# HPFS® Fused Silica Standard Grade

## Semiconductor Optics

*HPFS® Standard Grade, Corning code 7980, is a high purity synthetic amorphous silicon dioxide manufactured by flame deposition. 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[3,4] ppm | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Grade | | | | | | | |
| Class | Total Inclusion[1] Cross Section [mm$^2$] | Maximum[2] Size [mm] | AA ≤ 0.5 | A ≤ 1 | B ≤ 1.5 | C ≤ 2 | D ≤ 3 | E ≤ 4 | F ≤ 5 | G[5] 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$^2$ of inclusions per 100 cm$^3$ 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)

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## Mechanical and Thermal Properties:

Unless otherwise stated, all values @ 25°C

| | |
|---|---|
| Elastic (Young's) Modulus | 72.7 GPa |
| Shear Modulus | 31.4 GPa |
| Modulus of Rupture, abraded | 52.4 MPa |
| Bulk Modulus | 35.4 GPa |
| Poisson's Ratio | 0.16 |
| Density | 2.201 g/cm$^3$ |
| Knoop Hardness (100 g load) | 522 kg/mm$^2$ |

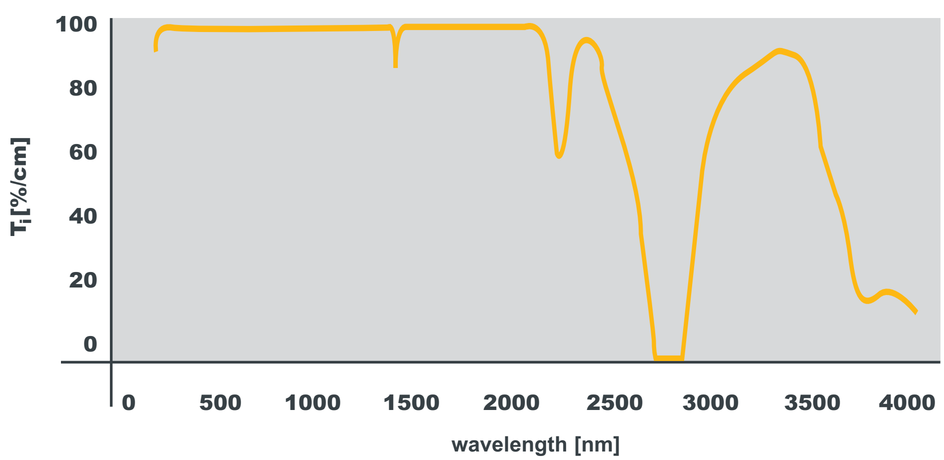
| | | |
|---|---|---|
| Softening Point | | 1585°C ($10^{7.6}$ poises) |
| Annealing Point | | 1042°C ($10^{13}$ poises) |
| Strain Point | | 893°C ($10^{14.5}$ poises) |
| Thermal Conductivity | | 1.30 W/m K |
| Thermal Diffusivity | | 0.0075 cm$^2$/s |
| Average C.T.E. | 0.52 ppm/K<br>0.57 ppm/K<br>0.48 ppm/K | 5°C-35°C<br>0°C-200°C<br>-100°C-200°C |

## Chemical Durability and Impurities

| Solution | | Time | Weight Loss [mg/cm²] |
|---|---|---|---|
| 5% HCL by weight | @ 95°C | 24 h | < 0.010 |
| 5% NaOH | @ 95°C | 6 h | 0.453 |
| 0.02N $NA_2CO_3$ | @ 95°C | 6 h | 0.065 |
| 0.02N $H_2SO_4$ | @ 95°C | 24 h | < 0.010 |
| Deionized $H_2O$ | @ 95°C | 24 h | 0.015 |
| 10% HF by weight | @ 25°C | 20 m | 0.230 |
| 10% $NH_4F$*HF by weight | @ 25°C | 20 m | 0.220 |

| Impurities |
|---|
| OH content (by weight): 800-1000 ppm |
| Impurities other than OH: ≤ 1000 ppb |

## 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 *2 n | Thermal Coefficient $\Delta n/\Delta T$*3 (ppm/K) |
|---|---|---|
| 1128.64 | 1.448870 | 9.6 |
| 1064.00 | 1.449633 | 9.6 |
| 1060.00 | 1.449681 | 9.6 |
| 1013.98 $n_t$ | 1.450245 | 9.6 |
| 852.11 $n_s$ | 1.452469 | 9.7 |
| 706.52 $n_r$ | 1.455149 | 9.9 |
| 656.27 $n_C$ | 1.456370 | 9.9 |
| 643.85 $n_{C'}$ | 1.456707 | 10.0 |
| 632.80 $n_{He\text{-}Ne}$ | 1.457021 | 10.0 |
| 589.29 $n_D$ | 1.458406 | 10.1 |
| 587.56 $n_d$ | 1.458467 | 10.1 |
| 546.07 $n_e$ | 1.460082 | 10.2 |
| 486.13 nF | 1.463132 | 10.4 |
| 479.99 $n_{F'}$ | 1.463509 | 10.4 |
| 435.83 $n_g$ | 1.466701 | 10.6 |
| 404.66 $n_h$ | 1.469628 | 10.8 |
| 365.01 $n_i$ | 1.474555 | 11.2 |
| 334.15 | 1.479785 | 11.6 |
| 312.57 | 1.484514 | 12.0 |
| 308.00 | 1.485663 | 12.1 |
| 248.30 | 1.508433 | 14.2 |
| 248.00 | 1.508601 | 14.2 |
| 214.44 | 1.533789 | 17.0 |
| 206.20 | 1.542741 | 18.1 |
| 194.17 | 1.559012 | 20.4 |
| 193.40 | 1.560208 | 20.5 |
| 193.00 | 1.560841 | 20.6 |
| 184.89 | 1.575131 | 22.7 |

### Polynomial Dispersion Equation Constants*1

| | |
|---|---|
| $A_0$ | 2.104025406 |
| $A_1$ | $-1.456000330 \times 10^{-4}$ |
| $A_2$ | $-9.049135390 \times 10^{-3}$ |
| $A_3$ | $8.801830992 \times 10^{-3}$ |
| $A_4$ | $8.435237228 \times 10^{-5}$ |
| $A_5$ | $1.681656789 \times 10^{-6}$ |
| $A_6$ | $-1.675425449 \times 10^{-8}$ |
| $A_7$ | $8.326602461 \times 10^{-10}$ |

### Sellmeier Dispersion Equation Constants *2

| | |
|---|---|
| $B_1$ | 0.68374049400 |
| $B_2$ | 0.42032361300 |
| $B_3$ | 0.58502748000 |
| $C_1$ | 0.00460352869 |
| $C_2$ | 0.01339688560 |
| $C_3$ | 64.49327320000 |

### $\Delta n/\Delta T$ Dispersion Equation Constants *3

| | |
|---|---|
| $C_0$ | 9.390590 |
| $C_1$ | 0.235290 |
| $C_2$ | $-1.318560 \times 10^{-3}$ |
| $C_3$ | $3.028870 \times 10^{-4}$ |

### Other Optical Properties

| | |
|---|---|
| $\nu_d$ | 67.79 |
| $\nu_e$ | 67.64 |
| $n_F - n_C$ | 0.006763 |
| $n_{F'} - n_{C'}$ | 0.006802 |
| Stress Coefficient | 35.0 nm/cm MPa |
| Striae | ISO 10110-4 Class 5/Thickness Direction |
| Birefringence | ≤ 1 nm/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 µm
*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 µm
*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 µm

*We are here to help you specify the best product for your application.*
*For further information, please contact:*

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