

Specification	PCP
Physical and chemical properties	D 6625

HC - PHOTOSOLAR® DUNKELBRAUN

D 6625

Colour: darkbrown

Application: High index glass sensitive to light for corrective lenses and sun glare filter;
luminous transmittance range 87% (τ_0) / 25% (τ_1) or filter categories 0 / 2 respectively and UV - absorption

The subsequent properties are based primarily upon the measuring results of the very latest standards and measuring methods, which are defined in corresponding "Measuring and Test Procedures". We retain the right to change the data in keeping with the latest technical standards. Non-toleranced numerical values are reference values of an average production quality.

Values marked with \diamond do not apply to the type of glass or no values are available.

Requirements deviating from these specifications must be defined in writing in a **customer agreement**.

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Physical and chemical properties			
1.	Optical properties		
1.1	Refractive indices (20°C)		
	Pretreatment of samples	n_g	1.6185
	[x] Condition as supplied	$n_{F'}$	1.6113
	[] annealed at 40°C/h	n_F	1.6104
		n_e	1.6040 ^{+0.0006} -0.0010
		n_d	1.6007
		n_D	1.6006
		$n_{C'}$	1.5972
		n_C	1.5965
1.1.1	Abbe value	v_e	42.8
		v_d	43.0
1.2	Transmittance data		
1.2.1	Spectral transmittance $\tau(\lambda)$		
1.2.1.1	$\tau(\lambda)$ - curve		
	Plot of spectral transmittance $\tau(\lambda)$ for the light state $\tau_{0'}$ and dark state $\tau_{15'}$	see annex	
1.2.1.2	$\tau(\lambda)$ - individual values in % ($d = 2.0$ mm)	$\tau_{0'}$	$\tau_{15'}$
	$\tau(\lambda)_{\max}$ for the λ - range 280 nm - 315 nm	< 0.003	< 0.003
	$\tau(\lambda)_{\max}$ for the λ - range 315 nm - 350 nm	2.5	2
	τ_{380}	28	8
	$\tau(\lambda)_{\min}$ for the λ - range 450 nm - 650 nm	77	19
	$\tau(\lambda)_{\min}$ for the λ - range 500 nm - 650 nm	77	19
1.2.1.3	Edge wavelength ($d = 2.0$ mm)		
	Edge wavelength λ_C ($\tau = 0,46$) in nm for $\tau_{0'}$	393	

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1.2.2	Luminous transmittance τ_v								
1.2.2.1	Luminous transmittance τ_{vD65} or τ_{vA} in % respectively under standard conditions ($d = 2.0$ mm)								
	Light state τ_{vD65}	$\tau_{0'} (\tau_0)$	87 ± 1						
	Dark state	$\tau_{15'} (\tau_1)$	25 ± 2						
		$\tau_{R5'}$	-						
	Regeneration τ_{vA}	$\tau_{R10'}$	71 ± 2						
		$\tau_{R30'}$	78 ± 2						
	Darkening-fading curve for 23 °C	see annex							
	Luminous transmittance τ_{vD65} in % in relationship to the thickness	$\tau_{0'} (\tau_0)$	$\tau_{15'} (\tau_1)$						
	Thickness in mm	2.0	25						
		3.0	19						
		4.0	16.5						
1.2.2.2	Scale number / Filter category ($d = 2.0$ mm)								
	Scale number	5 - 1.1 < 2.5							
		$\tau_{0'} (\tau_0)$	$\tau_{15'} (\tau_1)$						
	Filter category	0	2						
1.2.2.3	Luminous transmittance dark state $\tau_{15'}$ in % in relationship to the sample temperature ϑ in °C ($d = 2.0$ mm)								
		-	-	τ_w	τ_1	τ_s			
	ϑ	-10	-5	5	23	35			
	$\tau_{15'}$	◇	◇	16	25	39			
1.2.2.4	Luminous transmittance dark state $\tau_{15'}$ in % in relationship to the illuminance E in klx ($d = 2.0$ mm)								
		τ_1	-	-	τ_a	-			
	E	50	30	20	15	10			
	$\tau_{15'}$	25	31	37	41	47			
1.2.2.5	Luminous transmittance dark state $\tau_{15'}$ in % in relationship to the variation the excitation spectrum in dependance of the edge wavelength λ_c of a sharp cut filter in nm ($d = 2.0$ mm)								
	λ_c	328	353	369	389	410	433	454	468
	$\tau_{15'}$	25	26	27	30	34	44	57	60
	Diagram	see annex							

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1.2.3	Special transmittance values in % ($d = 2.0$ mm)		
1.2.3.1	UV - transmittance for τ_{15}		
		τ_{UVA}	2.2
		τ_{SUV}	0.8
		τ_{SUVA}	1.2
		τ_{SUVB}	< 0.05
1.2.3.2	IR - transmittance	τ_{SIR}	$\geq \tau_{VD65}$
1.2.3.3	Solar blue - light transmittance	τ_{sb}	17.5
1.3	Colour		
1.3.1	Visual evaluation		
	The visual evaluation is made on the basis of a simultaneous comparison with internal limit samples.		
1.3.2	Colorimetry		
	Chromaticity coordinates	A x_{10}	0.362 ₉
		y_{10}	0.350 ₄
	Chromaticity coordinates (colour locus) are referred to the Standard Illuminant D ₆₅ according to CIE 10°-observer for τ_{15} (τ_1) - for the time being they are only reference values ($d = 2.0$ mm) in view of the relative calibration possibility	B x_{10}	0.367 ₇
		y_{10}	0.348 ₉
	In case of verification, the measured values may additionally deviate by the measuring uncertainty of the used measuring devices.	C x_{10}	0.370 ₉
		y_{10}	0.354 ₁
	part of chromaticity coordinates	D x_{10}	0.366 ₀
		y_{10}	0.355 ₇
		see annex	
1.3.3	Signal light recognition		
	Relative visual attenuation coefficient Q	Q_{blue}	0.91
	for signal light recognition for τ_{15} (τ_1) ($d = 2.0$ mm)	Q_{green}	0.89
		Q_{yellow}	1.16
		Q_{red}	1.35
1.3.4	Yellowness index ($d = 10$ mm)		
		Y_i	\diamond

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2. Thermal properties			
2.1 Viscosities and corresponding temperatures			
	Designation	Viscosity lg η in dPas	Temperature ϑ in °C
	Strain point	14.5	516
	Annealing point	13.0	541
	Softening point	7.6	692
	Forming temperature	6.0	772
	Forming temperature	5.0	838
	Forming temperature	4.0	923
2.2	Transformation temperature T_g in °C	539	
2.3	Coefficient of mean linear thermal expansion $\alpha(20\text{ °C};300\text{ °C})$ in 10^{-6} K^{-1} (Statische Messung)	6.0	
2.4	Fuseability	◇	
2.5	Mean specific heat capacity $c_p(20\text{ °C to }100\text{ °C})$ in $\text{J}/(\text{g} \cdot \text{K})$	◇	

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3.	Mechanical properties	
3.1	Density ρ in g/cm ³	2.74
3.2	Stress optical coefficient C in $1.02 \cdot 10^{-12}$ m ² /N	3.49
3.3	<p>Breaking strength</p> <p>A higher mechanical strength can be realized by chemical toughening according to the ion exchange procedure (refer to annex 3.3.1).</p> <p>This toughening method may cause slightly transmittance - and colourchanges.</p>	
3.3.1	Chemical toughening	
	Processing temperature ϑ in °C	440
	Processing time t in h	16
	Compressive stress D_s as birefringence in nm/cm	2600
	Penetration depth Nz up to neutral zone in μm	51
	Further information	see annex
3.4	Young's modulus E in kN/mm ²	78
3.5	Poisson's ratio μ	0.229
3.6	Torsion modulus G in kN/mm ²	32
3.7	Knoop hardness HK 0.1/20	◇

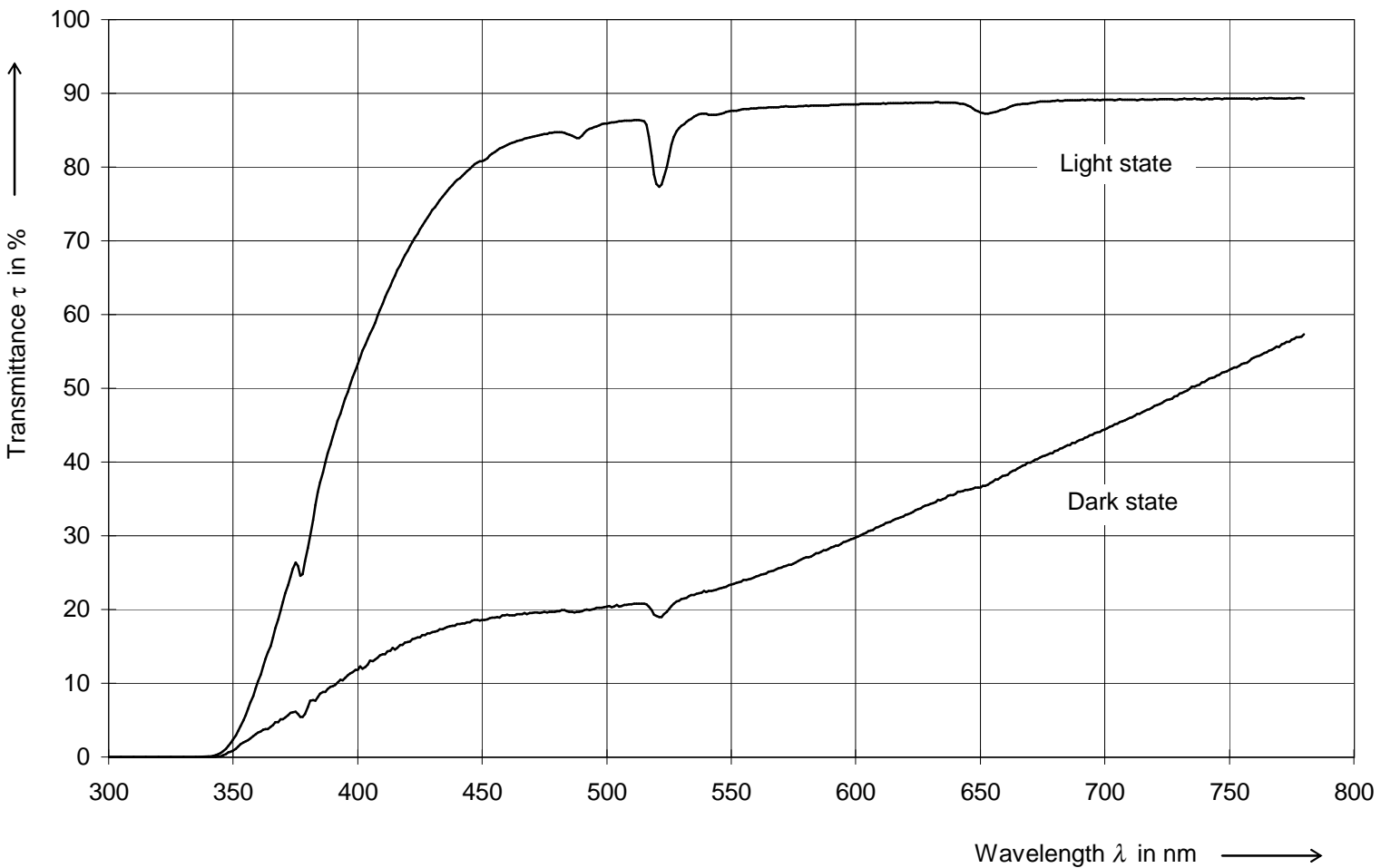
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Physical and chemical properties			
4.	Chemical properties		
4.1	Hydrolytic resistance acc. to DIN ISO 719		
		Hydrolytic class	HGB 2
	Equivalent of alkali (Na ₂ O) per gram of glass grains in µg/g		42
4.2	Acid resistance acc. to DIN 12 116		
		Acid class	S 4
	Half surface weight loss after 6 hours in mg/dm ²		253
4.3	Alkali resistance acc. to DIN ISO 695		
		Class	A 2
	Surface weight loss after 3 hours in mg/dm ²		100
4.4	Hazardous Substances		
	EC-directive 2002/95/EC (RoHS-directive)		on request
5.	Electrical properties	disregard	
6.	Other properties		
6.1	Anti-reflection processes		
	<p>During the anti-reflection process and burning in of the anti-reflection coatings respectively the luminous transmittance in the dark state may change.</p> <p>In annex 6.1 there is specified the deviation from the luminous transmittance dark state τ_{15} for $d = 2.0$ mm as a function of various additional heat treatments, corresponding to typical anti-reflection processes in temperature/time behaviour.</p>		
	Diagram	see annex	
	Additional heat treatment		
	<p>The sample is put on a kaolin plate (room temperature) and then placed in a box furnace, in which the treatment temperature is already existing.</p> <p>After the specified time, the sample and the kaolin plate are taken out and immediately put on a cold (room temperature) kaolin plate for rapid cooling.</p>		
7.	Annex (diagrams, curves)		

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Spectral Transmittance

Type of Glass: HC - PHOTOSOLAR® DUNKELBRAUN
Thickness: 2 mm

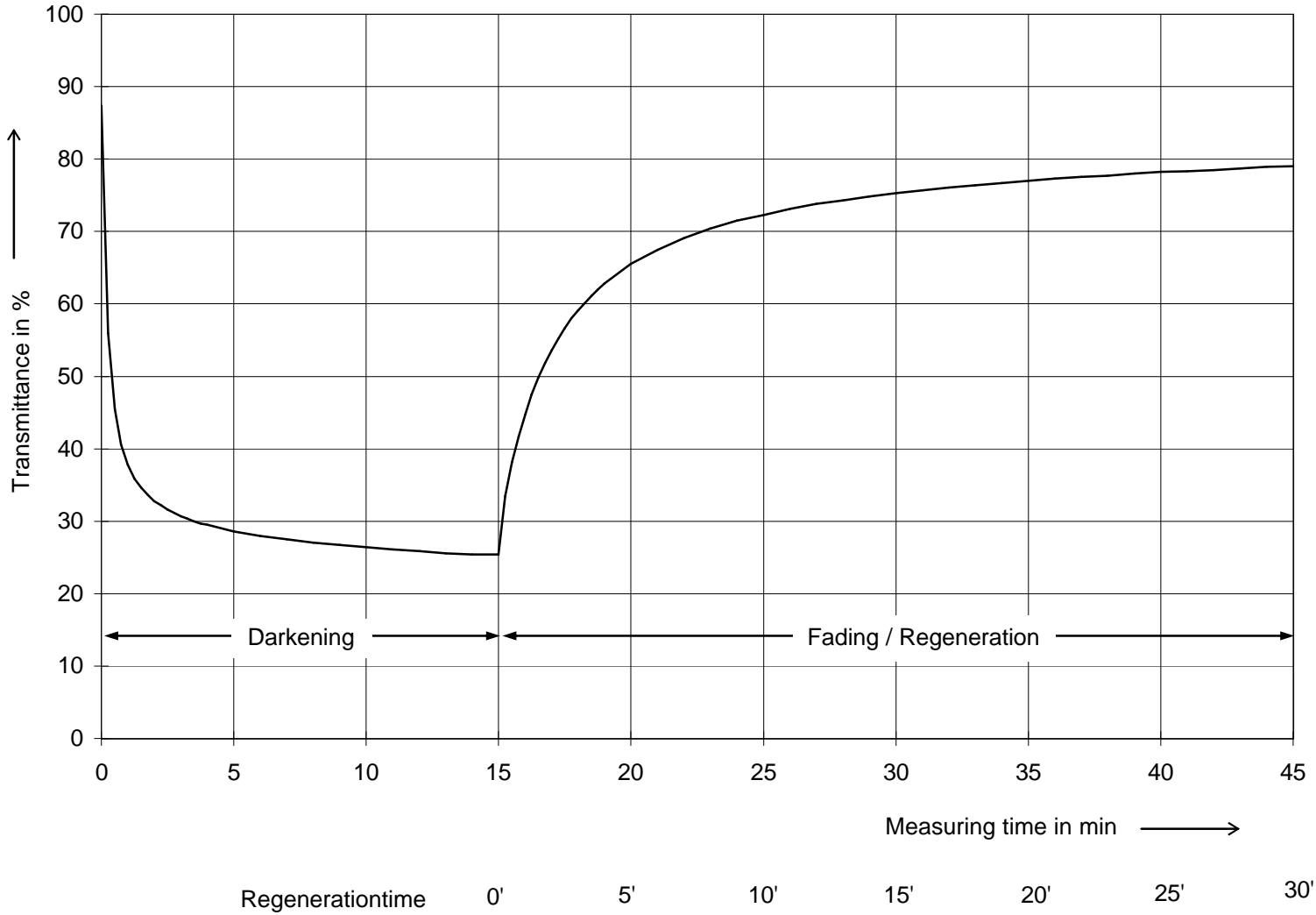


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Darkening - Fading - Curve

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Thickness: 2 mm



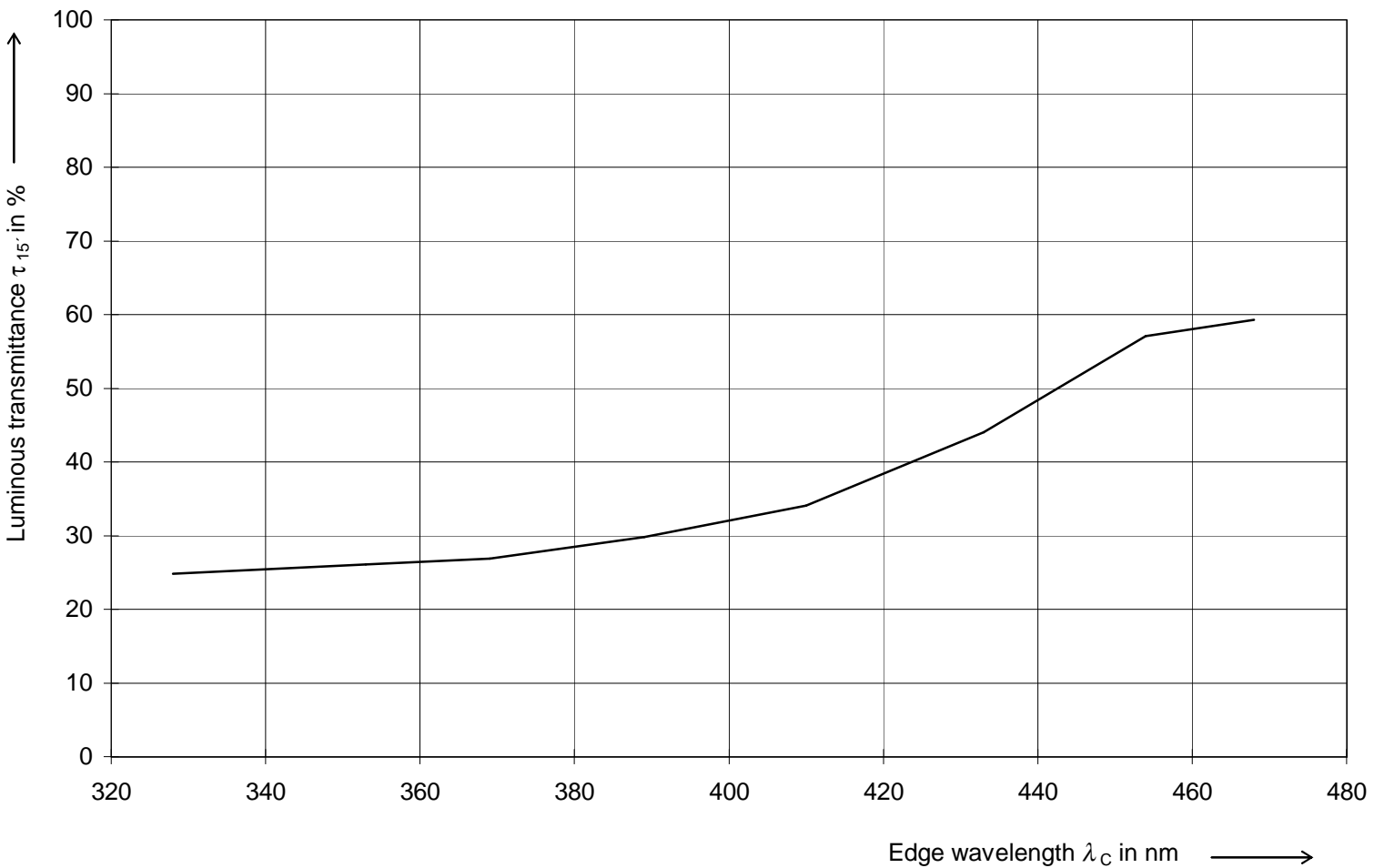
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Luminous transmittance dark state in relationship to the variation the excitation spektrum (sharp cut filter)

Type of Glass: HC - PHOTOSOLAR® DUNKELBRAUN

Thickness: 2 mm

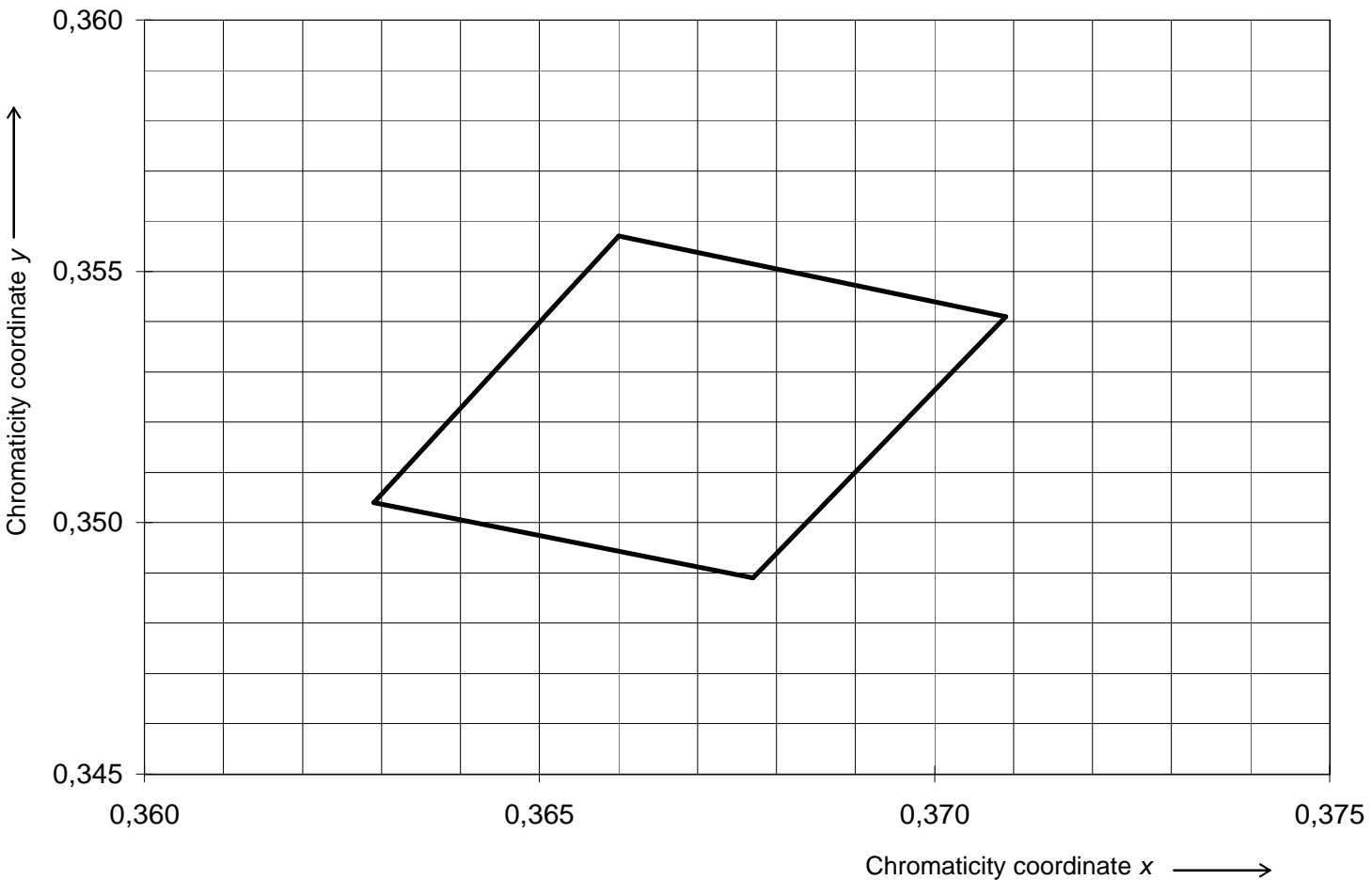


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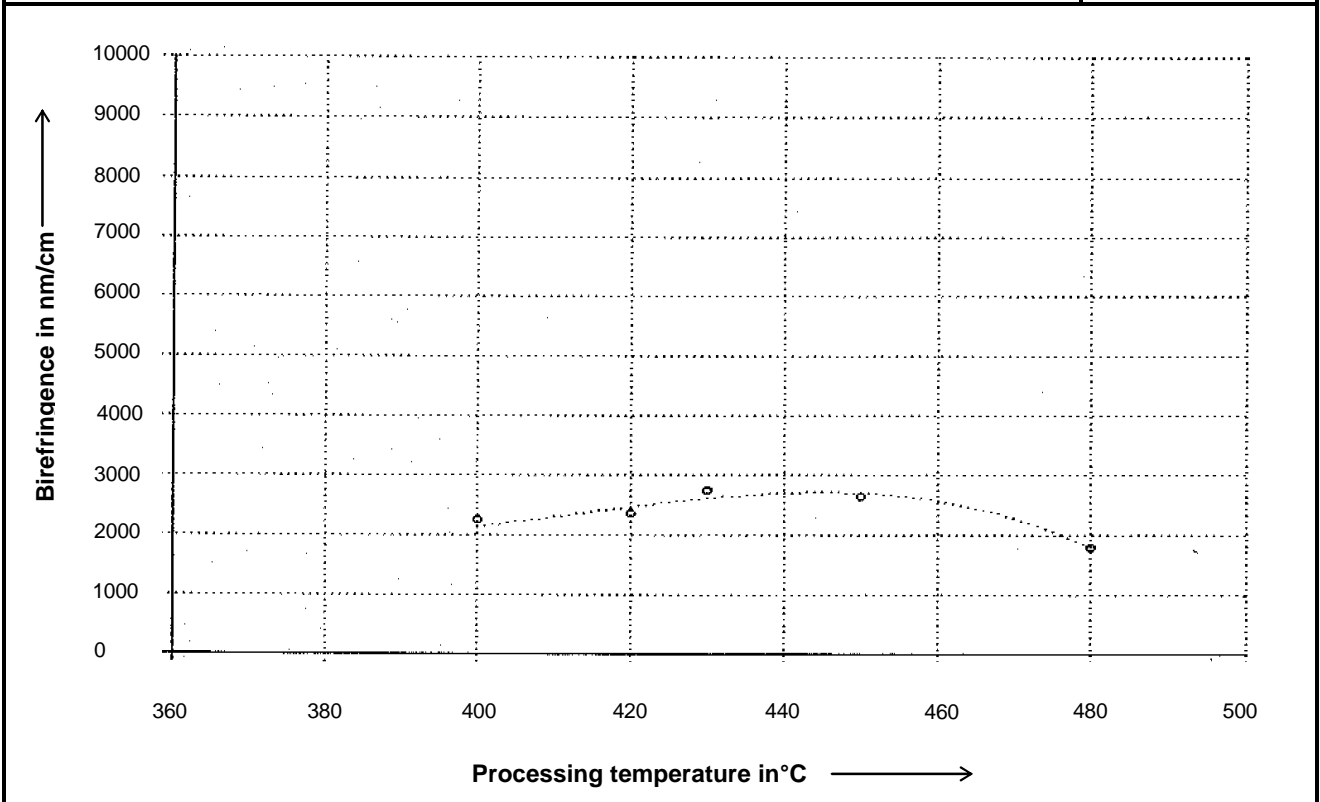
Chromaticity Coordinates

Type of Glass: HC - PHOTOSOLAR® DUNKELBRAUN
Thickness: 2 mm



Annex 3.3.1

Specification		PCP	
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Chemical toughening parameter			
Glass and chemical toughening parameters			
Transformation temperature	°C	539	
Glass thickness	mm	2	
Processing time	h	16	
Processing temperature	°C	440	
Salt bath (* weight percentages)	NaNO ₃ in % *	40.0	
	KNO ₃ in % *	59.5	
	SiO ₂ x H ₂ O in % *	0.5	
Chemical toughening results *			
Penetration depth	µm	51	
Birefringence	nm/cm	2600	
* measured across at a sample piece ground down to 0.3 mm ± 0.05 mm			
Ball drop test acc. FDA	% failed	passed	
Ball drop test acc. DIN	% failed	not carried out	



Form 0050/1e

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Anti - reflection processes $\Delta \tau_{15'} = f(\vartheta)$

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Thickness: 2 mm

