Heraeus

Standard Optics Information

POL-O/424M-E
06/94

HOQ 310

1. GENERAL PRODUCT DESCRIPTION

Heraeus HOQ 310 is manufactured by fusion of natural quartz crystals in an electrically heated furnace. HOQ 310 is economically priced and has been developed especially for applications in the technical optics field. 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

Combined with a low bubble content and an attractive price HOQ 310 is the preferred material for lower precision optical applications in a hostile environment, e.g. high temperature and/or thermal shock loads, pressure loads, chemically aggressive atmosphere, etc., such as inspection and/or illumination windows, cover plates, windows for pressurized cabins, etc.

For general technical data please refer to our data sheet POL-O/107E "Quartz Glass for Optics - Data and Properties".

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2. TECHNICAL DATA OF HOQ 310

2.1 Optical Properties

2.1.1 Bubbles and Inclusions

(Bubbles and Inclusions ≤ 0.08 mm diameter are disregarded)

2.1.1.1 Bubble class : 2...3 (as per DIN 58927 2/70)

i.e. total bubble cross section within the volume is ≤ 0.5 mm

2.1.1.2 Bubbles according to DIN ISO 10100

HOQ310	:	1 / 2*0,63	for pieces < 6
		1 / 2*1,0	for pieces 6 - 30

2.1.1.3 Inclusions : None

2.1.2 Spectral Transmission

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

2.1.3 Refractive Index

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

2.1.4 Dispersion

Abbe-Constant $$\nu_d = \frac{n_d - 1}{n_F - n_C} = 67.6 \pm 0.5$$

Principal Dispersion $n_F - n_C$ = 0.00678

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2.1.5 OH-Content

OH-Content $\left(with \ \varepsilon_{OH} = \frac{77.5 \ liter}{Mol \cdot cm} \ at \ 2.72 \ \mu m \right)$	≤ 30 ppm

Accordingly, there are weak infra-red absorption bands around 1.39 µm, 2.2 µm, and 2.72 µm.

2.1.6 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
Birefringence constant		3.61 · 0.05 nm / (cm · bar)

HOQ 310 is delivered annealed. When pieces of 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.

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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 η

Annealing point (lg η = 13.0) *)	ca. 1220°C
Strain point (lg η = 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 α in various intervals

ΔT (°C)	α (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.

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2.2.3 Heat conductivity λ

T (°C)	λ (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	$7.25 \cdot 10^4$
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.

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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

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

- **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	20	Li	1
Ca	1	Mg	0.1
Cr	0.1	Na	1
Cu	0.1	Ti	1
Fe	0.8	OH	30
K	0.8		