Heraeus

HOQ® 310

1. GENERAL PRODUCT DESCRIPTION

Heraeus HOQ (Heraeus Optical Quality) fused quartz material is economically priced and has been developed especially for applications in the technical optics field, such as inspection and illumination windows, cover plates, etc. HOQ material is manufactured by fusion of natural quartz crystals. Compared with "typical" optical glasses it provides a unique combination of attractive properties:

- Excellent optical transmission from the UV into the IR spectral region
- Outstanding high temperature resistance
- Extremely low coefficient of thermal expansion
- Superior temperature shock resistance
- Excellent chemical resistance
- Outstanding chemical purity

These properties - combined with low bubble content and an attractive price - make HOQ fused quartz a preferred material for lower precision optical components in a hostile environment, e.g., high temperature and/or thermal shock loads, pressure loads, chemically aggressive environment, etc.

HOQ 310 exhibits a significantly reduced bubble content. With the naked eye and daylight illumination, bubbles are scarcely observable (Bubble class 3 as per DIN 58927).

HOQ 310 is delivered in an annealed state without internal stress. This is particularly important for applications as a pressure vacuum window, or if high mechanical loads are to be expected.

2. TECHNICAL DATA

During manufacture, HOQ, like all other Heraeus quartz glass grades, undergo a multi-step process control and quality inspection. As a result, the material properties can be kept consistent within relatively narrow limits.

2.1 Optical Properties

2.1.1 Spectral Transmission

The transmission (including Fresnel reflection losses at two uncoated surfaces) for a 10 mm path length is shown in the figure.

2.1.2 Refractive Index

n_C (□ = 656.3 nm)	1.45646
n_d (□ = 587.6 nm)	1.45856
n_F (□ = 486.1 nm)	1.46324
n_g (□ = 435.8 nm)	1.46681

2.1.3 Dispersion

Abbe-Constant $v_d = \frac{n_d - 1}{n_F - n_C}$	= 67.6 ± 0.5
Principal Dispersion $n_F - n_C$	0.00678

2.1.4 OH Content

OH Content (with $□_{OH} = \frac{77.5 \text{ liter}}{\text{Mol} \cdot \text{cm}}$ at 2.72 µm)	≤ 30 ppm

Accordingly, there are weak infrared absorption bands around 1.39 µm, 2.2 µm, and 2.72 µm.

2.1.5 Birefringence

The birefringence remaining in an optical element is caused by mechanical internal stresses. It depends up to a great extent on the shape and size of the element.

Residual Strain

HOQ 310	≤ 10 nm/cm 10-20 nm/cm	across 80% of dia. at the rim area
Photoelastic Stress Constant		3.61 ± 0.05 nm/(cm • bar)

HOQ is delivered annealed and free of stresses. When pieces of stress-free fused quartz are being worked in the raw state, "cutting stresses" often occur along edges and at corners; these disappear again during subsequent fine working or by light etching with hydrofluoric acid.

2.2 Thermal Properties

2.2.1 Viscosity

The viscosity of fused quartz decreases very steadily with increasing temperature. The characteristic temperatures are solely defined by viscosity □.

Annealing point (lg □ = 13.0) *)	ca. 1220° C
Strain point (lg □ = 14.5) *)	ca. 1125° C
Maximum temperature (continuous)	ca. 1150° C
Maximum temperature (limited life)	ca. 1300° C
*) Viscosity in dPa • s	

2.2.2 Coefficient of Thermal Expansion

Mean linear CTE □ in various intervals

ΔT (°C)	□ (K^{-1})
0...100	$0.51 \cdot 10^{-6}$
0...200	$0.58 \cdot 10^{-6}$
0...300	$0.59 \cdot 10^{-6}$
0...600	$0.54 \cdot 10^{-6}$
0...900	$0.48 \cdot 10^{-6}$
-50...0	$0.27 \cdot 10^{-6}$

The extremely low coefficient of thermal expansion (CTE) results in an excellent thermal shock resistance, much superior to that of ordinary glasses or ceramics.

2.2.3 Heat Conductivity

T (°C)	(W/(K • m)
20	1.38
100	1.46
200	1.55
300	1.67
400	1.84
950	2.68

2.2.4 Mean Specific Heat C_p

T (° C)	C_p (J/(kg • K))
0...100	772
0...500	964
0...900	1052

2.3 Mechanical Properties

The following data are valid for room temperature

Density	g/cm^3	2.20
Young's modulus (at 20° C)	N/mm^2	$7.25 \cdot 10^4$
(at 1000° C)	N/mm^2	$7.95 \cdot 10^4$
Poisson's ratio	--	0.17
Compressive strength	N/mm^2	1150
Tensile Strength	N/mm^2	approx. 50
Knoop hardness (1 N load)	N/mm^2	5800...6200

The “real world” tensile strength is almost entirely determined by the surface quality of a piece. The tensile strength value listed above is a typical average value for a round disk with mechanically polished main faces and fine ground circumference. For strength calculations a sufficiently high safety factor must be included.

2.4 Chemical Properties

2.4.1 Chemical Resistance

Fused quartz is outstandingly resistant to water, salt solutions, acids, and alkaline solutions.

- **Hydrolytic resistance as per DIN 12 111**
  1. Hydrolysis class:
  Base discharge

  $< 0.01 \frac{\text{mg } Na_2O}{\text{2 g Grains}}$

- **Resistance to acids as per DIN 12 116**
  1. Acid class:
  Weight loss < 0.1 mg/dm^2 surface area

- **Resistance to alkaline solutions as per DIN 52 322**
  1. Alkaline solution class:
  Weight loss approx. 50 mg/dm^2 surface area

2.4.2 Impurities

Typical trace impurities in fused quartz HOQ® 310 (in weight ppm)

Al	10...22	K	0.1...0.5
As	≤ 0.002	Li	0.5...1
Au	≤ 0.0001	Mg	0.1...0.2
Ca	0.2...1	Na	0.1...2
Cr	≤ 0.06	Sb	≤ 0.0002
Cu	≤ 0.02	OH	≤ 30
Fe	0.1...0.3		

3. SHAPES AND DIMENSIONS

3.1 Formed Ingots

Grade	Circular Cross-Section	Rectangular Cross-Section
HOQ 310	25 to 250 mm diameter	not available

3.2 Cut and Ground Disks

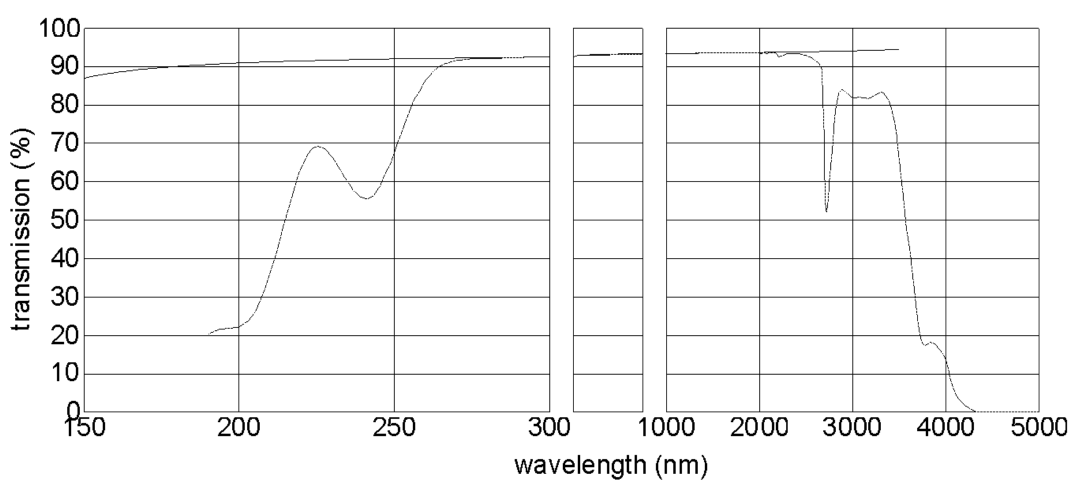
Upon request

3.3 Disks with Commercial Polish

Upon request

Heraeus
QUARZGLAS
03/98

HOQ 310
(path length: 10 mm)



Typical spectral transmission including Fresnel reflection loss. The uppermost nearly straight line indicates the calculated Fresnel reflection loss of two uncoated surfaces.