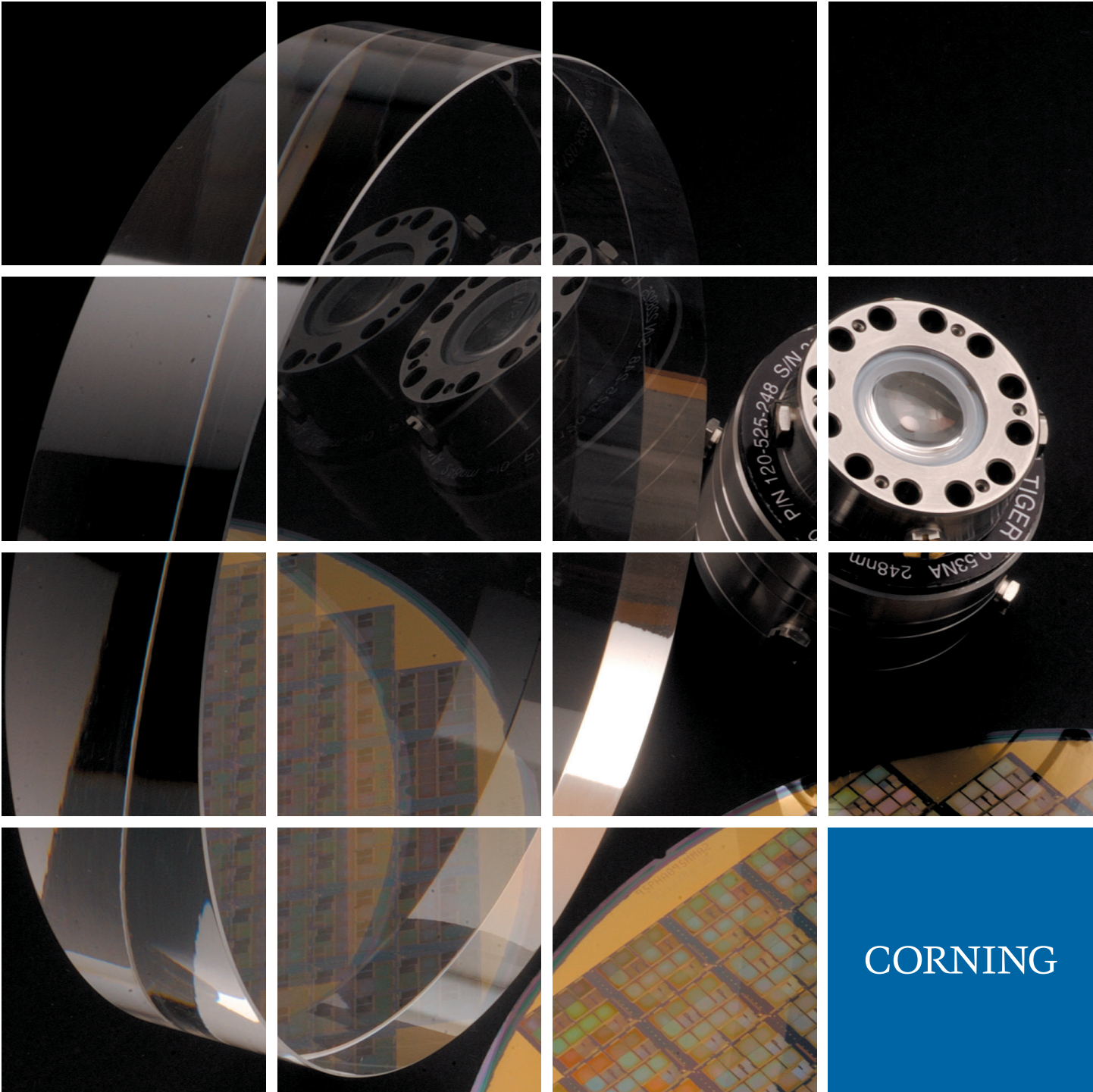


# Corning® HPFS® 7979, 7980, 8655 Fused Silica

Optical Materials Product Information



## HPFS® 7979, 7980 and 8655 Fused Silica

Dedication to technology leadership and world-class metrology capabilities play a major role in Corning's ability to produce leading edge materials. Corning is committed to ensuring that its customers are provided qualified, authentic products.

Corning has a minimum of 25 years of measurement experience and provides a certificate of compliance for each sale of product to verify the authenticity of our HPFS® Fused Silica Materials.

Fused Silica is offered in many different grades to support various product applications. Glass codes 7980, 7979, and 8655 are high purity non-crystalline silica glasses with excellent optical qualities.

Product characteristics include extraordinary low refractive index variations leading to state-of-the-art homogeneity values, lowest birefringence values, large size capabilities, exceptional transmittance from the deep ultraviolet through the infrared region, and an ultra-low thermal expansion coefficient; all of which are critical to our customers' demanding needs.

## HPFS® Summary of Key Attributes

Attribute	Fused Silica						
	7980 Standard Grade	7980 KRF Grade	7980 ArF Grade	7980 Mirror Grade	7980 Industrial Grade	7979 IR Grade	8655 ArF Grade
Visible Transmittance	■	■	■	■	■	■	■
UV Transmittance	■	■	■				■
Infrared Transmittance						■	■
Homogeneity Certified in Use-Axis AA, A, C, F (By Size)	■	■	■			■	■
Inclusion Class Certified 0, 1, 2, 5	■	■	■	■		■	■
Striae Certified ISO 10110-4 Class 5 (None)	■	■	■	■		■	■
Homogeneity Certified in Off-Axis AA, A, C, F (By Size)	■	■	■			■	■
Low Birefringence	■	■	■	■		■	■
UV Laser Resistant (Data available upon request)		■	■				■
Economical (No certification of any properties except visible transmission. Tooling applications.)						■	

## Quality Grade Selection Chart

For Mirror Grade - see chart on next page

Inclusion Class			Homogeneity <sup>3,4</sup> [ppm]							
			Grade							
Class	Total Inclusion Cross Section <sup>1</sup> [mm <sup>2</sup> ]	Maximum Size <sup>2</sup> [mm]	AA ≤ 0.5	A ≤ 1	B ≤ 1.5	C ≤ 2	D ≤ 3	E ≤ 4	F ≤ 5	G NS <sup>5</sup>
0	≤0.03	0.10	■	■	■	■	■	■	■	■
1	≤0.10	0.28		■	■	■	■	■	■	■
2	≤0.25	0.50			■	■	■	■	■	■
3	≤0.50	0.76				■	■	■	■	■
4	≤1.00	1.00				■	■	■	■	■
5	≤2.00	1.27				■	■	■	■	■

1. Defines the sum of the cross section in mm<sup>2</sup> of inclusions per 100 cm<sup>3</sup> of glass. Inclusions with a diameter ≤0.10 mm are disregarded.
2. Refers to the diameter of the largest single inclusion.
3. Index homogeneity: the maximum index variation (relative), measured over the clear aperture of the blank.
4. Index homogeneity is certified using an interferometer at 632.8 nm. The numerical homogeneity is reported as the average through the piece thickness. Blanks with a diameter up to 450 mm can be analyzed over the full aperture. Larger parts can be analyzed using multiple overlapping apertures. The minimum thickness for index homogeneity verification is 20 mm. For thinner parts, the parent piece is certified.
5. NS (Not Specified)

## HPFS® Data and Properties

	Inclusion Class	Homogeneity Grade	Birefringence Lower specifications available upon request [nm/cm]	Striae ISO 10110-4 Class	Metallic Impurities [ppb]	OH Content [ppm]
7979 IR Grade	0, 1, 2	AA, A, C, F	≤ 5	5	< 100	< 1
7980 Standard Grade**	0 - 5	AA - F	≤ 5	5	< 1000	800 - 1000
7980 KrF Grade*	0, 1, 2	AA, A, C, F	≤ 1	5	< 500	800 - 1000
7980 ArF Grade*	0, 1, 2	AA, A, C, F	≤ 1	5	< 100	800 - 1000
7980 Mirror Grade	See below	NS	≤ 5	1	NS	800 - 1000
7980 Industrial Grade	NS	NS	≤ 5	1	NS	800 - 1000
8655 ArF Grade*	0, 1, 2	AA, A, C, F	≤ 1	5	< 10	< 1

\* No visible fluorescence when exposed to deuterium source from 215 nm - 400 nm. Material contains hydrogen to minimize absorption under UV exposures.

\*\* HPFS® 7980 Standard Fluorescence-Free Grade available upon request.

## Mechanical Properties

Unless otherwise stated, all values @ 25 °C	
Elastic (Young's) Modulus	73 GPa
Shear Modulus	31 GPa
Modulus of Rupture, abraded	52.4 MPa
Bulk Modulus	35.9 GPa
Poisson's Ratio	0.16
Density	2.20 g/cm <sup>3</sup>
Knoop Hardness (100g load)	522 kg/mm <sup>2</sup>
Tensile Strength	54 MPa
Compressive Strength	1.14 GPa

## Thermal Properties

Glass Code:	7980	7979	8655	Viscosity
Softening Point*	1585 °C	1627 °C	1627 °C	10 <sup>7.6</sup> poises
Annealing Point*	1042 °C	1180 °C	1180 °C	10 <sup>13</sup> poises
Strain Point*	893 °C	1068 °C	1068 °C	10 <sup>14.5</sup> poises
Specific Heat				0.770 J/(g K)
Thermal Conductivity				1.38 W/(m K)
Thermal Diffusivity				0.0075 cm <sup>2</sup> /s
Thermal Expansion** (ppm/C):				
	5 °C to 35 °C			0.52 x 10 <sup>-6</sup>
	0 °C to 200 °C			0.57 x 10 <sup>-6</sup>
	-100 °C to +200 °C			0.48 x 10 <sup>-6</sup>
ASTM Procedures - *C-598, **E-228				

## Mirror Quality Grade Selection Chart

Mirror Grade: Inclusion Classes			
Critical Zone:	Blank Dimensions (Diameter or Diagonal)		
	< 508 mm (20")	508 - 1143 mm (20 - 45")	1143 - 2286 mm (45 - 90")
Max. Mean Diameter	0.254 mm (0.010")	0.762 mm (0.030")	1.524 mm (0.060")
Max. Avg. #/mm <sup>3</sup> (#/in <sup>3</sup> )	2 ppm (0.04)	3 ppm (0.05)	5 ppm (0.08)
Non-Critical Zone:	Blank Dimensions (Diameter or Diagonal)		
	< 508 mm (20")	508 - 1143 mm (20 - 45")	1143 - 2286 mm (45 - 90")
Max. Mean Diameter	1.016 mm (0.040")	1.524 mm (0.060")	3.81 mm (0.150")
Max. Avg. #/mm <sup>3</sup> (#/in <sup>3</sup> )	3 ppm (0.05)	3 ppm (0.05)	9 ppm (0.15)

# Refractive Index and Dispersion: HPFS® 7980

Conditions: 22 °C, 760 mm Hg, N <sub>2</sub>						
Wavelength [Vacuum] [nm]	Refractive Index <sup>2</sup> n	Thermal Coefficient $\Delta n/\Delta T^3$ [ppm/C]	Polynomial Dispersion Equation Constants <sup>1</sup> , 22 °C			
1128.950	1.448866	9.6	A <sub>0</sub>	2.104025406E+00		
1014.260 n <sub>t</sub>	1.450241	9.6	A <sub>1</sub>	-1.456000330E-04		
852.344 n <sub>s</sub>	1.452463	9.7	A <sub>2</sub>	-9.049135390E-03		
706.714 n <sub>r</sub>	1.455144	9.9	A <sub>3</sub>	8.801830992E-03		
656.454 n <sub>c</sub>	1.456364	9.9	A <sub>4</sub>	8.435237228E-05		
632.990	1.457016	10.0	A <sub>5</sub>	1.681656789E-06		
587.725 n <sub>d</sub>	1.458461	10.1	A <sub>6</sub>	-1.675425449E-08		
546.227 n <sub>e</sub>	1.460076	10.2	A <sub>7</sub>	8.326602461E-10		
486.269 n <sub>F</sub>	1.463123	10.4	Sellmeier Dispersion Equation Constants <sup>2</sup> , 22 °C			
435.957 n <sub>g</sub>	1.466691	10.6				
404.770 n <sub>h</sub>	1.469615	10.8	A <sub>1</sub>	0.68374049400		
365.119 n <sub>i</sub>	1.474539	11.2	A <sub>2</sub>	0.42032361300		
334.244	1.479764	11.6	A <sub>3</sub>	0.58502748000		
312.657	1.484493	12.0	$\Delta n/\Delta T$ Dispersion Equation Constants <sup>3</sup> , 20-25 °C			
253.728	1.505522	13.9			B <sub>1</sub>	0.00460352869
228.872	1.521154	15.5			B <sub>2</sub>	0.01339688560
214.506	1.533722	17.0	B <sub>3</sub>	64.49327320000		
206.266	1.542665	18.1	Other Optical Properties			
194.227	1.558918	20.3			C <sub>0</sub>	9.390590
184.950	1.575017	22.7			C <sub>1</sub>	0.235290
					C <sub>2</sub>	-1.318560E-03
			C <sub>3</sub>	3.028870E-04		
			nF'-nC'		0.006797	
			Stress Coefficient		35.0 nm/cm MPa	
			Abbe Constants:			
			V <sub>e</sub>	67.6		
			V <sub>d</sub>	67.8		

\*1 Polynomial Equation:  $n^2 = A_0 + A_1 \lambda^4 + A_2 \lambda^2 + A_3 \lambda^{-2} + A_4 \lambda^{-4} + A_5 \lambda^{-6} + A_6 \lambda^{-8} + A_7 \lambda^{-10}$  with  $\lambda$  in  $\mu m$

\*2 Sellmeier Equation:  $n^2 - 1 = A_1 \lambda^2 / (\lambda^2 - B_1) + A_2 \lambda^2 / (\lambda^2 - B_2) + A_3 \lambda^2 / (\lambda^2 - B_3)$  with  $\lambda$  in  $\mu m$

\*3  $\Delta n/\Delta T$  Equation:  $\Delta n/\Delta T$  [ppm/C] =  $C_0 + C_1 \lambda^{-2} + C_2 \lambda^{-4} + C_3 \lambda^{-6}$  with  $\lambda$  in  $\mu m$

The above dispersion equations were fit to the refractive indices of 20 wavelengths from 1129 nm to 185 nm.

# Refractive Index and Dispersion: HPFS® 8655 and 7979

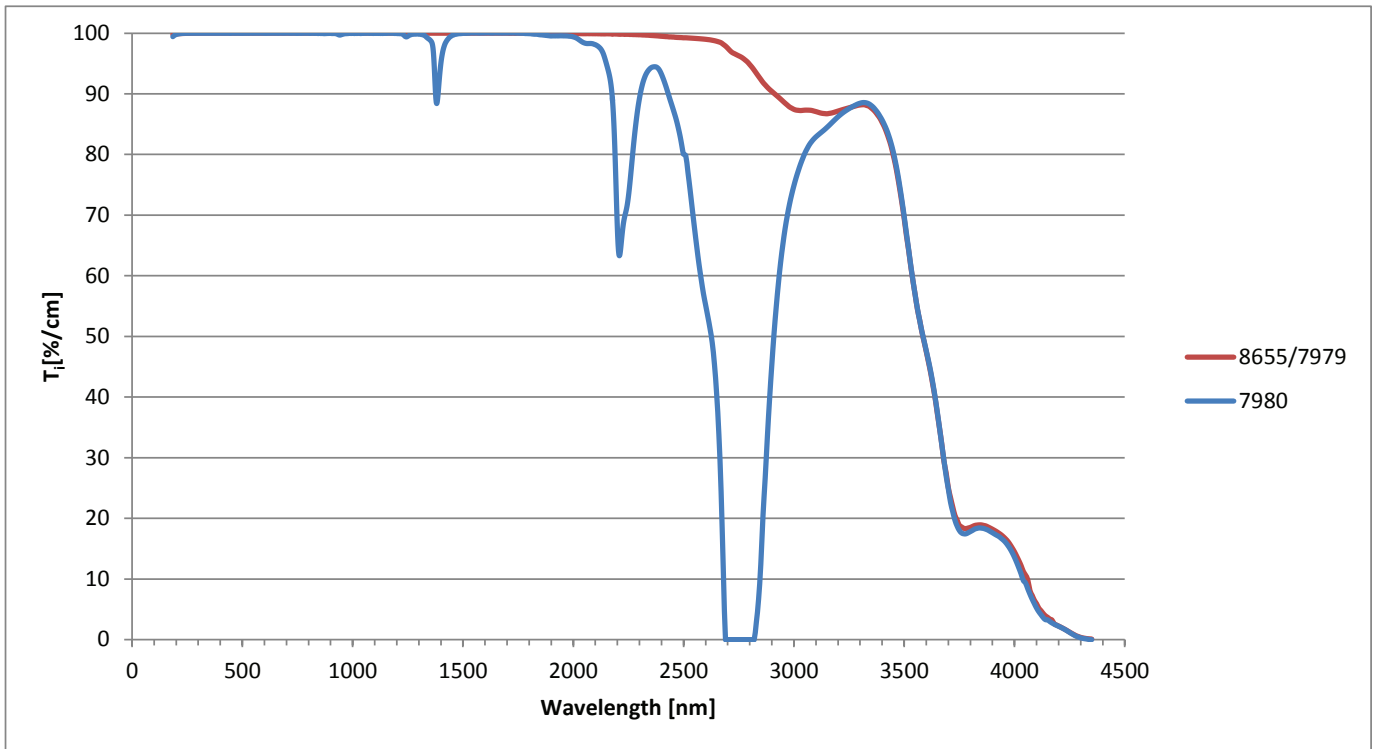
Conditions: 22 °C, 760 mm Hg, N <sub>2</sub>					
Wavelength [Vacuum] [nm]	Refractive Index <sup>1</sup> n	Thermal Coefficient <sup>2</sup> Δn/ΔT [ppm/°C]	Sellmeier Dispersion Equation Constants <sup>1</sup> , 20 °C		
2326.050	1.433027	8.7	A <sub>1</sub>	7.033574317E-02	
2058.650	1.437307	9.3	A <sub>2</sub>	7.241205497E-01	
1970.630	1.438601	9.6	A <sub>3</sub>	3.097807778E-01	
1813.570	1.440776	9.1	A <sub>4</sub>	9.309957497E-01	
1530.000	1.444337	9.7	B <sub>1</sub>	-2.301552288E-03	
1128.950	1.448930	9.7	B <sub>2</sub>	6.272886117E-03	
1014.26 n <sub>t</sub>	1.450304	9.6	B <sub>3</sub>	1.415449740E-02	
852.344 n <sub>s</sub>	1.452526	9.5	B <sub>4</sub>	1.016434845E+02	
780.237	1.453731	9.5	Sellmeier Dispersion Equation Constants <sup>1</sup> , 22 °C		
706.714 n <sub>r</sub>	1.455205	9.9			
656.454 n <sub>c</sub>	1.456425	10.1	A <sub>1</sub>	3.550277875E-02	
644.025 n <sub>c</sub>	1.456763	10.1	A <sub>2</sub>	7.353314507E-01	
632.990	1.457077	9.9	A <sub>3</sub>	3.334560303E-01	
587.725 n <sub>d</sub>	1.458522	10.2	A <sub>4</sub>	9.269506614E-01	
546.227 n <sub>e</sub>	1.460135	10.5	B <sub>1</sub>	-4.826183477E-03	
486.269 n <sub>f</sub>	1.463183	10.4	B <sub>2</sub>	5.808687673E-03	
480.126 n <sub>f</sub>	1.463561	10.4	B <sub>3</sub>	1.399572492E-02	
435.957 n <sub>g</sub>	1.466751	10.7	B <sub>4</sub>	1.012182926E+02	
404.770 n <sub>h</sub>	1.469674	10.9	Sellmeier Dispersion Equation Constants <sup>1</sup> , 25 °C		
388.975	1.471446	10.9			
365.119 n <sub>i</sub>	1.474599	11.3	A <sub>1</sub>	2.623483282E-02	
340.463	1.478646	11.6	A <sub>2</sub>	7.306029048E-01	
334.244	1.479824	11.7	A <sub>3</sub>	3.475321572E-01	
312.657	1.484554	12.0	A <sub>4</sub>	9.216052441E-01	
296.814	1.488798	12.5	B <sub>1</sub>	-5.783959035E-03	
289.444	1.491056	12.5	B <sub>2</sub>	5.600103210E-03	
253.728	1.505585	14.0	B <sub>3</sub>	1.389808930E-02	
228.872	1.521218	15.3	B <sub>4</sub>	1.006578079E+02	
226.572	1.523018	15.9	Δn/ΔT Dispersion Equation Constants <sup>2</sup> , 20-25 °C		
214.506	1.533786	16.8			
213.923	1.534371	17.0	D <sub>0</sub>	9.545124E+00	
206.266	1.542731	18.2	D <sub>1</sub>	-9.835579E-02	
202.613	1.547213	18.3	D <sub>2</sub>	2.003170E-01	
194.227	1.558985	20.4	D <sub>3</sub>	2.209816E-03	
184.950	1.575091	22.1	D <sub>4</sub>	1.980644E-04	
			Other Optical Properties		
			nF'-nC'		0.006797
			Stress Coefficient		35.0 nm/cm MPa
			Abbe Constants:		
			V <sub>e</sub>	67.6	
V <sub>d</sub>	67.8				

\*1 Sellmeier Equation:  $n^2-1 = A_1 \lambda^2/(\lambda^2 - B_1) + A_2 \lambda^2/(\lambda^2 - B_2) + A_3 \lambda^2/(\lambda^2 - B_3) + A_4 \lambda^2/(\lambda^2 - B_4)$  with  $\lambda$  in  $\mu\text{m}$

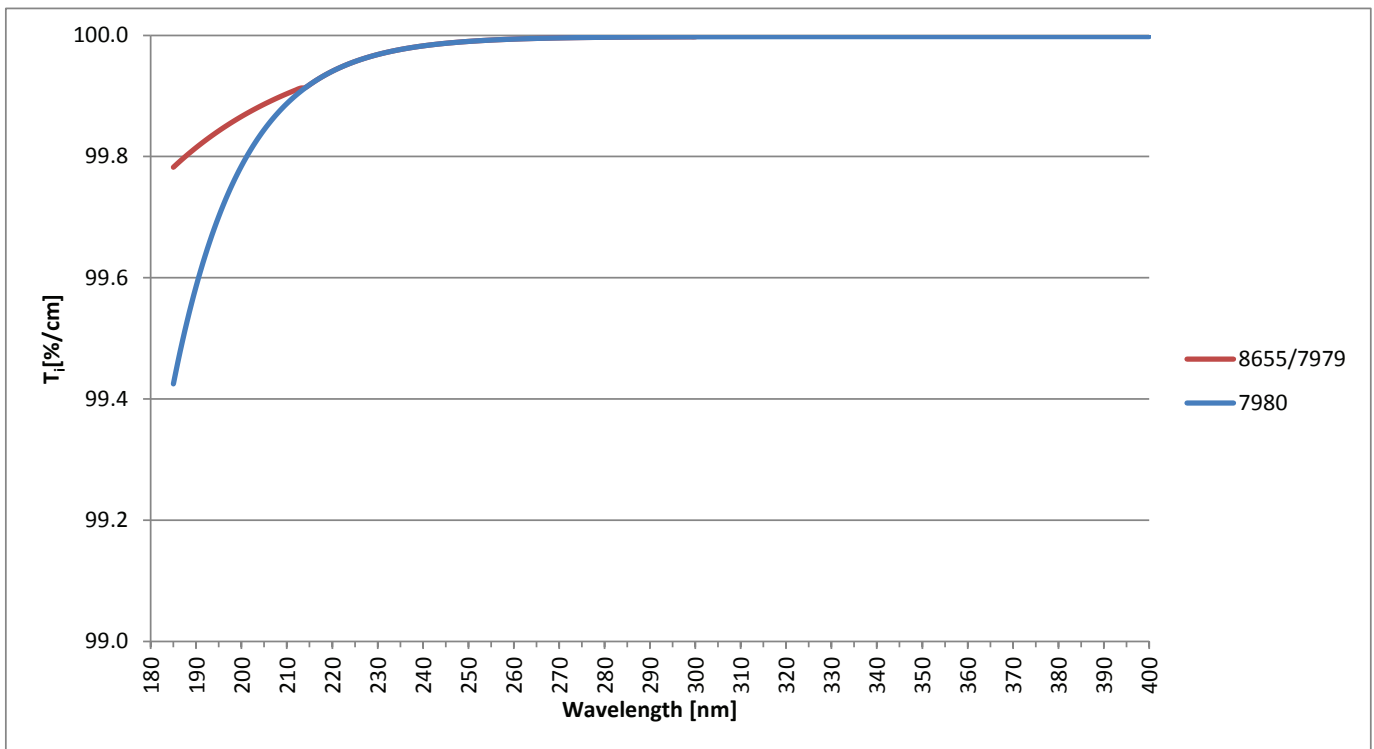
\*2 Δn/ΔT Equation:  $\Delta n/\Delta T$  [ppm/°C] =  $D_0 + D_1 \lambda^2 + D_2 \lambda^{-2} + D_3 \lambda^{-4} + D_4 \lambda^{-6}$  with  $\lambda$  in  $\mu\text{m}$

The above Sellmeier dispersion equation was used to fit the refractive indices of 35 wavelengths from 2326 nm to 185 nm.

## Broad Spectrum Internal Transmittance



## UV Internal Transmittance



HPFS<sup>®</sup> 7980 Standard Grade meets high  $T_i \geq 88.00$  %/cm @185 nm. (Equivalent to  $T_e \geq 80.00$  %/cm @185 nm)

HPFS<sup>®</sup> 7980 KrF Grade meets high  $T_i \geq 99.90$  %/cm @248 nm.

HPFS<sup>®</sup> 7980 ArF Grade meets high  $T_i \geq 99.50$  %/cm @193 nm.

HPFS<sup>®</sup> 8655 Grade meets high  $T_i \geq 99.75$  %/mm @193 nm.

HPFS<sup>®</sup> 8655 Grade Typical initial absorption  $k: \leq 0.0001$ /cm at 193 nm.

Higher transmittance is available upon request.

## Worldwide Accessibility

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To place an order, obtain additional technical information or specific requirements, please contact us at [hpfs@corning.com](mailto:hpfs@corning.com)

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Corning/Specialty Materials/Product Information Sheet 7979, 7980 and 8655 July, 2015