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Product Description

PLEXIGLAS® GS
Basic grades 233, 222, 221

General remarks

PLEXIGLAS® GS is a cast acrylic by the chemical name of polymethyl methacrylate (PMMA).

PLEXIGLAS® GS 233, 222 and 221 are our basic grades. They are clear-transparent with - normally - surfaces smooth as glass. They are manufactured in the form of 1.5 to 25 mm thick sheets (GS 233) as well as 30 to 80 mm (GS 222) and 90 to 150 mm (GS 221) thick blocks. For sizes see our Sales Range.

Further grades of PLEXIGLAS® GS and their most important characteristics are listed our "Product Description PLEXIGLAS® GS, PLEXIGLAS® XT, Ref. No. 211-1".
Separate documents for each type of semifinished product are available on request.

Applications

An enumeration of all possible applications for PLEXIGLAS® GS would fill many pages and will, therefore, not be attempted here. Let us mention, however, that they range from transparent models to showcases and from shelving to unusual ceiling lamps.

In short, PLEXIGLAS® GS is used wherever a lightweight plastics material is needed that transmits a maximum of light, has a brilliant appearance, is easy to machine by all conceivable methods at a high mechanical strength and shows good dimensional stability under heat.

PLEXIGLAS® is second to none where superior weather resistance is required. Special PLEXIGLAS® grades are available which satisfy more exacting demands on heat deflection temperature under load or behaviour towards corrosive media and are either UV-absorbing or highly UV-transmitting.

PLEXIGLAS® GS: Model

PLEXIGLAS® GS: Showcases

PLEXIGLAS® GS: Shelving

PLEXIGLAS® GS: Ceiling lamps made of rods, utilising their waveguide effect

Physical properties

The table 0f typical values give an overview of the physical properties of PLEXIGLAS® GS. As with all other materials, however - and plastics in particular - most of the properties listed there are influenced by time and temperature. The time and temperature functions of a few more important properties are shown below.

The temperature functions of the dynamic modulus in shear G and the mechanical damping decrement characterise PLEXIGLAS® GS as a homogeneous material with its main softening range between 100 and 150 °C. Below this range PLEXIGLAS® GS is hard-elastic, beyo nd 150 °C it is rubbery-elastic. Processing by thermoplastic (= melt) moulding techniques is not possible.
Figures illustrate the influence of the temperature on the stress-strain behaviour and the flexural strength as well as on the impact and notched impact strength. It is evident that the mechanical properties first change noticeably above 50 °C.

The influence of time and temperature on the tensile strength and creep elongation of PLEXIGLAS® GS is illustrated in other figures. For construction purposes, the reducing influence of high temperatures and notches must be borne in mind.

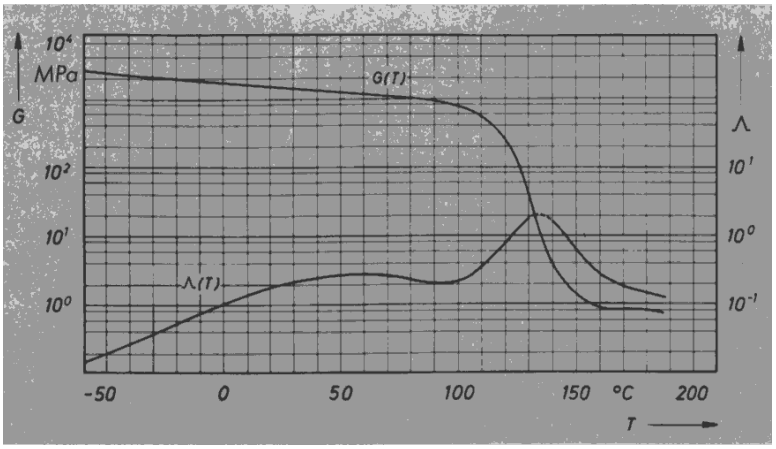
The influence of the temperature on the long-term behaviour is shown in a graph. Permanent exposure to corrosive media may also reduce the strength of PLEXIGLAS® GS. A figure illustrates the influence of water at different temperatures. Much more pronounced is the influence of corrosive media like ethanol or plasticisers such as dibutyl phthalate and dioctyl phthalate.

The **chemical behaviour** of PLEXIGLAS® GS in general is described in our documents "Chemical Behaviour, Ref. No. 211-2" and "Resistance to Crazing and Chemicals, Ref. No. 211-4".

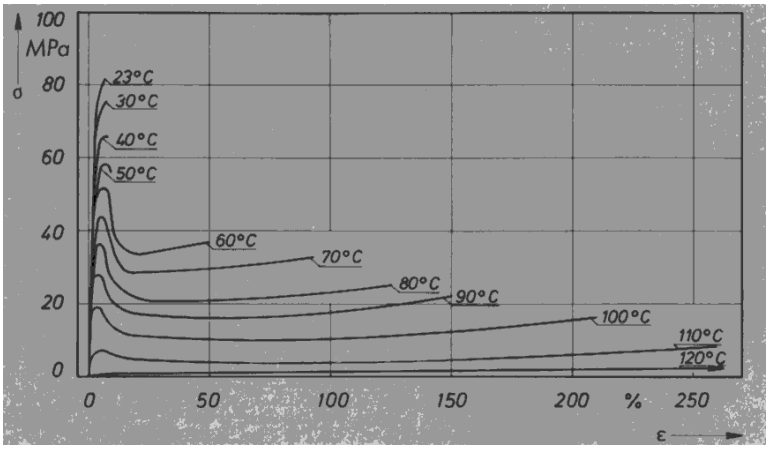
The light transmission of clear PLEXIGLAS® GS in the visible range (λ =380-780 nm) is about 92% irrespective of the wavelength. 8% of the incident light is reflected at the surfaces (4% each). The absorption is negligibly small, even at increased thicknesses. Only at a sheet thickness around 3m (!) is the absorption about 50%.

In the ultraviolet and near-infrared region, however, the light transmission does depend on the sheet thickness. In the adjacent spectral range up to about 25 µm, the transmission is negligible throughout. The refractive index of PLEXIGLAS® GS depends on the wavelength of the light. It decreases with increasing wavelength λ.

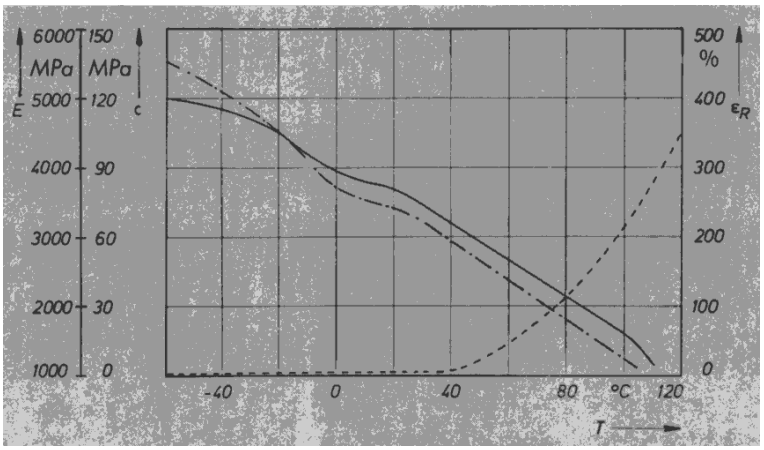
PLEXIGLAS® GS: Dynamic modulus in shear G and mechanical damping Λ as a function of the temperature T



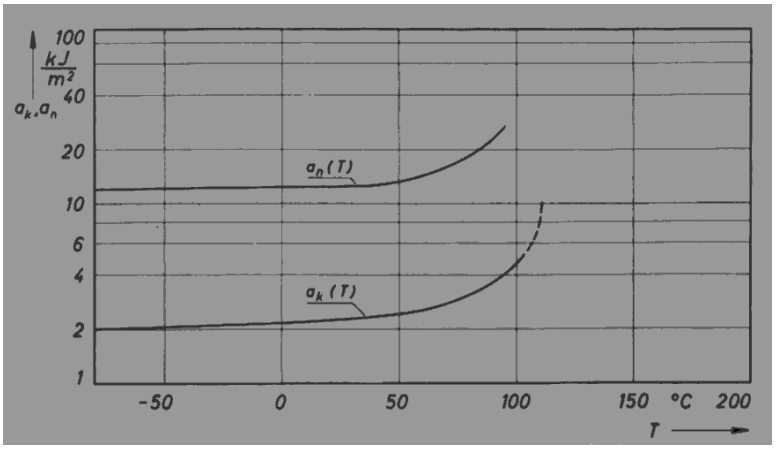
PLEXIGLAS® GS: σ-ε-diagrams at different temperatures



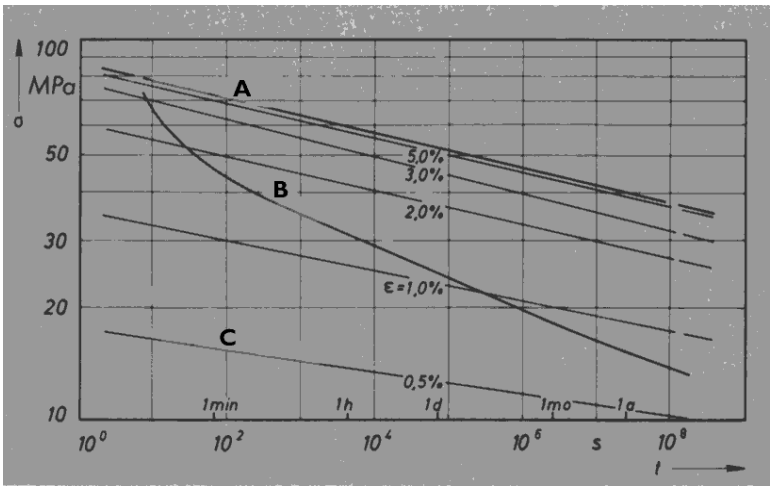
PLEXIGLAS® GS: Tensile strength σ (_____), elongation at break ε_R (------) and elastic modulus E (-.-.-.-) as a function of the temperature T



PLEXIGLAS® GS: Impact strength a_n and notched impact strength a_k (standard small test specimen) as a function of the temperature T

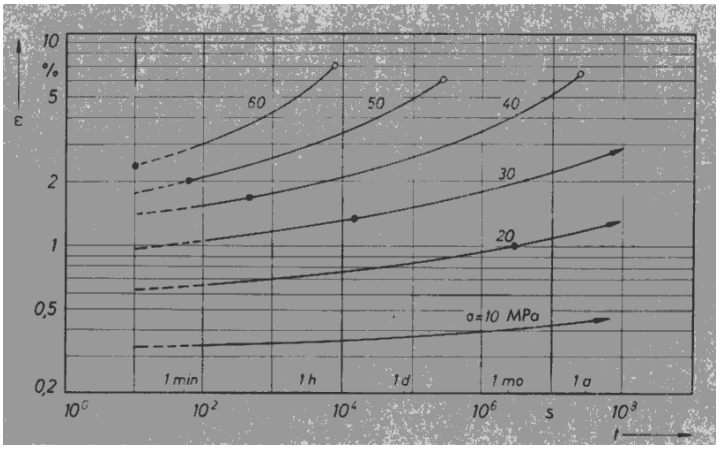


PLEXIGLAS® GS: Long-term mechanical behaviour at 23 °C and 50% RH



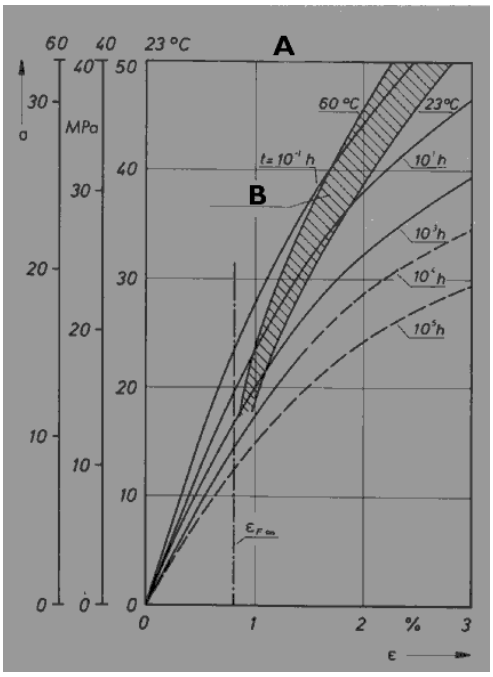
σ = stress
t = time
ε = strain
A = long-term tensile strength
B = long-term crazing strength
C = long-term stress relaxation

PLEXIGLAS® GS: Creep curves at constant stress σ at 23 °C and 50% RH



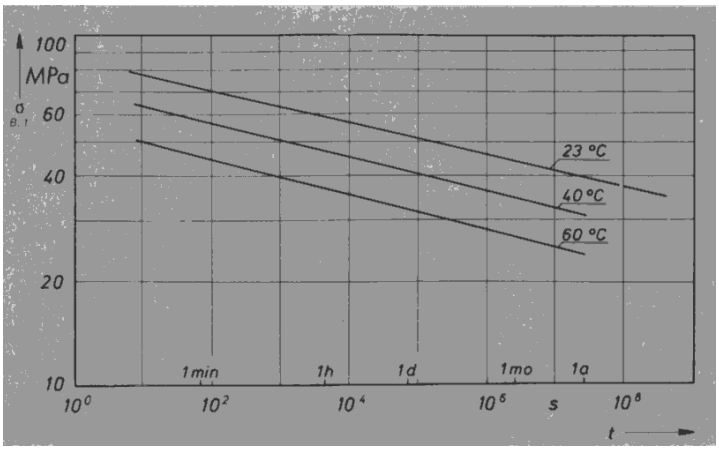
- onset of crazing o fracture

PLEXIGLAS® GS: lsochronous stress-strain curves at 23, 40 and 60 °C

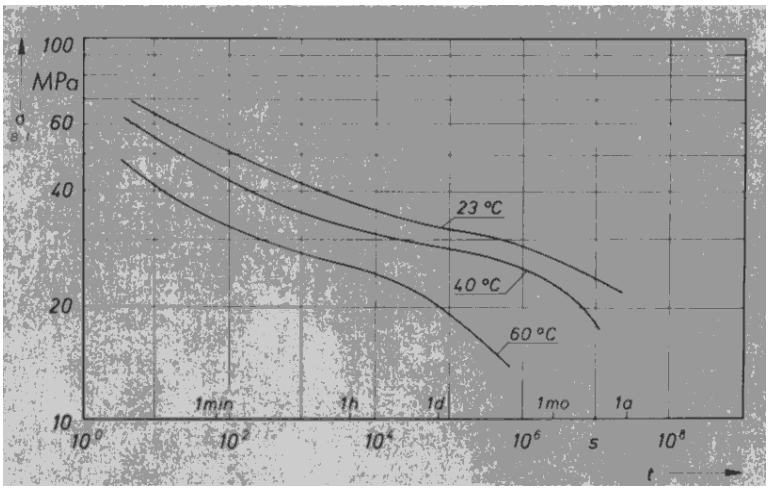


A = experimental temperature
B = area of flow

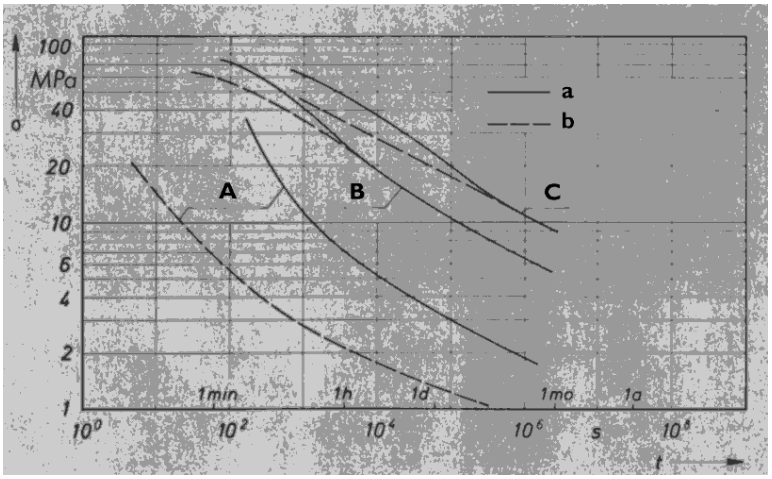
PLEXIGLAS® GS: Long-term tensile strength $\sigma_{B,t}$ in air at increased temperatures: 23, 40 and 60 °C



PLEXIGLAS® GS: Long-term tensile strength $\sigma_{B,t}$ in water at increased temperatures: 23, 40 and 60 °C

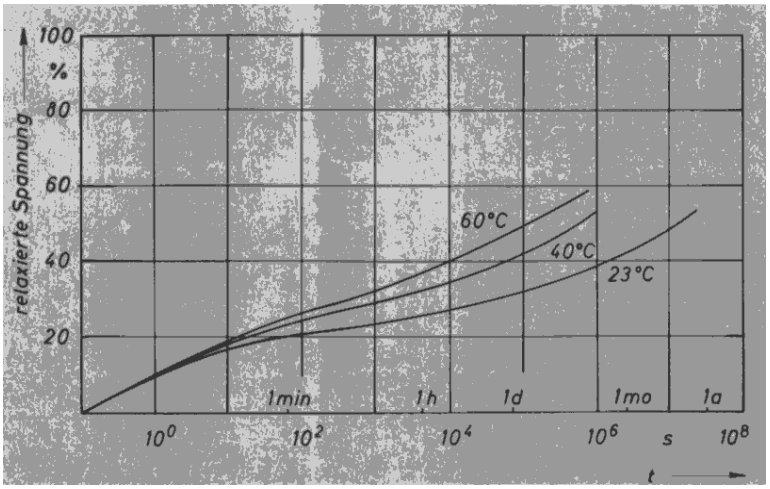


PLEXIGLAS® GS: Long-term mechanical behaviour towards various corrosive agents at 23 °C

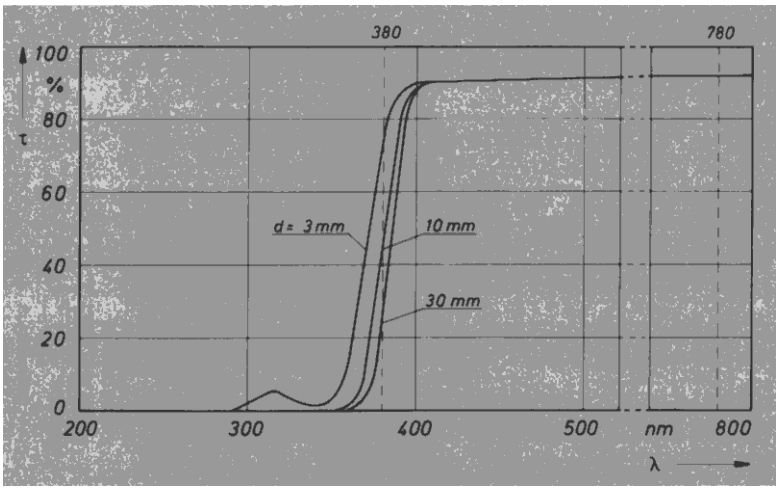


A = ethanol
B = dibutyl phthalate
C = dioctyl phthalate
a = long-term tensile strength
b = long-term crazing strength

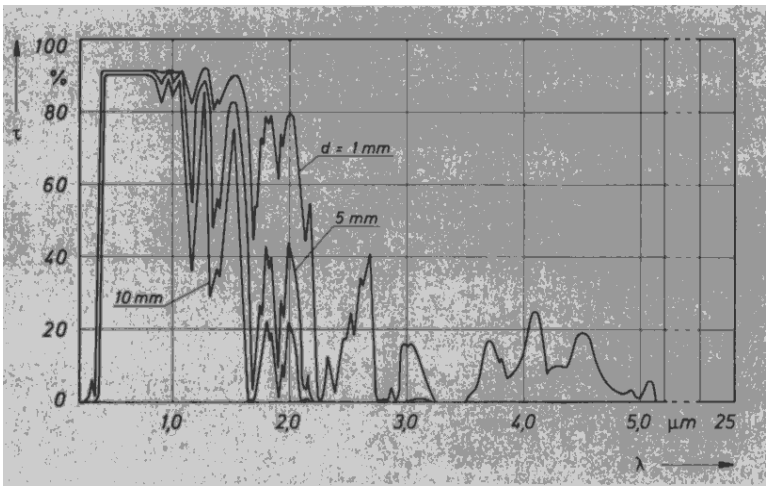
PLEXIGLAS® GS: Stress relaxation in per cent at different temperatures



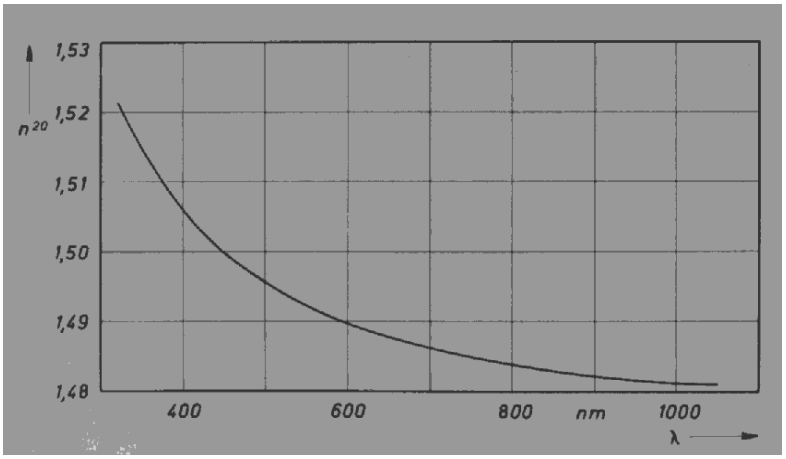
PLEXIGLAS® GS: Spectral transmittance τ in the ultraviolet and visible range (λ = wavelength)



PLEXIGLAS® GS: Spectral transmittance τ at a thickness of 1, 5 and 10 mm as a function of the wavelength λ



PLEXIGLAS® GS: Refractive index n^{20} as a function of the wavelength λ (at 20 °C)



Design hints

When designing a glazing project, care must be taken not to exceed certain limits of deflection and/or stress.

If PLEXIGLAS® GS is used flor flat glazing elements, deflections beyond the limits set for conventional materials - usually 0.5 to 1.0 % of the shorter sheet length - can be permitted.

The inherent stability and break resistance of PLEXIGLAS® GS allow us to increase this value - material-specifically - to l /50, i.e. 2 % of the shorter sheet length (= l).
Taking the usual environmental influences into account, the maximum safety stress for a structural element of PLEXIGLAS® GS in long-term use is

$\sigma_{max.}$ = 5 ... 10 MPa

(for aquaria up to $\sigma_{max.}$ = 3 MPa).

The lower safety value is recommended if the structural element is subject to influences that cause the above-mentioned reducing factors (e.g. increased temperatures, moisture, chemical influences, weathering, etc.). The higher stress value may be allowed for if the element is rarely or only briefly exposed to such influences.
What must be borne in mind is that the stress caused by external influences may be further increased by unintentional deformation, e.g. distortion during installation.
Moreover, internal stress may be present, generated by unskilful treatment, local heating, rapid cooling after thermoforming, etc. PLEXIGLAS® GS normally relaxes such internal stress. At high temperatures (c. 80 °C), the relaxation process occurs within a short period of time, whereas at room temperature a relaxation to only half the original value takes several months.

Hence the recommendation that internally stressed parts of PLEXIGLAS® GS be annealed before use.

Typical property values (at 23 °C and 50 % RH)

Mechanical properties	PLEXIGLAS® GS 233, 222, 221	Unit	Standard
Density	1.19	g/cm^3	ISO 1183
Impact strength to Charpy	15	kJ/cm^2	ISO 179/1 fu
Notched imp. Strength to lzod	1.6	kJ/m^2	ISO 180/1 A
Tensile strength a) - 40 °C b) 23°C c) 70°C	 110 80 40	MPa	ISO 527-2/1B/5
Elongation at break	5.5	%	ISO 527-2/1B/5
Flexural strength, standard test specimen (80 x 10 x 4 mm)	115	MPa	ISO 178
Compressive yield stress	110	MPa	ISO 604
Max. safety stress (up to 40°C)	5 ... 10	MPa	–
Fatigue strength in alternating bending test, c. 10^6 cycles a) unnotched specimen b) notched specimen	 40 20	 MPa MPa	 –
Modulus of elasticity (short-term value)	3300	MPa	ISO 527-2/1B/1
Dynamic shear modulus at c. 10 Hz	1700	MPa	ISO 537
Indentation hardness ($H_{961/30}$)	175	MPa	ISO 2039-1
Abrasion resistance in Taber abrader test (100 rev.; 5.4 N; CS-10F)	20...30	% haze	ISO 9352
Coefficient of friction a) plastic on plastic b) plastic on steel c) steel on plastic	 0.8 0.5 0.45	 –	 –
Poisson's ratio (at elongation rate of 5% per min, up to 2% elongation, at 23 °C)	0.37	–	ISO 527-1
Safety against ice hockey pucks, 15 mm thick (Test Certificate No. 46/13659)	Passed	–	similar to DIN 18032
Acoustical properties	PLEXIGLAS® GS 233, 222, 221	Unit	Standard
Sound velocity (at room temp.)	2700...2800	m/s	–
Weighted sound reduction index R_W Thickness: 4 mm 6 mm 10 mm	 26 30 32	dB	–
Optical properties (of clear grades, thickness 3 mm)	PLEXIGLAS® GS 233, 222, 221	Unit	Standard
Transmittance τ_{D65}	~ 92	%	DIN 5036, Part 3
Reflection loss in the visible range (for each surface)	4	%	–
Total energy transmittance	85	%	DIN 67507
Absorption in the visible range, at 3 mm thickness	< 0.05	%	–
Refractive index n_D^{20}	1.491	–	ISO 489

Thermal properties	PLEXIGLAS® GS 233, 222, 221	Unit	Standard
Coefficient of linear thermal expansion 0 ... 50°C	$7 \cdot 10^{-5}$ (=0.07)	1/K (mm/m°C)	DIN 53752-A
Thermal conductivity	0.19	W/mK	DIN 52612
U-value			
at thickness 1 mm	5.8		
3 mm	5.6	W/m^2K	DIN 4701
5 mm	5.3		
10 mm	4.4		
Specific heat	1.47	J/gK	–
Forming temperature	160 ... 175	°C	–
Max. surface temperature (IR heater)	200	°C	–
Max. permanent service temperature	80	°C	–
Reverse forming temperature	> 80	°C	–
Ignition temperature	425	°C	DIN 51794
Fire rating (material thickness ≥ 2 mm)	B 2, normally flammable	–	DIN 4102
	Class 3	–	BS 476, part 7 + 6
	TP(b)	–	BS 2782, method 508 A
	M 4	–	NF P 92 501 + 92 505
Vicat softening temperature	115	°C	ISO 306, meth. B50
Dimensional stability under heat, Martens method	95	°C	DIN 53458
Heat deflection temperature under load (HDT)			
a) deflection 1.8 MPa	105	°C	ISO 75
b) deflection 0.45 MPa	113		

Electrical properties	PLEXIGLAS® GS 233, 222, 221	Unit	Standard
Volume resistivity	$>10^{15}$	ohm • cm	DIN VDE 0303,
Surface resistivity	$5 \cdot 10^{13}$	ohm	Part 3
Dielectric strength (specimen thickness 1 mm)	~ 30	kV/mm	DIN VDE 0303, Part 2
Dielectricconstant			
at 50 Hz	3.6	–	DIN VDE 0303,
at 0.1 MHz	2.7	–	Part 4
Dissipation factor			
at 50 Hz	0.06	–	DIN VDE 0303,
at 0.1 MHz	0.02	–	Part 4
Tracking, CTI value	600	–	DIN VDE 0303, Part 1

Behaviour towards water	PLEXIGLAS® GS 233, 222, 221	Unit	Standard
Water absorption (24 hrs, 23 °C) from dry state	30	mg	ISO 62,
Max. weight gain during immersion	2.1	%	method 1
Permeability to water vapour	$2.3 \cdot 10^{-10}$	$\frac{g \cdot cm}{cm^2 \cdot h \cdot Pa}$	–
N_2	$4.5 \cdot 10^{-15}$		
O_2	$2.0 \cdot 10^{-14}$		
CO_2	$1.1 \cdot 10^{-13}$		
air	$8.3 \cdot 10^{-15}$		

Degussa
Methacrylates

Röhm GmbH
Certified to DIN EN ISO 9001 (Quality)
and DIN EN ISO 1400 (Environment)

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