

# HPFS® Fused Silica Standard Grade



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Discovering Beyond Imagination



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HPFS® Standard Grade, Corning code 7980, is a high purity synthetic amorphous silicon dioxide manufactured by flame hydrolysis. The noncrystalline, colorless, silica glass combines a very low thermal expansion coefficient with excellent optical qualities and exceptional transmittance in the ultraviolet. It is available in a number of grades for different applications.

In order to satisfy the challenging quality requirements of our customers in leading edge applications such as microlithography, Corning is dedicated to continuous improvement. Our investments in research and development, combined with Corning's quality systems, support our technology leadership position and ensure that we meet our customer's requirements on time, every time.

## Quality Grade Selection Chart — HPFS® Standard Grade

Corning defines and certifies the quality of HPFS® glass using two criteria: inclusions and homogeneity grade.

Inclusion Class			Homogeneity <sup>3,4</sup> ppm							
Class	Total Inclusion <sup>1</sup> Cross Section [mm <sup>2</sup> ]	Maximum <sup>2</sup> Size [mm]	Grade							
			AA ≤ 0.5	A ≤ 1	B ≤ 1.5	C ≤ 2	D ≤ 3	E ≤ 4	F ≤ 5	G <sup>5</sup> NS
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					■	■	■	■

### NOTES:

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)

**Mechanical and Thermal Properties:**

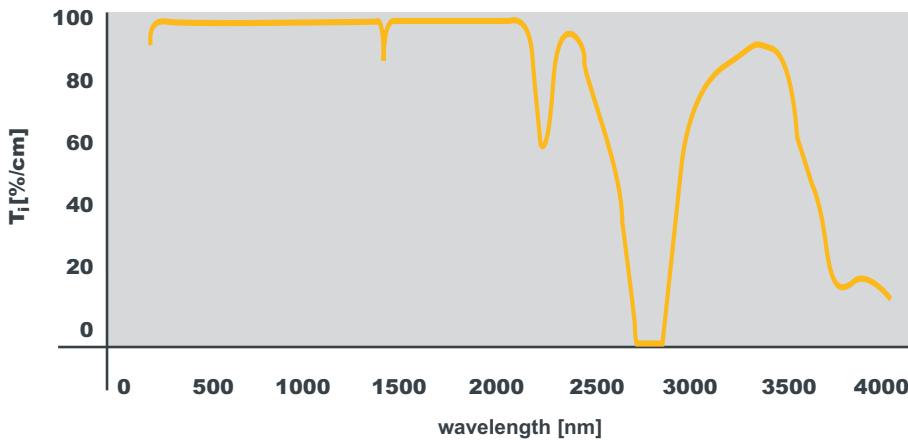
Unless otherwise stated, all values @ 25°C

Elastic (Young's) Modulus	72.7 GPa	Softening Point	1585 °C (10 <sup>7.6</sup> poises)
Shear Modulus	31.4 GPa	Annealing Point	1042 °C (10 <sup>13</sup> poises)
Modulus of Rupture, abraded	52.4 MPa	Strain Point	893 °C (10 <sup>14.5</sup> poises)
Bulk Modulus	35.4 GPa	Thermal Conductivity	1.30 W/m K
Poisson's Ratio	0.16	Thermal Diffusivity	0.0075 cm <sup>2</sup> /s
Density	2.201 g/cm <sup>3</sup>	Average C.T.E.	0.52 ppm/K      5 °C-35 °C
Knoop Hardness (100 g load)	522 kg/mm <sup>2</sup>		0.57 ppm/K      0 °C-200 °C
			0.48 ppm/K      -100 °C-200 °C

**Chemical Durability and Impurities**

Solution		Time	Weight Loss [mg/cm <sup>2</sup> ]	Impurities
5% HCL by weight	@95 °C	24 h	<0.010	OH content (by weight): 800-1000 ppm Impurities other than OH: ≤ 1000 ppb
5% NaOH	@95 °C	6 h	0.453	
0.02N NA <sub>2</sub> CO <sub>3</sub>	@95 °C	6 h	0.065	
0.02N H <sub>2</sub> SO <sub>4</sub>	@95 °C	24 h	<0.010	
Deionized H <sub>2</sub> O	@95 °C	24 h	0.015	
10% HF by weight	@25 °C	20 m	0.230	
10% NH <sub>4</sub> F*HF by weight	@25 °C	20 m	0.220	

**Internal Transmittance**



HPFS® Standard Grade is certified to meet T external ≥ 80%/cm@185nm (T internal ≥ 88%/cm@185nm), when measured through a polished, uncoated sample. A typical internal transmittance curve for HPFS® Standard Grade fused silica is shown here.

### Refractive Index and Dispersion

Data in 22°C in 760mm Hg dry nitrogen gas

Wavelength [air] $\lambda$ [nm]	Refractive Index <sup>*2</sup> n	Thermal Coefficient $\Delta n/\Delta T$ <sup>*3</sup> (ppm/K)	Polynomial Dispersion Equation Constants <sup>*1</sup>	
			A <sub>0</sub>	
1128.64	1.448870	9.6	A <sub>0</sub>	2.104025406
1064.00	1.449633	9.6	A <sub>1</sub>	-1.456000330 x 10 <sup>-4</sup>
1060.00	1.449681	9.6	A <sub>2</sub>	-9.049135390 x 10 <sup>-3</sup>
1013.98 n <sub>t</sub>	1.450245	9.6	A <sub>3</sub>	8.801830992 x 10 <sup>-3</sup>
852.11 n <sub>s</sub>	1.452469	9.7	A <sub>4</sub>	8.435237228 x 10 <sup>-5</sup>
706.52 n <sub>t</sub>	1.455149	9.9	A <sub>5</sub>	1.681656789 x 10 <sup>-6</sup>
656.27 n <sub>c</sub>	1.456370	9.9	A <sub>6</sub>	-1.675425449 x 10 <sup>-8</sup>
643.85 n <sub>c'</sub>	1.456707	10.0	A <sub>7</sub>	8.326602461 x 10 <sup>-10</sup>
632.80 n <sub>He-Ne</sub>	1.457021	10.0	Sellmeier Dispersion Equation Constants <sup>*2</sup>	
589.29 n <sub>D</sub>	1.458406	10.1	B <sub>1</sub>	0.68374049400
587.56 n <sub>d</sub>	1.458467	10.1	B <sub>2</sub>	0.42032361300
546.07 n <sub>e</sub>	1.460082	10.2	B <sub>3</sub>	0.58502748000
486.13 n <sub>F</sub>	1.463132	10.4	C <sub>1</sub>	0.00460352869
479.99 n <sub>F'</sub>	1.463509	10.4	C <sub>2</sub>	0.01339688560
435.83 n <sub>g</sub>	1.466701	10.6	C <sub>3</sub>	64.49327320000
404.66 n <sub>h</sub>	1.469628	10.8	$\Delta n/\Delta T$ Dispersion Equation Constants <sup>*3</sup>	
365.01 n <sub>i</sub>	1.474555	11.2		
334.15	1.479785	11.6		
312.57	1.484514	12.0		
308.00	1.485663	12.1	C <sub>0</sub>	9.390590
248.30	1.508433	14.2	C <sub>1</sub>	0.235290
248.00	1.508601	14.2	C <sub>2</sub>	-1.318560 x 10 <sup>-3</sup>
214.44	1.533789	17.0	C <sub>3</sub>	3.028870 x 10 <sup>-4</sup>
206.20	1.542741	18.1	Other Optical Properties	
194.17	1.559012	20.4		
193.40	1.560208	20.5		
193.00	1.560841	20.6		
184.89	1.575131	22.7		
			v <sub>d</sub>	67.79
			v <sub>e</sub>	67.64
			n <sub>F</sub> -n <sub>C</sub>	0.006763
			n <sub>F'</sub> -n <sub>C'</sub>	0.006802
			Stress Coefficient	35.0 nm/cm MPa
			Striae	ISO 10110-4 Class 5/Thickness Direction
			Birefringence	≤ 1nm/cm, lower specifications available

\*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  $\mu\text{m}$

\*2 Sellmeier Equation:  $n^2 - 1 = B_1 \lambda^2/(\lambda^2 - C_1) + B_2 \lambda^2/(\lambda^2 - C_2) + B_3 \lambda^2/(\lambda^2 - C_3)$  with  $\lambda$  in  $\mu\text{m}$

\*3  $\Delta n/\Delta T$  Equation (20–25°C) =  $C_0 + C_1 \lambda^{-2} + C_2 \lambda^{-4} + C_3 \lambda^{-6}$  with  $\lambda$  in  $\mu\text{m}$