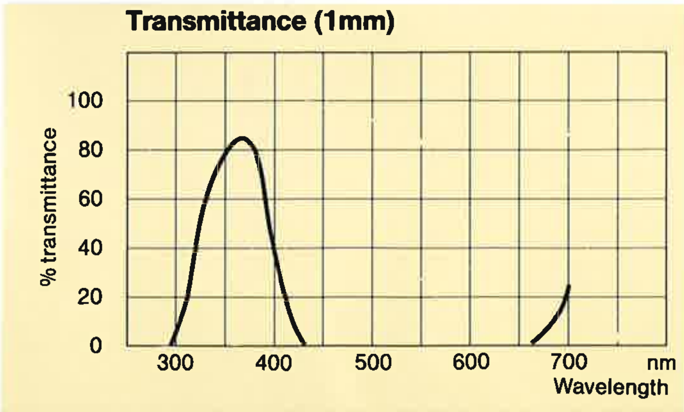
PHILIPS

Philips 175 glass









Technical information

Address: Philips Lighting Division
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Data subject to change without notice

1013 010 00431
Lighting Division

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Introduction

Philips 290 glass is a soda-lime glass, available as clear machine-drawn tubing.
The thermal expansion curve is matched to that of Philips 291 stem tubing.
Type 290 glass has excellent transmittance properties in the visible region of the spectrum. The transmittance in the UV-A part of the spectrum makes 290 glass favourable for the production of UV-A suntanning lamps.
Main application areas are:

- production of fluorescent lamps for general lighting purposes
- production of fluorescent lamps for suntanning installations
- production of tubular incandescent lamps
- outer envelopes of SOX lamps and solar collectors.

Technical data of Philips 290 glass

Thermal properties

Coefficient of expansion	25-300°C	$°C^{-1}$ (x 10^{-6})	9,5
Transformation temperature		°C	510
Conductivity	20°C	$W \cdot m^{-1} \cdot °C^{-1}$	–
Viscosity data			
Strain point	$10^{14,5}$ dPa.s	°C	482
Annealing point	10^{13} dPa.s	°C	515
Softening point	$10^{7,6}$ dPa.s	°C	695
Working temperature	10^{4} dPa.s	°C	1005

Mechanical properties

Density	20°C	$kg \cdot m^{-3}$ ($x10^3$)	2,48
Young's modulus		GPa	–
Poisson's ratio			–

Electrical properties

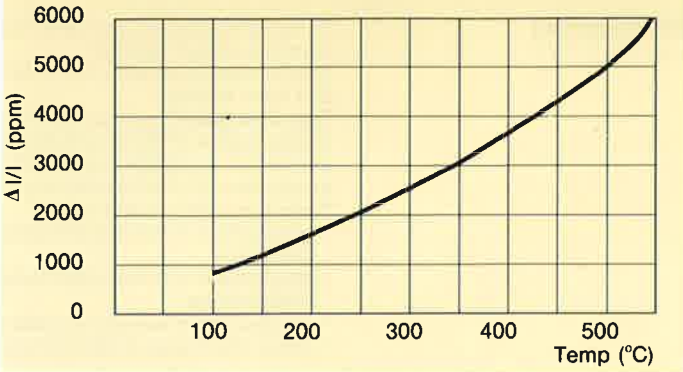
Volume resistivity	$^{10}\log \rho$ 250°C	$\Omega \cdot cm$	6,3
	$^{10}\log \rho$ 350°C	$\Omega \cdot cm$	5,0
^{t}k 100	10^{8} $\Omega \cdot cm$	°C	160
Dielectric constant	at 20°C and 1 MHz		–
Loss tangent	at 20°C and 1 MHz	(x 10^{-4})	–

Optical properties

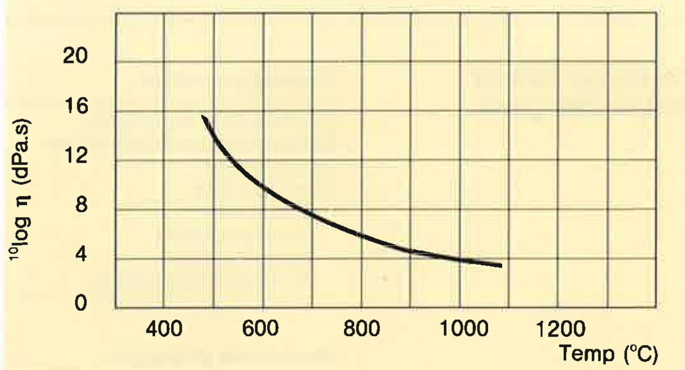
Index of refraction n_D.	at $\lambda = 589{,}3$ nm		1,51
Transmittance (thickness 1 mm) including surface losses			See graph

Philips 290 glass

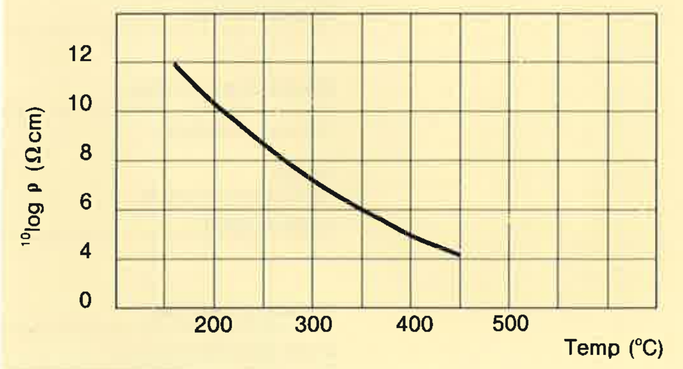
Thermal expansion curve



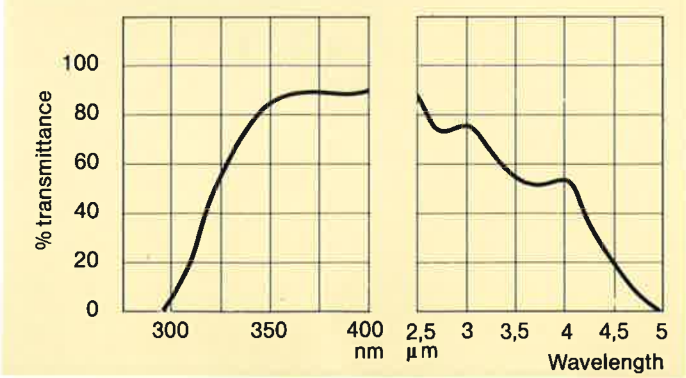
Viscosity curve



Electrical resistivity



Transmittance (1mm)



Technical information

Address: Philips Lighting Division
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Data subject to change without notice

1013 010 00451
Lighting Division

4/84
Printed in the Netherlands

Introduction

Philips 291 glass is an alkali-lead-silicate glass, available as clear machine-drawn tubing and rod.
The expansion characteristics allow direct sealing to copper-clad wire (dumet), chromium-nickel-iron alloys and platinum.
Main applications areas are:
- stem making for incandescent and fluorescent lamps
- bulb production for miniature, automotive, neon glow and similar lamps.

Technical data of Philips 291 glass

Thermal properties

Coefficient of expansion	25-300°C	$°C^{-1}$ (x 10^{-6})	9,4
Transformation temperature		°C	430
Conductivity	20°C	$W \cdot m^{-1} \cdot °C^{-1}$	0,82
Viscosity data			
Strain point	$10^{14,5}$ dPa.s	°C	405
Annealing point	10^{13} dPa.s	°C	445
Softening point	$10^{7,6}$ dPa.s	°C	640
Working temperature	10^{4} dPa.s	°C	990

Mechanical properties

Density	20°C	$kg \cdot m^{-3}$ (x 10^3)	2,81
Young's modulus		GPa	62
Poisson's ratio			0,21

Electrical properties

Volume resistivity	$^{10}\log \rho$ 250°C	$\Omega \cdot cm$	8,6
	$^{10}\log \rho$ 350°C	$\Omega \cdot cm$	6,8
^{t}k 100	10^8 $\Omega \cdot cm$	°C	280
Dielectric constant	at 20°C and 1 MHz		6,9
Loss tangent	at 20°C and 1 MHz	(x 10^{-4})	–

Optical properties

Index of refraction n_D.	at $\lambda = 589,3$ nm	1,53
Transmittance (thickness 1 mm) including surface losses		See graph

Lighting & Industrial Glass

GLASS

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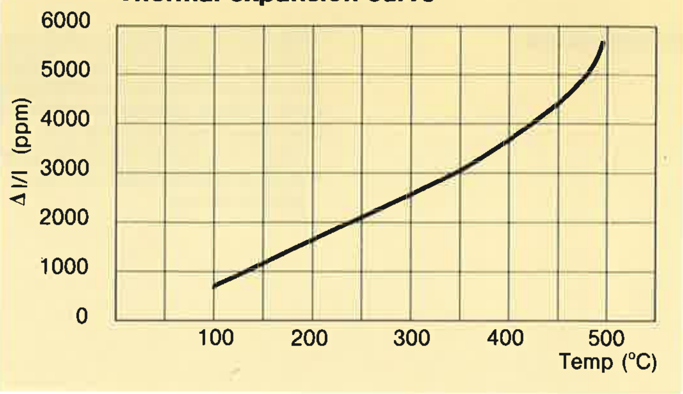
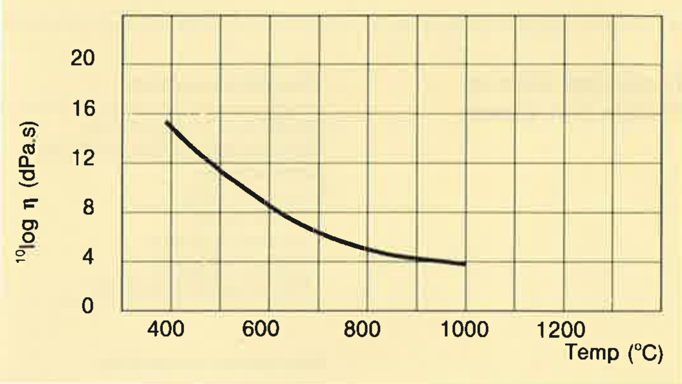
Philips 291 glass

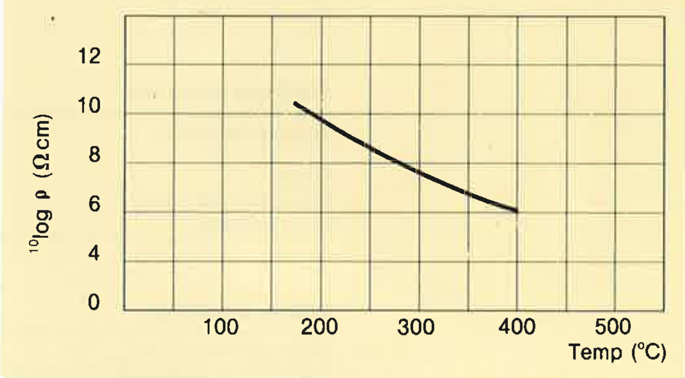
Thermal expansion curve



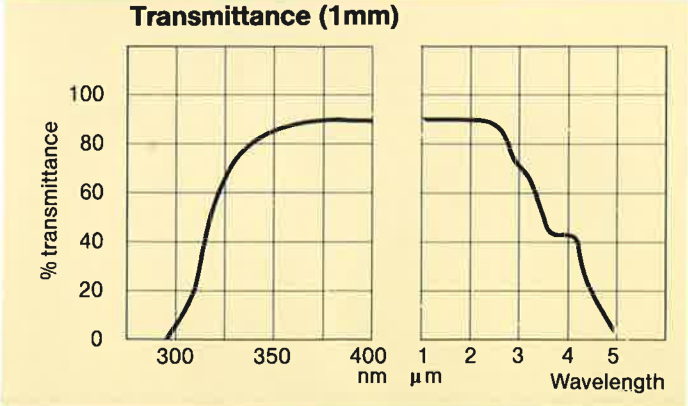
Viscosity curve



Electrical resistivity



Transmittance (1mm)



Technical information

Address: Philips Lighting Division
C.D. Glass Components
5600 MD Eindhoven
The Netherlands

Telex: 35000 phtc nl/nleevlt
Tel: 40 7 32002

Data subject to change without notice

1013 010 00461
Lighting Division

4/84
Printed in the Netherlands

Introduction

Philips 300 glass is a fused silica, available as clear machine-drawn tubing and rods.
It has high transmittance between 150nm (short UV region) and 4200 (IR). The typical transmittance at 185nm (mercury spectral line) is 65%.
The maximum operating temperature is at least 1000°C.
Main application areas are:
- envelopes for high-pressure mercury vapour discharge tubes and metal halide discharge tubes
- envelopes for tungsten halogen lamps
- envelopes for infrared heaters.

Technical data of Philips 300 glass

Thermal properties

Coefficient of expansion	25-300°C	$°C^{-1}$ (x 10^{-6})	0,58
Transformation temperature		°C	approx. 1150
Conductivity	20°C	$W \cdot m^{-1} \cdot °C^{-1}$	1,4
Viscosity data			
Strain point	$10^{14,5}$ dPa.s	°C	1110
Annealing point	10^{13} dPa.s	°C	1210
Softening point	$10^{7,6}$ dPa.s	°C	1670
Working temperature	10^{4} dPa.s	°C	—

Mechanical properties

Density	20°C	$kg \cdot m^{-3}$ (x10^3)	2,2
Young's modulus		GPa	73
Poisson's ratio			0,17

Electrical properties

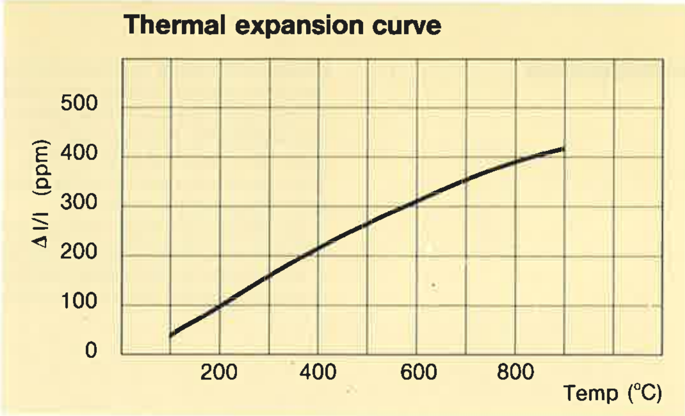
Volume resistivity	^{10}log ρ 250°C	Ω·cm	—
	^{10}log ρ 350°C	Ω·cm	10
^{t}k 100	10^8 Ω·cm	°C	—
Dielectric constant	at 20°C and 1 MHz		3.7
Loss tangent	at 20°C and 1 MHz	(x 10^{-4})	< 2

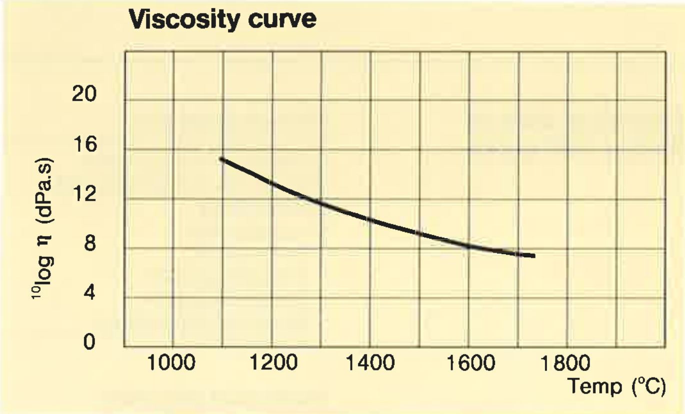
Optical properties

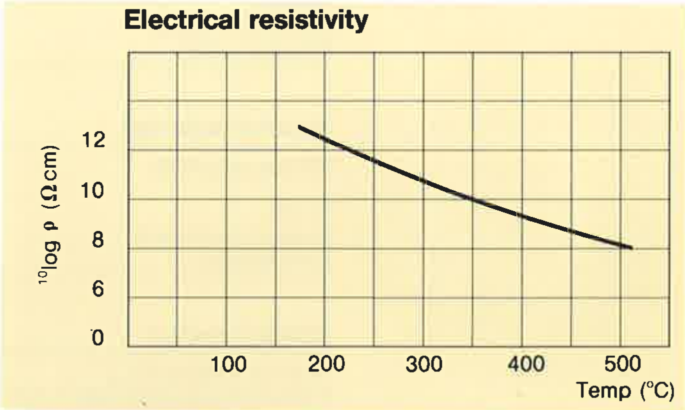
Index of refraction n_D.	at λ = 589,3 nm		1,459
Transmittance (thickness 1 mm) including surface losses			See graph

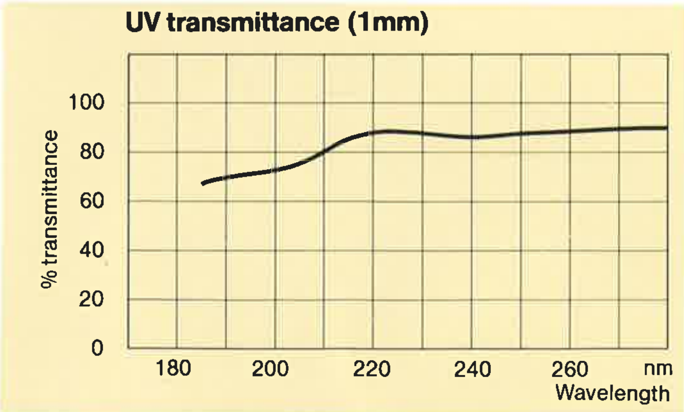
Lighting & Industrial Glass
GLASS

Philips 300 glass









Technical information

Address: Philips Lighting Division
C.D. Glass Components
5600 MD Eindhoven
The Netherlands

Telex: 35000 phtc nl/nleevlt
Tel: 40 7 32002

Data subject to change without notice

1013 010 00381
Lighting Division

4/84
Printed in the Netherlands

Introduction

Philips 303 glass is a fused silica doped with 0,125%wt TiO_2, available as clear machine-drawn tubing.
The transmittance of 303 glass is cut off at 230nm (at 20°C).
Main application areas are:
- suntanning lamps
- ozone-free reprographic lamps.

Technical data of Philips 303 glass

Thermal properties

Coefficient of expansion	25-300°C	$°C^{-1}$ (x 10^{-6})	0,58
Transformation temperature		°C	approx. 150
Conductivity	20°C	$W \cdot m^{-1} \cdot °C^{-1}$	1,4
Viscosity data			
Strain point	$10^{14,5}$dPa.s	°C	1110
Annealing point	10^{13} dPa.s	°C	1210
Softening point	$10^{7,6}$dPa.s	°C	1670
Working temperature	10^{4} dPa.s	°C	–

Mechanical properties

Density	20°C	$kg \cdot m^{-3}$($x10^3$)	2,2
Young's modulus		GPa	73
Poisson's ratio			0,17

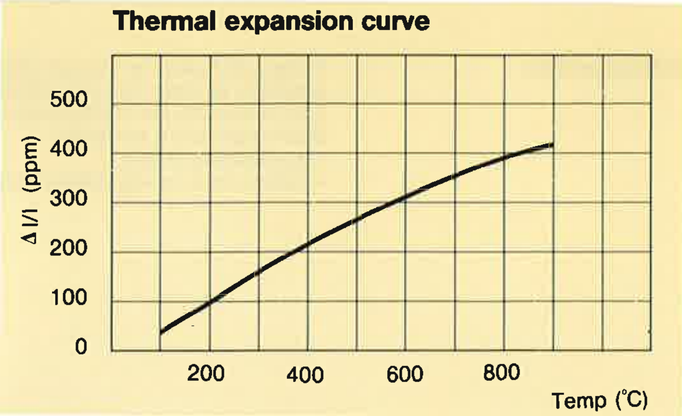
Electrical properties

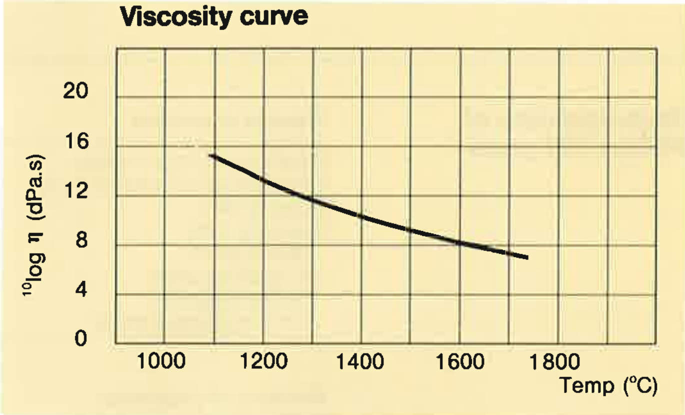
Volume resistivity	$^{10}\log\ \rho$ 250°C	$\Omega \cdot cm$	–
	$^{10}\log\ \rho$ 350°C	$\Omega \cdot cm$	10
^{t}k 100	10^8 $\Omega \cdot cm$	°C	–
Dielectric constant	at 20°C and 1 MHz		3,7
Loss tangent	at 20°C and 1 MHz	(x 10^{-4})	<2

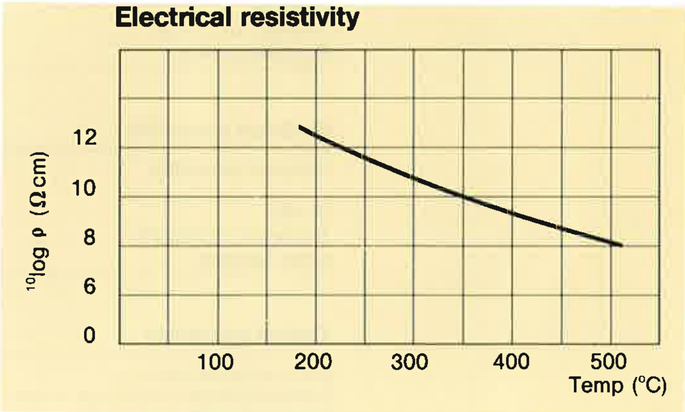
Optical properties

Index of refraction n_D.	at λ= 589,3 nm	1,459
Transmittance (thickness 1 mm) including surface losses		See graph

Philips 303 glass



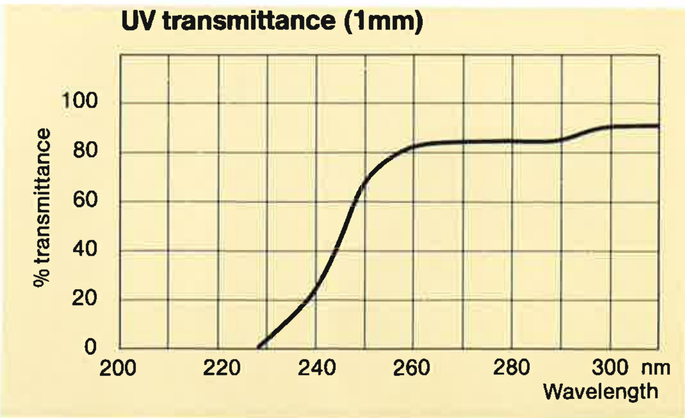




Technical information

Address: Philips Lighting Division
C.D. Glass Components
5600 MD Eindhoven
The Netherlands

Telex: 35000 phtc nl/nleevlt
Tel: 40 7 32002



Data subject to change without notice

1013 010 00391
Lighting Division

4/84
Printed in the Netherlands

PHILIPS

Lighting

Glass

Introduction

Philips 304 glass is a fused silica doped with 0,02%wt TiO_2, available as clear machine-drawn tubing.
The transmittance of 304 glass is cut off at 220nm (at 20°C).
Main application areas are:
- ozone-free reprographic lamps
- high-pressure xenon discharge lamps
- industrial applications, such as hardening of lacquers and inks, and polymerisation of plastics.

Technical data of Philips 304 glass

Thermal properties

Coefficient of expansion	25-300°C	$°C^{-1}$ (x 10^{-6})	0,58
Transformation temperature		°C	approx. 1150
Conductivity	20°C	$W \cdot m^{-1} \cdot °C^{-1}$	1,4
Viscosity data			
Strain point	$10^{14,5}$dPa.s	°C	1110
Annealing point	10^{13} dPa.s	°C	1210
Softening point	$10^{7,6}$dPa.s	°C	1670
Working temperature	10^{4} dPa.s	°C	–

Mechanical properties

Density	20°C	$kg \cdot m^{-3}$($x10^3$)	2,2
Young's modulus		GPa	73
Poisson's ratio			0,17

Electrical properties

Volume resistivity	$^{10}\log\ \rho$ 250°C	$\Omega \cdot cm$	–
	$^{10}\log\ \rho$ 350°C	$\Omega \cdot cm$	10
t_k 100	10^8 $\Omega \cdot cm$	°C	–
Dielectric constant	at 20°C and 1 MHz		3,7
Loss tangent	at 20°C and 1 MHz	(x 10^{-4})	< 2

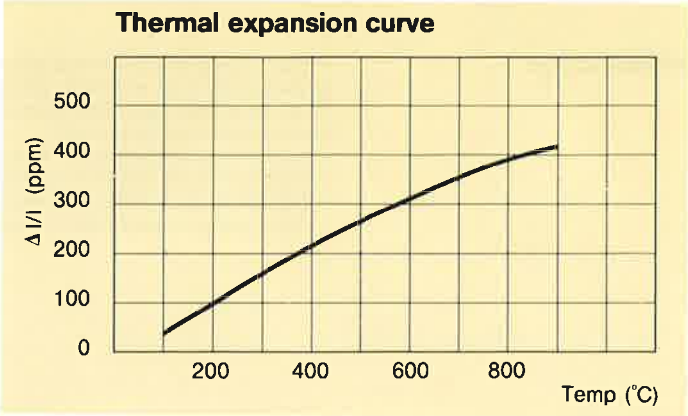
Optical properties

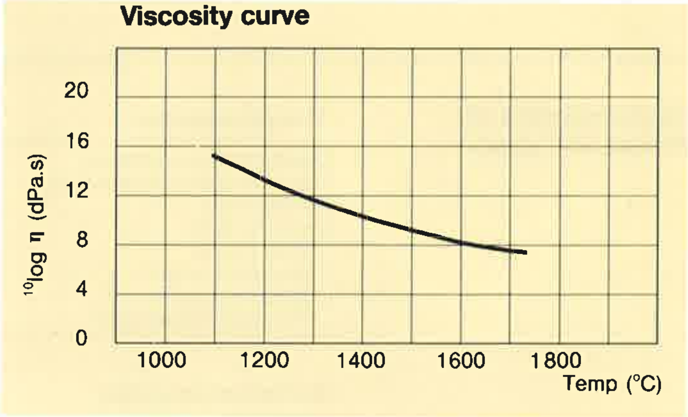
Index of refraction n_D.	at λ = 589,3 nm		1,459
Transmittance (thickness 1 mm) including surface losses			See graph

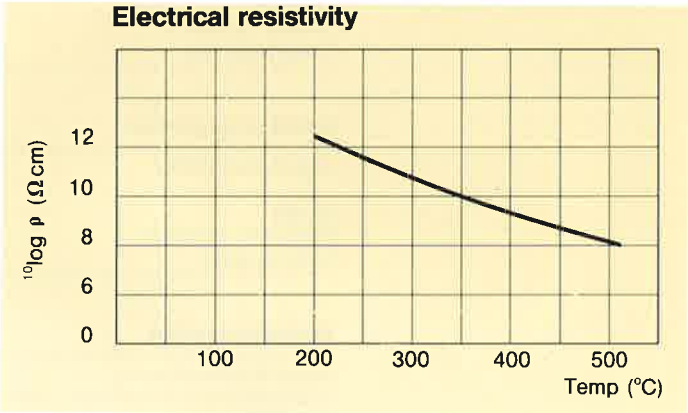
Lighting & Industrial Glass GLASS

PHILIPS

Philips 304 glass



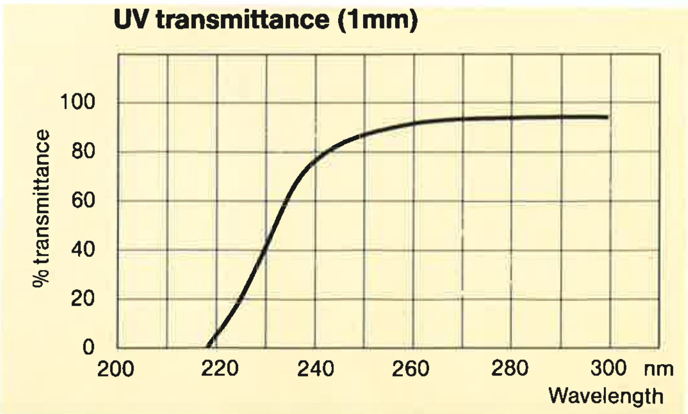




Technical information

Address: Philips Lighting Division
C.D. Glass Components
5600 MD Eindhoven
The Netherlands

Telex: 35000 phtc nl/nleevlt
Tel: 40 7 32002



Data subject to change without notice

4/84
Printed in the Netherlands

PHILIPS

Introduction

Philips 308 glass is a fused silica, available as clear machine-drawn tubing.
Main application areas are:
– exhaust tubing
– thermocouple tubing.

Technical data of Philips 308 glass

Thermal properties

Coefficient of expansion	25-300°C	$°C^{-1}$ (x 10^{-6})	0,58
Transformation temperature		°C	approx. 1150
Conductivity	20°C	$W \cdot m^{-1} \cdot °C^{-1}$	1,4
Viscosity data			
Strain point	$10^{14,5}$ dPa.s	°C	1110
Annealing point	10^{13} dPa.s	°C	1210
Softening point	$10^{7,6}$ dPa.s	°C	1670
Working temperature	10^{4} dPa.s	°C	–

Mechanical properties

Density	20°C	$kg \cdot m^{-3}$ ($x 10^{3}$)	2,2
Young's modulus		GPa	73
Poisson's ratio			0,17

Electrical properties

Volume resistivity	$^{10}\log \rho$ 250°C	$\Omega \cdot cm$	–
	$^{10}\log \rho$ 350°C	$\Omega \cdot cm$	10
^{t}k 100	10^{8} $\Omega \cdot cm$	°C	–
Dielectric constant	at 20°C and 1 MHz		3,7
Loss tangent	at 20°C and 1 MHz	(x 10^{-4})	< 2

Optical properties

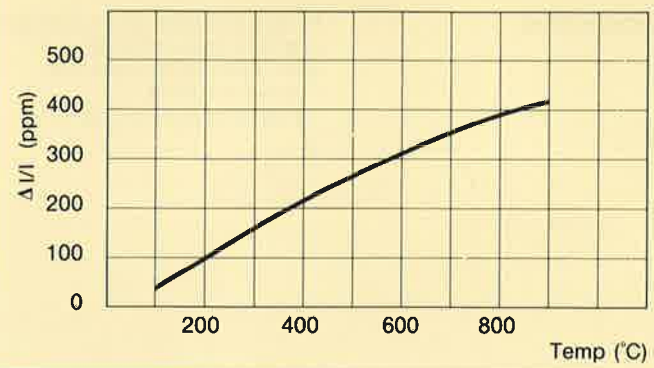
Index of refraction n_D.	at $\lambda = 589{,}3$ nm	1,459
Transmittance (thickness 1 mm) including surface losses		

Lighting & Industrial Glass
GLASS

PHILIPS

Philips 308 glass

Thermal expansion curve



Viscosity curve

Technical information

Address: Philips Lighting Division
C.D. Glass Components
5600 MD Eindhoven
The Netherlands

Telex: 35000 phtc nl/nleevlt
Tel: 40 7 32002

Data subject to change without notice

4/84
Printed in the Netherlands

PHILIPS

Introduction

Philips 319 glass is a sodium-barium-silicate glass, available as clear machine-drawn tubing.
It has a high transmittance in the UV-A and UV-B regions of the spectrum. At a wavelength of 297nm the typical transmittance at 1mm thickness is 75%
The thermal expansion is matched to Philips 291 stem tubing.
Main application areas are:
- envelopes for low-pressure mercury vapour lamps for medical treatment and for industrial applications (weathering tunnels).

Technical data of Philips 319 glass

Thermal properties

Coefficient of expansion	25-300°C	$°C^{-1}$ (x 10^{-6})	9,9
Transformation temperature		°C	470
Conductivity	20°C	$W \cdot m^{-1} \cdot °C^{-1}$	–
Viscosity data			
Strain point	$10^{14,5}$ dPa.s	°C	460
Annealing point	10^{13} dPa.s	°C	490
Softening point	$10^{7,6}$ dPa.s	°C	670
Working temperature	10^{4} dPa.s	°C	1000

Mechanical properties

Density	20°C	$kg \cdot m^{-3}$ (x10^3)	2,53
Young's modulus		GPa	–
Poisson's ratio			–

Electrical properties

Volume resistivity	$^{10}\log\ \rho$ 250°C	$\Omega \cdot cm$	8,0
	$^{10}\log\ \rho$ 350°C	$\Omega \cdot cm$	6,3
ᵗk 100	10^8 $\Omega \cdot cm$	°C	250
Dielectric constant	at 20°C and 1 MHz		–
Loss tangent	at 20°C and 1 MHz	(x 10^{-4})	–

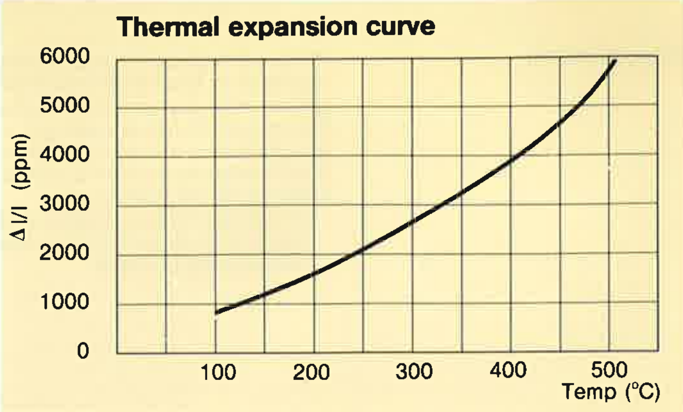
Optical properties

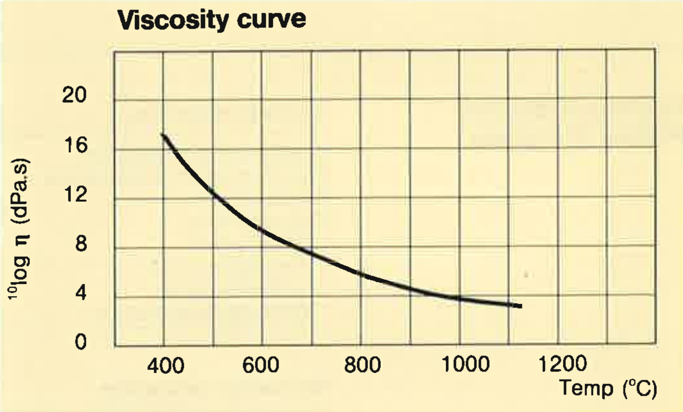
Index of refraction n_D.	at $\lambda = 589{,}3$ nm		1,508
Transmittance (thickness 1 mm) including surface losses			See graph

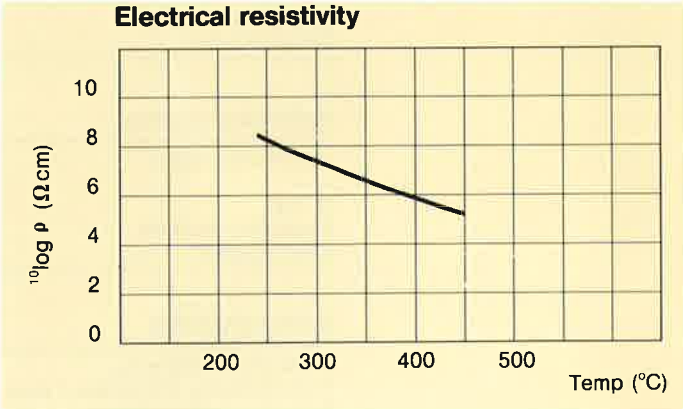
Lighting & Industrial Glass

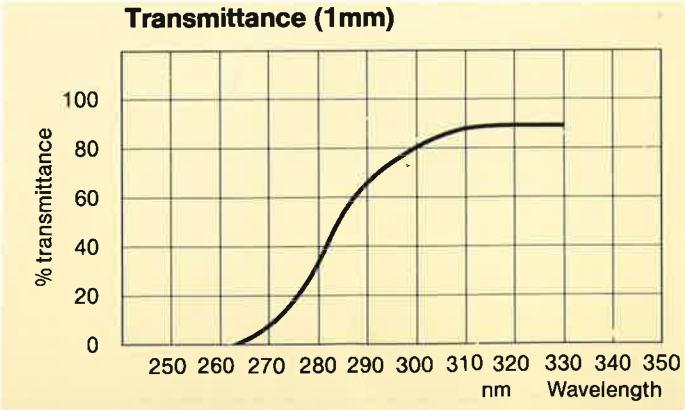
GLASS

Philips 319 glass









Technical information

Address: Philips Lighting Division
C.D. Glass Components
5600 MD Eindhoven
The Netherlands

Telex: 35000 phtc nl/nleevlt
Tel: 40 7 32002

Data subject to change without notice

1013 010 0351
Lighting Division

4/84
Printed in the Netherlands

PHILIPS

Introduction

Philips 321 glass is a transparent, doped, vitreous silica glass, available as machine-drawn tubing.
The applied additives strongly influence the viscosity behaviour, but they affect neither the low thermal expansion nor the thermal shock resistivity which are similar to those of quartz glass.
Main applications areas are:
- halogen motor car head-lamps
- halogen projection lamps
- germicidal lamps.

Technical data of Philips 321 glass

Thermal properties

Coefficient of expansion	25-100°C	°C^{-1} (x 10^{-6})	0,5
	-200°C		0,55
	-300°C		0,6
	-400°C		0,55
	-500°C		0,5
	-600°C		0,45
	-700°C		0,35
Viscosity data			
Strain point	$10^{14,5}$dPa.s	°C	850
Annealing point	10^{13} dPa.s	°C	930
Softening point	$10^{7,6}$dPa.s	°C	1400
Max. operating temperature		°C	800

Mechanical properties

Density	20°C	kg·m·$^{-3}$(x10^3)	2,2
Young's modulus		GPa	72
Poisson's ratio			0,17

Optical properties

Index of refraction n_D.	at λ= 589,3 nm		1,459
Transmittance (thickness 1 mm) including surface losses			See graph

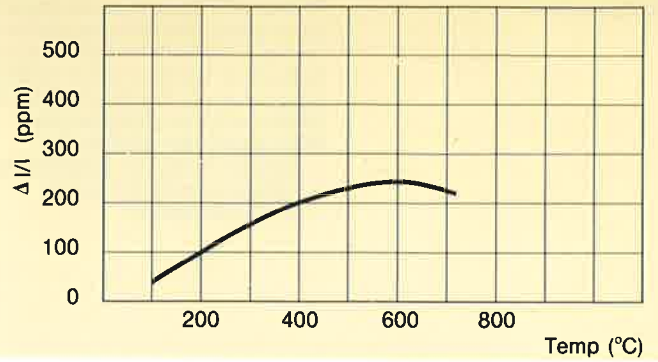
Lighting & Industrial Glass

GLASS

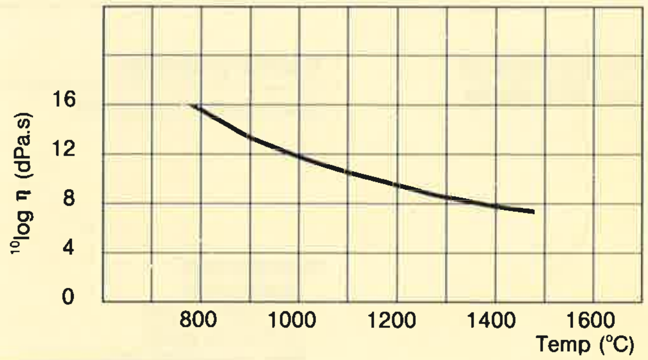
PHILIPS

Philips 321 glass

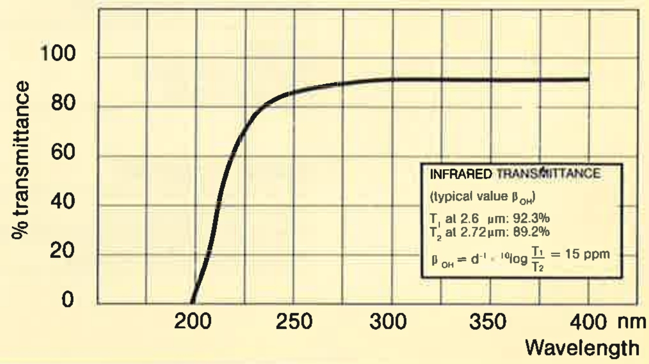
Thermal expansion curve



Viscosity curve



UV transmittance (1mm)



Technical information

Address: Philips Lighting Division
C.D. Glass Components
5600 MD Eindhoven
The Netherlands

Telex: 35000 phtc nl/nleevlt
Tel: 40 7 32002

Data subject to change without notice

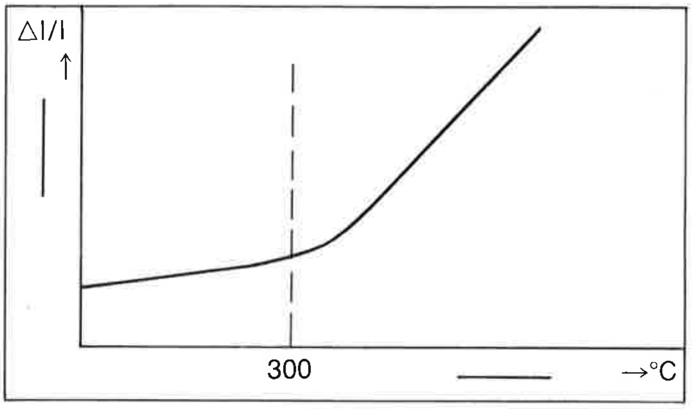
4/84
Printed in the Netherlands

Glass Properties

Chemical and physical properties are most determining for the application range of all industrial glasses.
In the electrical and electronical application range mainly the physical data are relevant.
On the following alineas we want to give some definitions of the most important physical properties

Mean coefficient of expansion

The mean coefficient of expansion (linear) over a certain temperature range is the elongation in cm. of a glass rod in a temperature range specified, divided by the product of its length in cm. and the number of degrees centigrade of the specified temperature range.



The quotation is normaly given as $\alpha(30 - 300°C) = ...x10^{-7}$ cm./cm./°C. Other temperature ranges are of course possible.
In the expansion curve we can distinguish two approximate linear pieces and a curvation area.
It has only sense to give the mean coefficient of expansion according to the temperature range below the curvation area.
If more information is desirable the total curve has to be drawn.

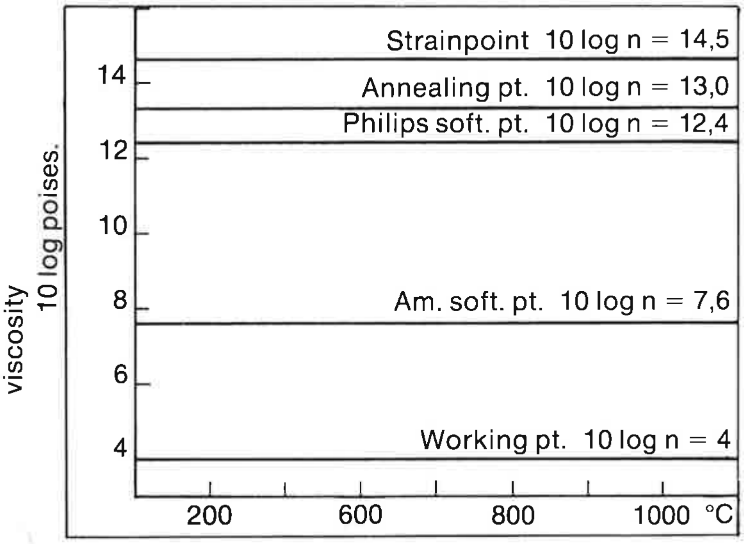
Expansion coefficient control is normally executed as a strain control by melting together the said glass to a standard glass with well known coefficient of expansion.
The quotation is given in - compressive or
- tensile strain in the standard glass.
(dimension: Nm./cm.)

Specific gravity. (Density)

The specific gravity of a glass is a direct function of its chemical composition.
Measurement of the specific gravity can be done easily by the Archimedes method or by the sink-float method.
All specific gravity measurements are given at 20°C; dimension: g/cm^3

Viscosity

The viscosity of a glass depends strongly on its chemical composition and is a functional relation of the temperature.
At room-temperature the viscosity of a glass is $> 10^{20}$ poises.



On the viscosity - temperature curves some reference points have been stated to characterise the distinguished glasses.
Definitions of these reference points are:

Strainpoint: Temperature at which the viscosity of the glass is approximately $10^{14,5}$ poises. At this temperature internal strain will disappear, until a commercial acceptable level, within a few hours.

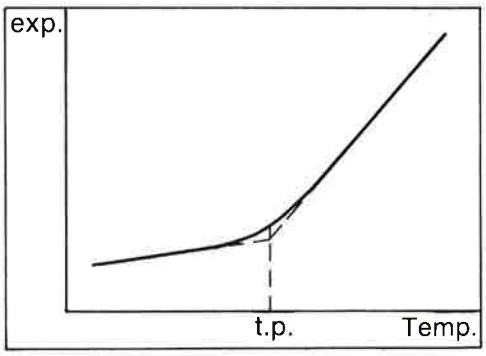
Annealing point: Temperature at which the viscosity of the glass is approximately 10^{13} poises. At this temperature internal strain will disappear until a commercial acceptable level, within 15 minutes. Technical annealing normaly starts from a temperature slightly above the annealing point. Cooling down to below the strainpoint must be done in a well programmed way.

Philips' softening point: Temperature at which the viscosity of the glass is approximately $10^{12,4}$ poises. The Philips' softening point is the highest temperature at which a glass may be heated to remove any strain without being deformed.

American softening point: Temperature at which the viscosity of the glass is approximately $10^{7,6}$ poises. At the American softening point glass deforms rapidly.
The American softening point is interesting in judging the length of a glass; defined as the difference between the temperatures corresponding with the strain point ($10^{14,5}$ poises) and the American softening point ($10^{7,6}$ poises).

Working point: Temperature at which the viscosity of the glass is approximately 10^4 poises. Normal hot glass working is done in the working point area.

Transformation point: The transformation point is the temperature corresponding to the intersection of the two straight lines that can be drawn along the practically straight sections of the expansion curve at both sides of the curvation area.
The transformation area is the switching erea from vast to liquid glassfase. In this area not only the expansion curve changes abruptly but also the electrical properties are changing in a significant way.



Electrical properties

Glass can be considered as an electrolite. The electrical properties depend strongly from the glass composition and the temperature.
At room-temperature the transport of electricity is mainly due to the content of monovalent ions, such as Na^+ and in a minor degree K^+.

The electrical conductivity is given as a temperature (tp) at which the resistance of the glass is $10^{6,52}$ Ω .cm. $t_{K\,100}$ is given as the temperature at which the resistance of the glass is 10^8 Ω .cm.

The specific resistance is normally given as a 10 log-value of the resistance at 250°C and 350°C.

Dielectric constant: If used as a capacitor, the dielectric constant ε of a glass is the value which, for unit capacitor dimensions, is a measure for the ratio between the maximum charge that can be put on the capacitor at a specific voltage and this voltage. The dielectric constant is given at 20°C and for different frequencies.

Loss factor: If an alternating current flows through a condensor, the phase difference between the charging current and the voltage will not be exactly 90°. This phase difference is caused by some energy absorbed into the dielectricum. The amount of energyloss is given by the "loss factor" ε . tg S at which δ (loss-angle) gives the phase-difference to 90° and ε is the dielectric constant of the glass.
The dielectric losses depend on the frequency of the alternating current and on the temperature; also the glass composition, and mainly the Na^{6+}-ion content, has great influence on the loss-factor.

2

I Introduction

The Special Glass Centre in Eindhoven, Netherlands, manufactures a range of handmade blown and handmade pressed components of various shapes.

II List of glasses

Philips Glass Code	Application
03	according to GLN-X 03003, is a limeglass for bulbs
13	according to GLN-X 03013, is a long-wave UV-transmitting barium glass used for bulbs of mercury lamps
28	according to GLN-X 03028, is a glass type to which fernico and molybdenum can be joined. Some of its applications are bases and quartz oscillators.
142	according to GLN-X 03142, is a borosilicate glass of the Pyrex type
146	according to GLN-X 03146, is a leadglass for bulbs and bottoms of electrode tubes
158	according to GLN-X 03158, is a borosilicate glass to which fernico can be joined, used for X-ray tubes
160	according to GLN-X 03160, is a short-wave, UV-transmitting barium glass, used for making lamps with a germicidal radiation.
R3988	is a UV-transmitting barium glass used for making solarium lamps
175	according to GLN-X 03175, is a long-wave, UV-transmitting blue leadglass (black, light blue) for making TL-lamps, used for attractive lighting, inspection of bank-notes, in phylately and mineralogy.
189	according to GLN-X 03189, is a borosilicate glass for pressing support rods for electron gun
195	according to GLN-X 03195, is a barium glass for making pressed pieces for capacitor feed-through, and can be supplied in various colours.
199	according to GLN-X 03199, is a borosilicate glass to which tungsten can be joined
219	according to GLN-X 03219, is a borosilicate glass to which fernico can be joined. It is used for making KLS-cups. Applied for narrow-gauge film and slide projection.
238	according to GLN-X 03238, is a limeglass for bulbs of cathode ray tubes
250	according to GLN-X 03250, is a borosilicate glass to which tungsten can be joined, used for making exhaust tubing and flares
258	according to GLN-X 03258, is a leadglass for delay lines
280	according to GLN-X 03280, is an alumino-borosilicate glass used for heavily loaded thermal lamps
281	according to GLN-X 03281, is a barium glass used for making reed contacts
294	according to GLN-X 03294, is a barium glass used for making neon lamps
295	according to GLN-X 03295, is a borosilicate glass for bulbs of X-ray image amplifiers

GLASS

Philips Glass Code	Application
298	according to GLN-X 03298, is a glass type to which femico can be joined, used for bulbs; pressed bases of transmitter tubes and photoflux lamps
302	according to GLN-X 03302, is a leadglass used for diodes
910	is used as discharge tubes in SOX-lamps
911	is used as bead glass for the electrodes of the SOX-lamps
	Quartz glass types
300	is made of sand and used for various purposes, such as gas discharge lamps and halogen lamps.
303	is used for making sun lamps
304	is used for making ozone free lamps
308	hardly shows air streaks and is used for exhaust tubing and supporting beams (in halogen lamps).

III General properties

The values are subject to normal manufacturing variations.
They are given for your own guidance

Glass Code	Density γ	Thermal expansion x10⁻⁷	Viscosity					
			Transf. point	Strain point	Annealing point	Philips Softening point	American Softening point	Working point
13	2,70	α30-300°C = 97.0 α30-400°C = 100,5 α30-450°C = 101,0 α30-500°C = 108,5 α30-550°C = 118,5	485°C	475°C	495°C	515°C	660°C	
28	2,25	α30-300°C = 48,0 α30-400°C = 48,0 α30-450°C = 48,0 α30-500°C = 57,0	470°C	460°C	490°C	520°C	715°C	1080°C
142	2,20	α30-300°C = 32,0 α30-400°C = 31,0 α30-450°C = 30,5 α30-500°C = 29,5 α30-550°C = 32,5 α30-600°C = 38,5	520°C	535°C	565°C	595°C	795°C	
146	3,05	α30-300°C = 94,5 α30-400°C = 97,0 α30-450°C = 108,5	420°C	400°C	430°C	450°C	620°C	
158	2,30	α30-300°C = 50,5 α30-400°C = 50,5 α30-450°C = 51,5 α30-500°C = 55,0 α30-550°C = 67,5	490°C	495°C	520°C	540°C	715°C	
160	2,55	α30-300°C = 100,0 α30-400°C = 102,0 α30-450°C = 103,0 α30-500°C = 114,5	470°C	445°C	477°C	500°C	685°C	
R3988	2,55	α30-300°C = 100,0 α30-400°C = 102,0 α30-450°C = 103,0 α30-500°C = 114,0	470°C	445°C	477°C	500°C	685°C	

Lighting and Industrial Glass.

GLASS

Glass Code	Density γ	Thermal expansion x10⁻⁷	Viscosity					
			Transf. point	Strain point	Annealing point	Philips Softening point	American Softening point	Working point
175	2,85	α30-300°C = 105,5 α30-400°C = 109,0 α30-450°C = 125,5	420°C	390°C	420°C	440°C	615°C	
189	2,15	α30-300°C = 30,0 α30-400°C = 29,0 α30-450°C = 29,0 α30-500°C = 31,0 α30-550°C = 34,0 α30-600°C = 36,5	470°C	505°C	540°C	570°C	780°C	
195	2,62	α30-300°C = 93,5 α30-400°C = 97,5 α30-450°C = 101,0 α30-500°C = 112,0	470°C	450°C	475°C	500°C	670°C	
199	2,30	α30-300°C = 39,0 α30-400°C = 39,0 α30-450°C = 39,0 α30-500°C = 39,0 α30-550°C = 45,5	520°C	510°C	545°C	570°C	770°C	
219	2,30	α30-300°C = 51,0 α30-400°C = 51,0 α30-450°C = 51,0 α30-500°C = 57,0 α30-550°C = 66,0	485°C	475°C	505°C	535°C	715°C	
238	2,55	α30-300°C = 97,0 α30-400°C = 101,0 α30-450°C = 102,0 α30-500°C = 105,0 α30-550°C = 116,0	520°C	510°C	530°C	555°C	715°C	
250	2,25	α30-300°C = 39,0 α30-400°C = 39,0 α30-450°C = 39,0 α30-500°C = 39,0 α30-550°C = 44,0	530°C	520°C	550°C	580°C	770°C	

Glass Code	Density γ	Thermal expansion x10⁻⁷	Viscosity					
			Transf. point	Strain point	Annealing point	Philips Softening point	American Softening point	Working point
258	$^{3.705}/_{3.741}$	α30-300°C = 64,0	495°C	460°C	490°C	515°C	695°C	
		α30-400°C = 64,0						
		α30-450°C = 64,0						
		α30-500°C = 67,0						
280	2,65	α30-300°C = 41,0	750°C	720°C	750°C	775°C	955°C	ca 1230°C
		α30-400°C = 43,0						
		α30-500°C = 44,5						
		α30-600°C = 45,0						
		α30-700°C = 45,0						
281	2,65	α30-300°C = 92,0	470°C	460°C	480°C	500°C	660°C	
		α30-400°C = 96,0						
		α30-450°C = 98,0						
		α30-500°C = 111,0						
294	2,53	α30-300°C = 102,0	475°C	450°C	480°C	505°C	680°C	
		α30-400°C = 104,5						
		α30-450°C = 106,0						
		α30-500°C = 119,0						
295	2,30	α30-300°C =		500°C	530°C	555°C	740°C	
		α30-400°C =						
		α30-450°C =						
		α30-500°C =						
		α30-550°C =						
		α30-600°C =						
298	2,30	α30-300°C = 51,0	485°C	475°C	505°C	535°C	715°C	
		α30-400°C = 51,0						
		α30-450°C = 51,0						
		α30-500°C = 57,0						
		α30-550°C = 66,0						
302	4,22	α30-300°C = 91,5	436°C	430°C	445°C	465°C	595°C	
		α30-400°C = 94,0						
		α30-450°C = 103,5						
		α30-500°C =						
		α30-550°C =						
		α30-600°C =						

Lighting and Industrial Glass.

GLASS

Viscosity

Glass Code	Density γ	Thermal expansion x10^{-7}	Transf. point	Strain point	Annealing point	Philips Softening point	American Softening point	Working point
300	2,20	α30-300°C = 6,5 α30-400°C = 6,5 α30-450°C = 6,5 α30-500°C = 6,0 α30-550°C = 6,0 α30-600°C = 6,0 α30-650°C = 6,0 α30-700°C = 6,0 α30-750°C = 6,0 α30-800°C = 5,5		1140°C	1200°C	1260°C	1600°C	
303	2,20	α30-300°C = 6,5 α30-400°C = 6,5 α30-450°C = 6,5 α30-500°C = 6,0 α30-550°C = 6,0 α30-600°C = 6,0 α30-650°C = 6,0 α30-700°C = 6,0 α30-750°C = 6,0 α30-800°C = 5,5		1140°C	1200°C	1260°C	1600°C	
304	2,20	α30-300°C = 6,5 α30-400°C = 6,5 α30-450°C = 6,5 α30-500°C = 6,0 α30-550°C = 6,0 α30-600°C = 6,0 α30-650°C = 6,0 α30-700°C = 6,0 α30-750°C = 6,0 α30-800°C = 5,5		1140°C	1200°C	1260°C	1600°C	
308	2,20	α30-300°C = 6,5 α30-400°C = 6,5 α30-450°C = 6,5 α30-500°C = 6,0 α30-550°C = 6,0 α30-600°C = 6,0 α30-650°C = 6,0 α30-700°C = 6,0 α30-750°C = 6,0 α30-800°C = 5,5		1140°C	1200°C	1260°C	1600°C	

IV Electrical properties

Glass Code	conductivity Tp	conductivity Tk 100	Specific Resistance Log p 20°C	Specific Resistance Log p 250°C	Specific Resistance Log p 350°C	Dielectric Properties Frequency c/s	Dielectric Properties Dielectrical constant ε (20°C)	Dielectric Properties loss angle tg δ (20°C)
13	315°C	230°C		7,6	6,0			
28	390°C	280°C	16	8,6	7,0	10^3 4×10^4 $1,5 \times 10^6$ 10^8 $9,4 \times 10^9$ $2,4 \times 10^{10}$	5,5 5,4 5,3 5,1 4,9 4,7	$38,8 \times 10^{-4}$ $31,3 \times 10^{-4}$ $28,5 \times 10^{-4}$ 36×10^{-4} 67×10^{-4} 78×10^{-4}
142	415°C	300°C		8,9	7,3	10^3 4×10^4 $1,5 \times 10^6$ 10^8 $9,4 \times 10^9$ $2,4 \times 10^{10}$	5,0 5,0 5,0 4,7 4,6 4,6	94.3×10^{-4} $63,1 \times 10^{-4}$ $50,1 \times 10^{-4}$ $50,0 \times 10^{-4}$ $73,0 \times 10^{-4}$ $92,0 \times 10^{-4}$
146	355°C	264°C		8,3	6,6			
158	310°C	210°C		7,5	6,0			
160	360°C	270°C		8,4	6,7			
R3988	360°C	270°C		8,4	6,7			
175	345°C	245°C		7,9	6,5			
189		540°C		10,4*	9,0**			
195	340°C	250°C		8,0	6,4			
199	380°C	275°C	14,8	8,4	6,8			
219	480°C	380°C	19	10,6	8,5		4,6	$35,0 \times 10^{-4}$
238	365°C	270°C		8,3	6,8			
250	360°C	260°C		8,1	6,6			

* Log p = 350°C
** Log p = 450°C

GLASS

Glass Code	conductivity		Specific Resistance Log p				Dielectric Properties	
	Tp	Tk 100	20°C	250°C	350°C	Frequency c/s	Dielectrical constant ε (20°C)	loss angle tg δ (20°C)
258	621°C	495°C						
280	800°C	595°C			11,5			
281	305°C	225°C		7,5	5,9			
294	345°C	260°C		8,2	6,4			
295	460°C	350°C		10,0	8,1			
298	480°C	380°C	19	10,6	8,5		4,6	35×10^{-4}
302	> tt	> tt		11,3	9,4			
300	520°C	370°C		9,7	8,1			
303	520°C	370°C		9,7	8,1			
304	520°C	370°C		9,7	8,1			
308	520°C	370°C		9,7	8,1			

3

I Introduction

Tube drawing factory Lommel

Our leadglass tubing and finishing centre at Lommel Belgium started in October 1964.
Before this date leadglass tubing for lampmaking and electronic purposes was made at our Roosendaal fluorescent-bulb centre, and leadglass for colour T.V. necktubing was made at our Eindhoven special-glass centre.
A rich experience on glass tube drawing was being concentrated in the Lommel tube drawing plant.
The Lommel leadglass factory now concentrates all leadglass tubing for W.-Europe Philips requirements and a lot of the production is shipped all over the world to Philips lampmaking and electronic centres.
An important part of our leadglass production is also send to non-Philips customers. The latter can share the same experience of years of tube drawing as our own concern-customers. Security of delivery for non-Philips customers is garanteed at the same conditions as to Philips customers.

The leadglass centre Lommel has two production departments:

- The tube - drawing department and
- the finishing department

II List of glasses

Philips Glass Code	Utilisation
01	01 glass is a leadglass containing approximately 30% PbO. It is used as glass tubing for radio-valves and for bulbs of miniature lamps (cut or blown from glass tubing), for monochrome TV-necks and for moulded valve bottoms.
78	78 glass is a lead-glass containing approximately 35% PbO. The glass is mainly used for necks for colour-tubes, for necks for cathode-ray tubes and in a serie of applications where the risk for glas-electrolyse is high. The linear Röntgen-absorption coefficient at 20.6 KV = 98.0
291	291 glass is a leadglass containing 20% Pbo. The glass is used for flare making and exhaust tubing for incandescent lampmaking and for miniature bulbmaking

III General properties

The values are subject to normal manufacturing variations.
They are given for your own guidance

Glass Code	Density γ	Thermal expansion	Viscosity					
			Transf. point	Strain point	Annealing point	Philips Softening point	American Softening point	Working point
01	3.05	α30-300°C = 92,0 x 10^{-7} α30-400°C = 95,0 x 10^{-7} α30-450°C = 106,0 x 10^{-7}	425	405	435	455	625	965
78	3.3	α30-300°C = 96,5 x 10^{-7} α30-400°C = 99,0 x 10^{-7} α30-450°C = 101,5 x 10^{-7} α30-500°C = 115,0 x 10^{-7}	465	450	475	500	660	965
291	2.81	α30-300°C = 94,0 x 10^{-7} α30-400°C = 96,0 x 10^{-7} α30-450°C = 104,0 x 10^{-7}	430	405	435	460	640	990

IV Electrical properties

Glass Code	conductivity		Specific Resistance Log p			Dielectric Properties		
	Tp	Tk 100	20°C	250°C	350°C	Frequency c/s	Dielectrical constant ε (20°C)	loss angle tg δ (20°C)
01	365°C	280°C		8,6	6,8	10^3	7.3	$22,0 \times 10^{-4}$
						$4,0 \times 10^4$	7,3	$16,6 \times 10^{-4}$
						$1,5 \times 10^6$	7.2	$16,2 \times 10^{-4}$
						10^8	7.1	$22,0 \times 10^{-4}$
						$9,4 \times 10^9$	6.9	$65,0 \times 10^{-4}$
						$2,4 \times 10^{10}$	6.9	$96,0 \times 10^{-4}$
78		380°C		10.6	8.6			
291	365°C	280°C		8.6	6.8			

Lighting and Industrial Glass.

GLASS

V Tube-drawing department

In a few words said this department encloses the all chain of activities starting with the receipt of the raw materials, mixing of the securely weighed quantities of them, melting the raw material mixture, tube drawing, packing and transport to the storage rooms.
Our mixing room is a fully automised unit where, apart from accuracy of weighing the raw materials, full attention is paid to reliability and security. Pulverised materials are transported pneumatically in closed circuits and mixtures containing leadoxydes cannot cause any danger to our people.
Furnace feeding is automatically controled via level and output control. Glasstemperature control and regulation is fully automised.

We use the Danner-principle for tube drawing. Studying the production process for years and years we were able to build a perfect equipment so that tube drawing now is done on fully automised way.
High speed drawing devices take care of a constant drawing-speed and provide tube glass at the desired length.
Trimming and glazing can be done before packing.
Process control and continuous automatic diameter gauging assure the desired dimensional quality.
Visual control is done by well schooled people.
In the following table we want to give our normal tolerances for diameter and wall thickness in our production process.
Likewise we want to indicate the most optimum diameter - wall thickness ratio's.

all dimensions in mm.

∅ group	∅ toler.	wall thickness 0,4	0,5	0,6	0,7	0,8	0,9	1,0	1,1	1,2	1,3	1,4	1,5	1,6	1,7	1,8	1,9	2,0	2,1	2,2	2,3	2,4
3 - 6	±0,17	a	a	I/a/	/a/	/a/I	a	a	b	b												
6 - 12	±0,25		a	a	I/a/	/a/	/a/	/a/I	a	a	b	b	b	b	b							
12 - 20	±0,25			a	a	I/a/	/a/	/a/	/a/I	a	a	a	b	b	b	b	b	b				
20 - 30	±0,50				a	a	I/a/	/a/	/a/	/a/	/a/	/a/I	a	b	b	b	b	b	b	b		
30 - 40	±0,75				a	a	I/a/	/a/	/a/	/a/	/a/	/a/I	a	a	a	b	b	b	b	b	b	b

Legend a: ± 0,07 mm
b: ± 0,1 mm
I////////I: optimum ratio ∅ - W

Notes to the table:
1) Tolerances deviating from above mentioned will always be matter of discussion. If necessary price consequences will be calculated.
2) Diameters smaller than 3 mm. only on request.
3) Rod glass on request.
4) Miniumum serie 5 tons a year. For smaller quantities serial costs will be charged.
5) All glass tubing a) diameter < 6 mm: rough cut
b) diameter > 6 mm: trimmed (on request) and glazed.

VI List of products

Code	Application	Glass Diameter Wall thickness Length
	g.l.s (incandescent)	
1122 065 01056		291/11,5 ± 0,25/0,8 ± 0,07/1100
1122 065 01026		291/11,5 ± 0,25/0,9 ± 0,07/1100
3222 201 60861		291/3,87 ± 0,17/0,7 ± 0,07/110
3222 201 60871		291/3,87 ± 0,17/0,7 ± 0,07/115
3222 201 60881		291/3,87 ± 0,17/0,7 ± 0,07/120
	t.l. (fluorescent)	
1122 065 01026		291/11,5 ± 0,25/0,9 ± 0,07/1100
3222 201 73291		291/4,87 ± 0,17/0,7 ± 0,07/100
3222 201 65486		291/4,87 ± 0,17/0,7 ± 0,07/90
	(candle)	
1122 065 01061		291/8,75 ± 0,25/0,8 ± 0,07/1100
1122 065 98046		291/8,75 ± 0,25/0,8 ± 0,07/1365
3222 201 60681		291/3,62 ± 0,17/0,7 ± 0,07/95
3222 201 66511		291/3,62 ± 0,17/0,7 ± 0,07/110
	(miniature tubes)	
3222 201 60341		291/6,25 ± 0,17/0,9 ± 0,07/80
3222 201 62662		291/8,75 ± 0,17/1,2 ± 0,07/85
	(miniature tubing)	
1122 065 01009		291/4,85 ± 0,12/0,5 ± 0,07/1100
1122 065 98086		291/4,85 ± 0,12/0,5 ± 0,07/1365
1122 065 98164		291/6,6 ± 0,12/0,5 ± 0,07/1365
1122 065 98142		291/8,5 ± 0,15/0,6 ± 0,07/1365
1122 065 98165		291/9,42 ± 0,15/0,6 ± 0,07/1365
	(miniature bulbs)	
3222 169 49203		291/4,85 ± 0,12/0,5 ± 0,07/16,5 (t5)
8222 191 81551		291/6,6 ± 0,12/0,5 ± 0,07/12,5 (t6,6)
3222 171 43802		291/8,5 ± 0,15/0,6 ± 0,07/18,0 (t8,5)
3222 169 06504		291/9,42 ± 0,15/0,6 ± 0,07/23,9 (t10)
	(t.v. necks)	
8204 071 00411		01/20,25 ± 0,25/1,27 ± 0,07/115
		291/20,25 ± 0,25/1,27 ± 0,07/115
3322 041 44604		01/28,9 ± 0,5/2,1 ± 0,1/140
4304 168 70191		01/28,9 ± 0,5/2,1 ± 0,1/135
8204 071 00182		291/28,9 ± 0,5/2,1 ± 0,1/140
8204 071 00431		291/28,9 ± 0,5/2,1 ± 0,1/135
	(c.t.v. necks)	
8222 041 06671		78/29,3 ± 0,5/2,4 ± 0,1/49,0 ± 3,0/127
3322 044 69601		78/37,0 ± 0,5/2,4 ± 0,1/49,0 ± 3,0/150

4

Lighting and Industrial Glass.

GLASS

I Introduction

The soda-lime glass tube drawing centre in Roosendaal, Netherlands, manufactures bulbs for fluorescent lamps

II List of glasses

Philips Glass Code	Utilisation
290	290 glass is a soda-lime glass especially manufactured for fluorescent lamps

III General properties

The values are subject to normal manufacturing variations.
They are given for your own guidance

Glass Code	Density γ	Thermal expansion	Viscosity					
			Transf. point	Strain point	Annealing point	Philips Softening point	American Softening point	Working point
290	2,477	α30-100°C = 8,80 x 10^{-6} α30-200°C = 9,25 x 10^{-6} α30-300°C = 9,70 x 10^{-6} α30-400°C = 10,0 x 10^{-6} α30-500°C = 10,4 x 10^{-6}		487	519		697	1007°

IV Electrical properties

Glass Code	conductivity		Specific Resistance Log p			Dielectric Properties		
	Tp	Tk 100	20°C	250°C	350°C	Frequency c/s	Dielectrical constant ε (20°C)	loss angle tg δ (20°C)
290	233°C	159°C		6,25	4,90			

V

Products: Tube glas in diameters of 25 - 80 mm wall thickness of 0,6 - 1,4 mm

Standard products: All lenghts of 15 - 100 W
diameter 37,25 ± 0,65 mm.
wall thickness 0,75 ± 0,08 mm.
These bulbs can be supplied both with straight and with pre-shaped extremities, according to specifications. Bulbs of different diameters, wall thickness or lenghts are also available at the above tolerances.

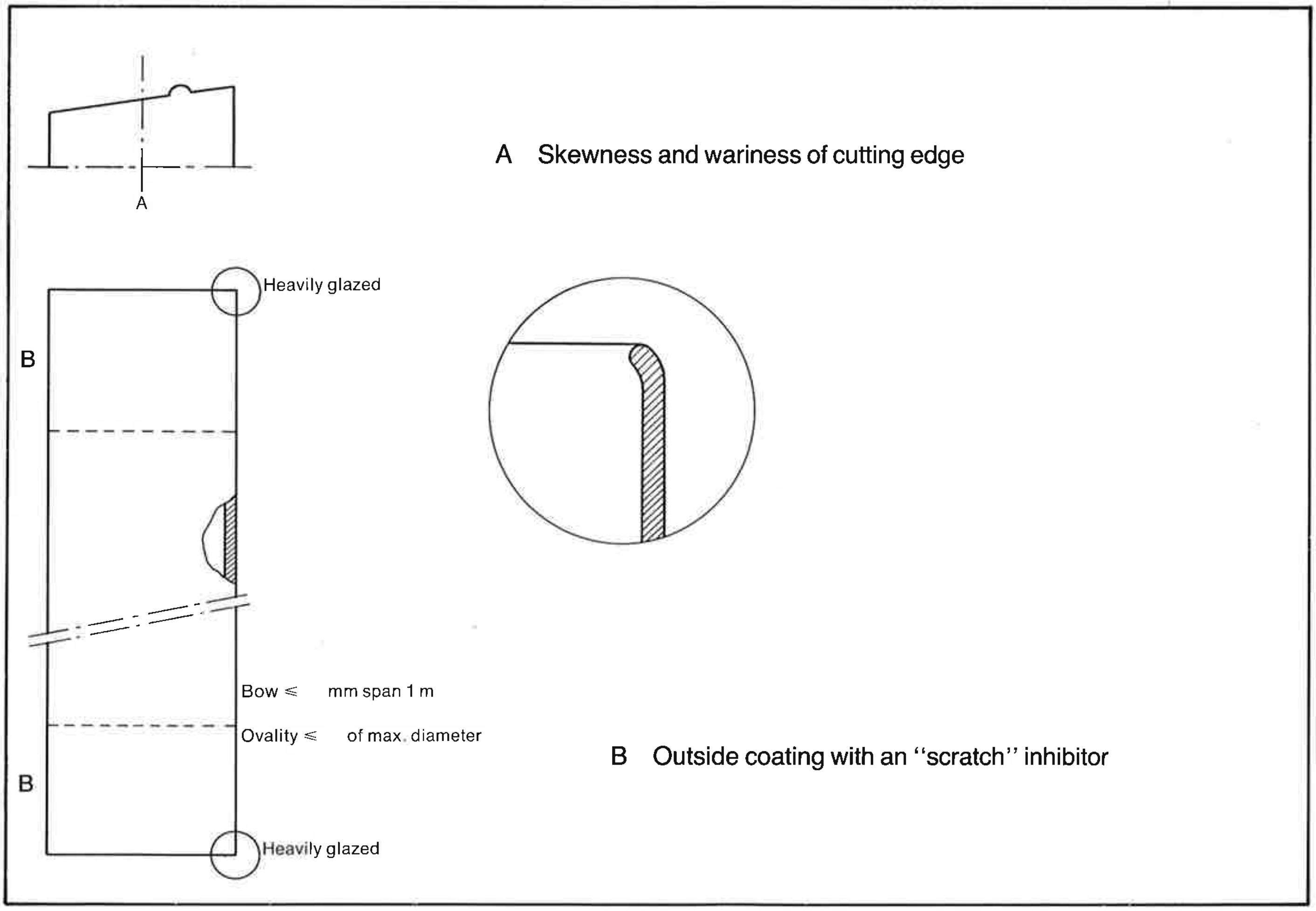
VI List of products

Code:			Length	Diameter	Wall thickness	Application	kg/1000
8222	191	80641	840	31.75	1.15	TLE 32 Watt	231
		81171	1160	-	-	TLE 40 Watt	318
3222	173	53503	1160	-	-	TLE 40 Watt	318
		80401	565	65.0	1.2	SOX 90 Watt	325
		80601	812	-	-	SOX 135 Watt	468
		80801	1148	-	-	SOX 180 Watt	661
		55002	1225	37.25	1.35	TLU 40 Watt	466
		54202	1535	-	-	TLU 65 Watt	583
8222	190	08961	1170	-	-	TLU Mod-U-line	445
3222	167	32601	1194	29.75	1.0	Philinea 1194	268
		80911	1230	-	-	Philinea 1230	276
8222	191	81441	654	25.7	0.7	TLD 20 Watt	90
		81461	1565	-	-	TLD 65 Watt	214
		81451	1264	-	-	TLD 40 Watt	173
3222	173	70401	502	-	-	TLD 15 Watt	69
		71001	959	-	-	TLD 30 Watt	132
		71201	2434	-	-	S 96 T 8 (Long-thin)	334
		71401	1824	-	-	S 72 T 8 (Short-thin)	251
4322	118	02461	1270	37.25	0.90	TL 40 Watt (1270)	325
3222	173	10032	1264	35.25	0.87	TLM 100 Watt	297
		12032	1565	-	-	TLM 120 Watt	368
		01531	502	37.25	0.75	TL 15 Watt	108
		02031	654	-	-	TL 20 Watt	141
		03031	959	-	-	TL 30 Watt	206
		02531	1035	-	-	TL 25 Watt	223
		32501	1111⁷	-	-	TL 42 Watt	239
		30031	1215	-	-	S 48 T 12	261
		32031	1240	-	-	TL 40 Watt V.I.R.	265
		04031	1264	-	-	TL 40 Watt	272
		06531	1565	-	-	TL 65 Watt	336
		13531	1824	-	-	S 72 T 12 (Short-Thick)	392
		08531	2439	-	-	S 96 T 12 (Long-thick)	524

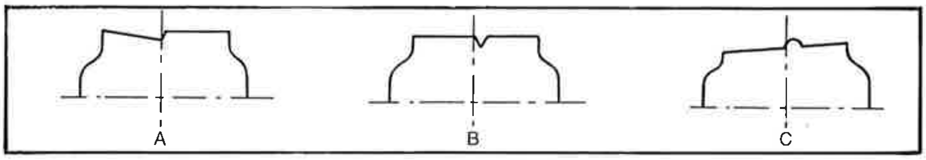
Code			Length	Diameter	Wall thickness	Application	kg/1000
8222	191	81331	1065	37.25	0.75	TL 25 Watt + 3 cm	227
		80891	952^{1}	-	-	TL 25 Watt (Shouldered)	206
		80851	1181^{9}	-	-	TL 40 Watt (Shouldered)	256
		80701	1482^{4}	-	-	TL 65 Watt (Shouldered)	320
1122	064	98001	684	51.0	1.2	SOX 35 Watt	308
		98002	910	-	-	SOX 55 Watt	410
		98003	794	29.75	1.0	Phil. 35 Watt	179
		00002	1304	37.25	1.35	TLU 20 Watt	496
	995	97938	1130	65.0	1.2	SOX 90 Watt	650
		97939	1004	25.7	0.7	TLD 15 Watt	138
		97941	1308	-	-	TLD 20 Watt	179

VII Bulb shapes

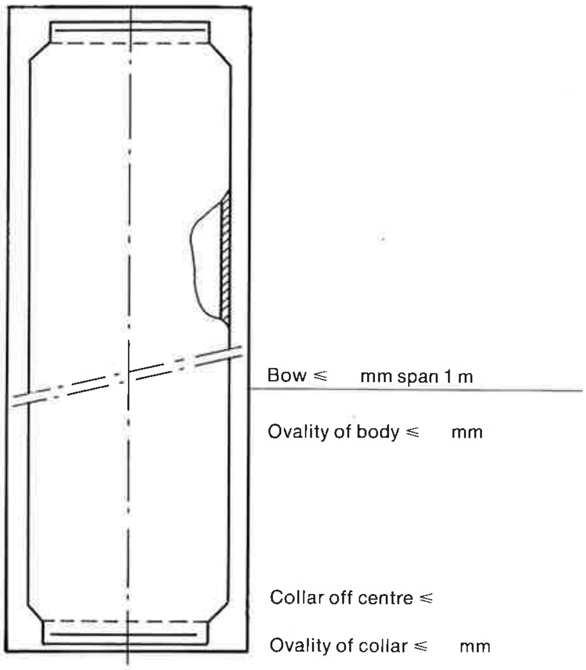
A Bulb for fluorescent lamps



B. Shouldered bulb for fluorescent lamps



A. Cascade
B. -"V" chipped
C. -Squareness of ends



Both ends slightly glazed

5

The finishing department
A most important part of our leadglass production drawn in Lommel is going to be manufactured to glass products in our finishing department.
Also glasstubing coming in from our other glass factories (Roosendaal and Eindhoven) is manufactured in the Lommel finishing dept.
The latter means that we have a lot of experience in working all kinds of glass sorts e.g. soft - hard and very special glasses.
Because we are the Philips' W.-European glass finishing centre we have also the knowledge about a various assortment of glassworking technics.
Price pressure and severe quality requirements obliged us to develop far avanced technics on glass finishing and our development and process groups every day are still studying about improved technics.

GLASS

In the finishing department some main groups can be distinguished:

Exhaust tube cutting:
Lampmaking now a days is very strictly mechanised. Standardization of all parts concerned gave us the opportunity to develop high speed horizontal cutting machines. Standardization on cut length was introduced. Standard lengths for exhaust tubes are (in mm.): 65 - 70 - 75 - 80 - 85 - 90 - 95 - 100 - 105 - 110 - 115 - 120 - 125 - 130, for diameter 2,5 mm up-to 5,3 mm.
Diameters outside this range, just as all lengths not mentioned above, can also be made of course.
Pricewise standardized products are of course always more interesting. The introduction of new standard lengths will depend on the yearly demand and mechanical possibilities of our equipment.
Cut tubing (thermo-shock):
High cutting-quality requirements on products for bulb - and flaremaking and for exhaust tubes, in the diameter range 5,3 mm up-to 12 mm obliged us to introduce a high speed thermo - shock cutting technic.
Here also standardization in length is obligatory to cut costs. Standard lengths in the diameter range 5,3 mm up-to 12 mm are at the moment: 41 - 54 - 63 - 85 - 90 mm. (41 mm. is min. length)
Of course tooling can be adjusted, for other lengths, for large production series into the mentioned diameter field. Small series of non - standardized lengths can naturely always be discussed.

Flare making:
Because flares are products that are mostly adapted to the customers lampmaking technics we want to discuss all dimensional and physical requirements in advance.
Flare making is done as well for soft glass as for hard glass applications.
On dimensional approach we are producing as well flares for miniature applications as for normal lampmaking and for very special lampmaking purposes.

T.V. - necks:
High quality glass tubing, as well on dimensional as on visual requirement is worked up to T.V.-necks in a very specialised subdepartment.
Mono-chrome necks used to be made out of 30% leadglass (01 glass); colour necks out of 35% leadglass (78 - glass)
T.V.-neck making is a very speciality of our Lommel finishing department. The high quality glass-tubing from our tube drawing department makes it very favorable to produce T.V.-necks. Our thorougly studied quality control system on these products assure high quality deliveries to our customers.

Bulb blowing:
Bulb blowing technics, out of tubing glass or cut tubing, are also installed in our Lommel finishing department.
Mainly tubular bulbs are being made directly out of tube-drawn glass; but also mould - formed bulbs are produced.
Motorcar lampbulbs as well as projection lampbulbs as a whole range of miniature bulbs belong to our normal production range.
Mainly soft glass is worked, but also hard glass and very special glasses (e.g. yellow selectiva) can be worked if desired.

Diamond cutting:
Very severe requirements on lenght-tolerances and cutting quality were at the base of the introduction of the diamond Sawing technic.
Tube and rod glass, as well soft as hard glass and quartz, are worked in this finishing sub-department.
Very specialised manufacturers of diodes and halogen motorcarlamps are really pleased with our diamond cutting services.

In all above mentioned finishing sub-departments well trained people are looking after the product quality. Advanced technics, well developped processes and thoroughly done process control assure a good quality level to all our customers.