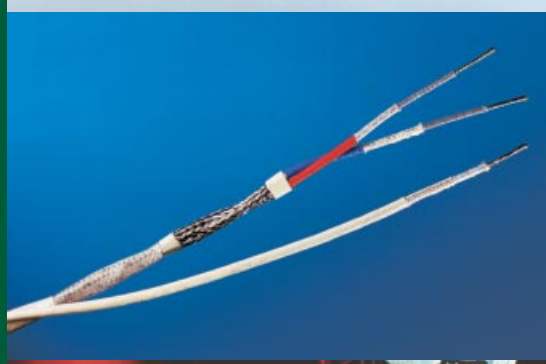

Quartzel®

Fused Quartz textiles

SAINT-GOBAIN
QUARTZ

Le Louvre – Paris

SAINT-GOBAIN

Saint-Gobain employs over 170 000 people and operates in 46 countries worldwide with more than 1 000 consolidated companies. It is the world's 59th leading industrial corporation with a turnover of approximately € 30 billion.

Cover pictures: – Quartzel® Yarn, Roving, Chopped Strands, Wool, Felts, Rigid Silica Block and Sewing Thread (© Saint-Gobain Quartz)
– A340-600 Civil Aircraft *(courtesy of Airbus)* **– Global Hawk** *(courtesy of US Department of Defense)* **– Eurofighter Typhoon** *(courtesy of Chelton Radomes)*
– High Temperature Resistance Cable – Metal Foundry – Rollers with sleeve.

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Courtesy of US Department of Defense

Global Hawk – Unmanned Aerial Vehicle

Conversion table

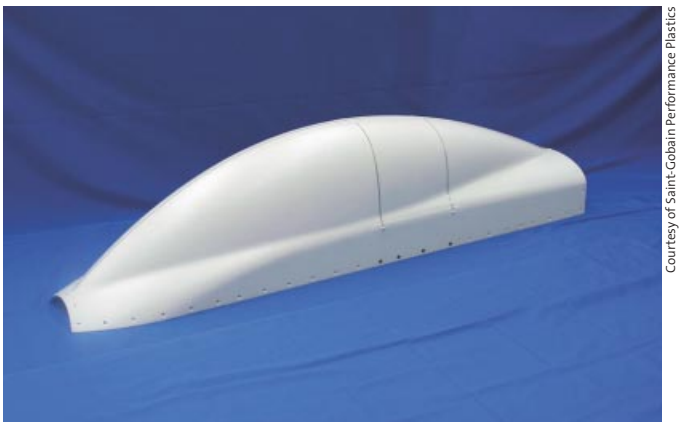
1 MPa = 1 N/mm^2	°C = (°F - 32) x 5/9
1 GPa = 1 000 MPa	°F = 9/5 x °C + 32
1 psi = 6.89 x 10^{-3} MPa	1 W.m^{-1}.K^{-1} = 0.860 kcal.m^{-1}.h^{-1}.K^{-1} = 6.9 Btu.in/(ft^2.hr.°F)
1 ksi = 6.89 MPa	1" = 25.4 mm
1 tex = 9 denier	1 oz/yd^2 = 33.91 g/m^2
1 denier = 0.111 tex	1 lb/ft^2 = 4.89 kg/m^2
1 tex = 496 238 yard per pound	1 lb/ft^3 = 16.05 kg/m^3

Introduction

Saint-Gobain Quartz is the worldwide leader in the production of fused quartz fiber (trademark Quartzel) with two manufacturing sites. Saint-Gobain Quartz is part of the Crystals Division / Ceramics & Plastics Branch / High Performance Materials Sector of Saint-Gobain Group.

- Saint-Gobain Quartz S.A.S. has been established in 1922 and started manufacturing Quartzel® fibers in 1963 in Nemours, France.
- Saint-Gobain Quartz USA has been manufacturing Quartzel® fibers since 1988 in Louisville, Kentucky.

Over the years, Quartzel® fused quartz fiber has been qualified in many aerospace and industrial programs, proving its position as a leading material where reliability and outstanding technical performance is expected. Quartzel® fiber has been recognized by our customers for its excellent dielectric, thermal, mechanical and chemical properties.



Courtesy of Saint-Gobain Performance Plastics

Bombardier Global Express SATCOM radome

Courtesy of US Department of Defense

F/A-22 Raptor

More and more often, one single material is asked to perform in a number of functions at the same time. By its nature, Quartzel® fused quartz fiber is often the best choice and has major advantages compared to other materials when a combination of properties is required. Virtually no shrinkage, withstanding very high temperatures, its production process being respectful for the environment, not causing concern by any health or safety issue, the Quartzel® fiber is an all winning material, leaving far behind ceramic fiber and leached silica.

Therefore, Quartzel® fiber is a unique product line, which has found its way to a large variety of applications. For example, Quartzel® is used as a reinforcement fiber in aircraft radomes, as felt in thermal blankets for aircraft engines, as the shielding material for fireproof cables, as a contact material for hot glass handling, and recently as a photocatalytic substrate for air purification.

In all these cases, Quartzel® has allowed these products to go beyond the limits imposed by other materials.

We have been serving our customers for more than 40 years, constantly improving our product quality, customer service and technical information.

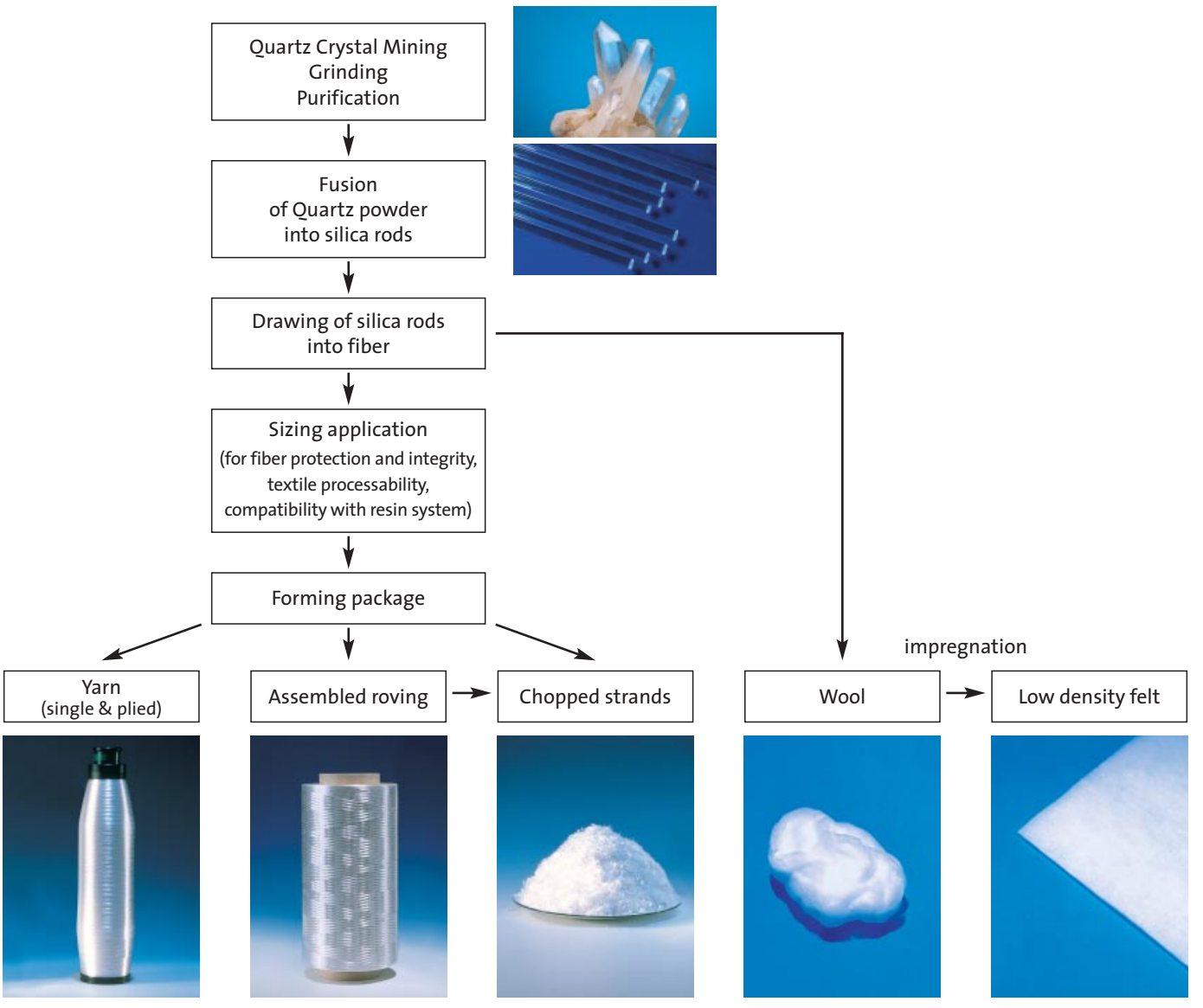
But what is more, the Quartzel® product variety is increasing allowing more and more applications. Why not try yours!

Quartzel® fiber is produced from quartz crystal, the world's purest form of silica, that is ground, purified to enhance chemical purity, fiberized by a fusion process.

Quartzel® fiber is homogeneous, non porous, continuous, amorphous, ultra pure silica glass.

Six major Quartzel® product lines are available

	Product	Description
Textile fiber products	Yarn	Single yarns Plied yarns
	Roving	Assembly of parallel untwisted continuous fused quartz filaments
	Chopped strands	Fiber is chopped to a pre-determined length
Other products	Wool	Standard wool: continuous fibers presented in a bulk form
	Felt	Low density felts: flat sheets, consisting of wool impregnated with an organic binder Needle punched felts
	Rigid silica	Quartzel® fibers sintered in a solid form



Other textile products available: needle punched felt, sewing thread, fabric, packing, braid, veil, tape.

Dielectric applications

Quartzel® fiber is recognized as the ultimate material in dielectric performance.

The dielectric constant and the loss tangent factor are the best to date among all mineral fibers. Even better, these outstanding performances are maintained at high frequencies and high temperatures.

For these reasons along with low density (2.2 g/cm³), nil moisture absorption and excellent mechanical properties, Quartzel® is considered as the prime choice for radomes, electromagnetic windows and low dielectric related applications.

Quartzel® is currently used in the following applications:

- Civil aircraft sandwich radomes,
- SATCOM radomes (telephone) / DBS radomes (television), radomes for inflight Internet services,
- Military aircraft radomes (fighters, bombers, surveillance...),
- Advanced missiles radomes,
- Electromagnetic windows (countermeasures, jamming devices...),
- Stealth materials with structural performance (missiles, Unmanned Aerial Vehicles, Uninhabited Combat Aerial Vehicles, fighters, bombers, ships, submarines...),
- High frequency printed circuit boards (cellular phone technology, super computers),
- Antennas and radomes for combat ships,
- Satellite antennas.

Courtesy of Airbus Industries

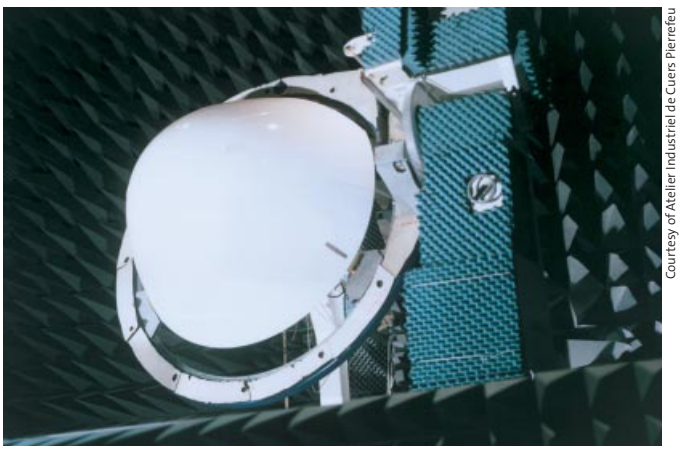
A330 – A340 Civil Aircraft


Courtesy of US Department of Defense

F/A-22 Raptor

Courtesy of Eurocopter

NH90


Courtesy of Atelier Industriel de Cuers Pierrefeu

Quartzel® hybrid A320 radome under radioelectric test at Atelier Industriel de Cuers Pierrefeu


Courtesy of Alenia Spazio

Rosetta satellite

Thermal applications

Quartzel® use in thermal protection applications is due to the intrinsic temperature resistance of Silicon Dioxide. Standard Quartzel® maintains its integrity up to 1 050°C and Quartzel® 4 can be used at temperature up to 1 200°C. Quartzel® can be used at temperatures above 1 200°C for limited periods of exposure or for ablative applications.

Quartzel® has virtually no shrinkage at elevated temperatures.

Other properties of Quartzel® include low coefficient of thermal expansion good resistance to thermal shock and low thermal conductivity.

Courtesy of US Department of Defense

Titan IV B launch – Quartzel® thermal insulation

Courtesy of Hi Temp Insulation Inc.

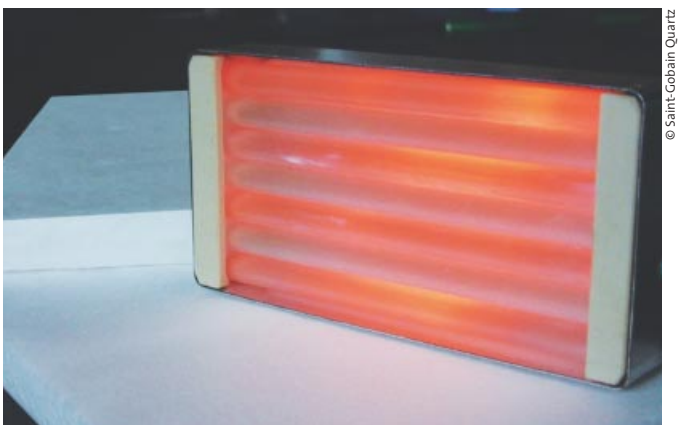
Quartzel® insulation blankets

Quartzel® is currently used in the following applications:

- Glass industry,
- Infrared reflectors for thermoforming and lighting industry,
- Thermal insulation or catalytic functions in automotive / heavy duty vehicles exhausts,
- Asbestos replacement / Ceramic fibers replacement,
- Insulation in semiconductor industry,
- Fiber optic processes,
- Fuses wire supports,
- Hot gas filtration,
- Thermocouple insulation,
- Welding blankets,
- Furnace lining,
- Aircraft engine environment:
  - Fire proof cables
  - Blankets for firewalls
  - Thermal insulation,
- Aircraft fuselage fire barrier,
- Thermal protection systems (TPS) of space launchers,
- Booster insulation of launchers,
- Ablative atmospheric re-entry materials,
- Ablative launching pads materials,
- Missile exhaust cones (ablative or insulation), rocket motors.

Courtesy of Bayer Chemie Protac

Mica – Rocket motor with quartz/phenolic nozzle



© Saint-Gobain Quartz

FSK® cassette with a Quartzel® rigid silica IR reflector

Quartzel® technical data

Composition and properties

Chemical composition measured on quartz glass before fiberizing (excluding binder)

Typical chemical analysis: SiO_2 > 99.99%

Trace elements in ppm										
Al	B	Ca	Cr	Cu	Fe	K	Li	Mg	Na	Ti
18	<0.1	0.5	<0.08	<0.03	0.6	0.6	0.7	0.06	0.8	1.5
AAS	ICP	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS	Colorimetry

Notes: AAS = Atomic Absorption Spectrometry ICP = Inductive Coupled Plasma

Physical properties of fused quartz

Properties	Description	Unit	Value
Physical	Density	g/cm³	2.2
	Hardness	Mohs scale	7
	Poisson's coefficient	–	0.16
	Ultrasonic wave propagation		
	longitudinal	m.s⁻¹	5 960
	transversal	m.s⁻¹	3 770
	Internal dampening	dB m⁻¹ MHz⁻¹	0.08
Electrical	Dielectric constant at 10 GHz	–	3.74
	Loss factor at 10 GHz	–	0.0002
	Dielectric strength	V.m⁻¹	≈ 3.7 x 10^7
	Resistivity at 20°C	Ω.m	1 x 10^{20}
	at 800°C	Ω.m	6 x 10^8
	at 1 000°C	Ω.m	1 x 10^8
Thermal	Linear expansion coefficient	K⁻¹	0.54 x 10^{-6}
	Specific heat at 20°C	J.kg⁻¹.K⁻¹	7.5 x 10^2
	Heat conductivity at 20°C	W.m⁻¹.K⁻¹	1.38
	Annealing point ($log_{10}\eta$ = 13)	°C	1 220
	Softening point ($log_{10}\eta$ = 7.6)	°C	1 700
Optical	Refractive index	–	1.4585
	Dispersion	–	67
	Field of transparency	µm	0.2 to 4

Health and safety

Tensile strength test performed on Quartzel®

• General:

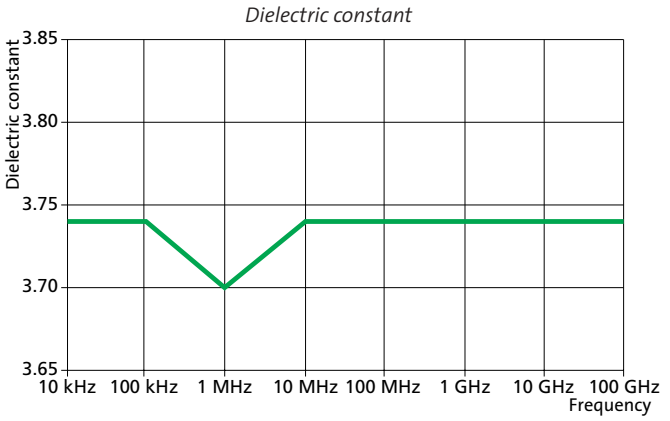
- Quartzel® fibers are amorphous silica fibers. Silicosis is only caused by crystalline silica not amorphous silica.
- In its hazardous fibers studies the WHO (World Health Organization) does not take into account fibers with a length above 20 microns and filament diameter below 3 microns. In the case of Quartzel® fiber length is always above 20 microns.
- Specialists in Health & Safety aspects agree on the fact that fibers for which the length/diameter ratio is superior to 3 are not respirable. In case of Quartzel® this ratio is well above 3.
- Quartzel® is not a silicate (analysis performed by BRGM, France, 1999). It is not subjected to European Regulation 97/69/CE.
- Air samplings were performed according to ISO 8672 on Quartzel® 9 microns silica wool and Quartzel® low density felts in working conditions of Quartzel® manufacturing in November 1999. The results show that at any production stage the fiber concentration level is 0.046 fiber/cm³ maximum. This is well under the 0.5 fibers/cm³ TRK value for manufactured mineral fibers which has been determined by the MAK commission in Germany as the safe level.

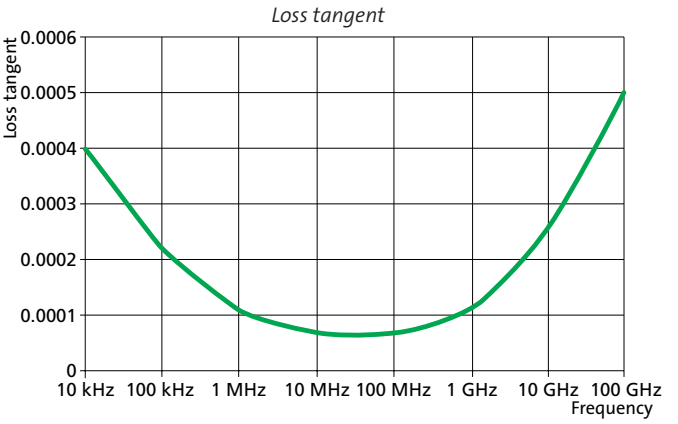
• Recommended personnal protective equipment:

- Respiratory Protection: Wear paper mask.
- Hand protection: Highly recommended to wear gloves.
- Eye protection: Wear protective glasses.
- Skin and Body Protection: Wear long sleeves to avoid irritation.

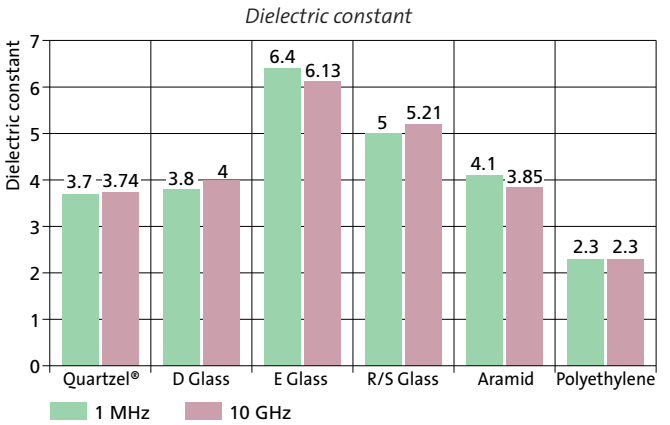
Material Safety Data Sheets are available for each product.

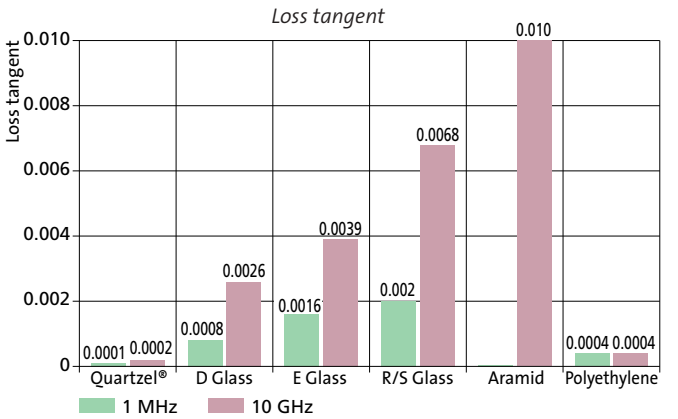
Dielectric constant and loss tangent versus frequency measured on quartz glass

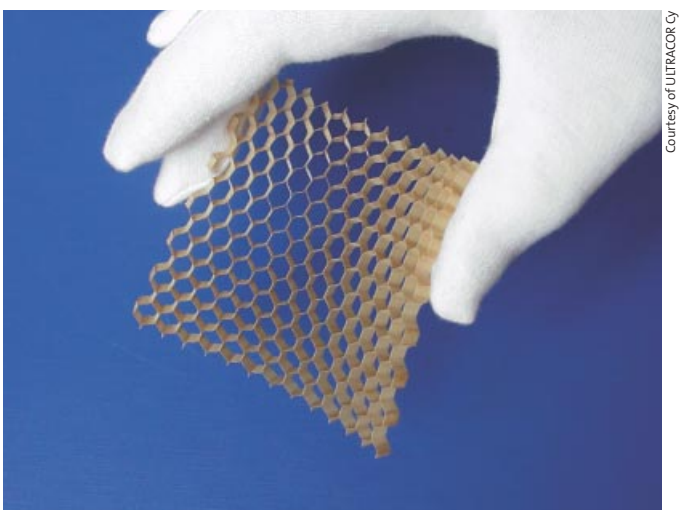




Comparative dielectric properties of fibers







Courtesy of ULTRACOR Cy

Quartz Ultracor® honeycomb, used in phased array antennas

Courtesy of radome Consortium Partner Companies Chelton Radomes, ESW, ALENIA, INTA

Eurofighter Typhoon nose radome

Courtesy of U.S Navy photo by Photographer's Mate 3rd Class Jason T. Poplin

F/A-18F Super Hornet

Dielectric properties (ctd)

Comparative dielectric properties on composites

Comparison of different fibers with same resin

Values measured with RP 13 polyester resin at room temperature.

	Frequency	Dielectric constant	Loss tangent
Quartzel®	9.368 GHz	3.08	0.0022
D Glass		3.11	0.0037
Aramid		3.12	0.0049
E Glass		3.95	0.0055
Quartzel®	37.50 GHz	3.07	0.0024
D Glass		3.10	0.0045
Aramid		3.11	0.0057
E Glass		3.86	0.0090

Data from Gec Marconi, Materials Technology. Radar Transparent Materials, RP 13 resin, data sheet 908/SM/Z3040/000 ISSUE I.

Dielectric properties versus temperature

Reinforcement: 581 style Quartzel® fabric.
Resin: F 650 Bismaleimide resin.
Frequency = 9.375 Ghz.

Temperature	Dielectric constant	Loss tangent
24°C	3.31	0.0030
149°C	3.33	0.0040
232°C	3.34	0.0050

Source of information: HEXCEL, F 650 Bismaleimide resin data sheet supplement, Jan 88.

Courtesy of Saint-Gobain Performance Plastics Corp.

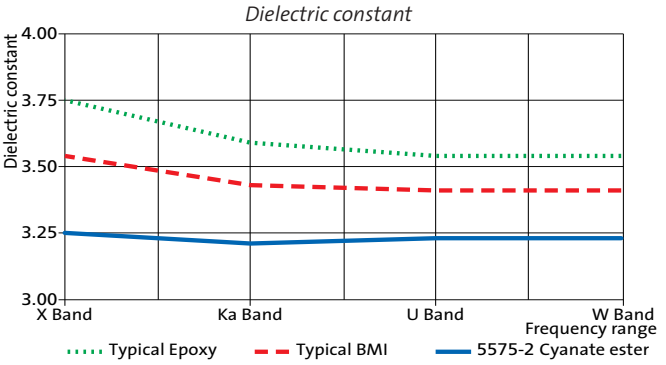
Boeing 757 radome under test at Saint-Gobain Performance Plastics

Comparison of different resins with Quartzel® fiber

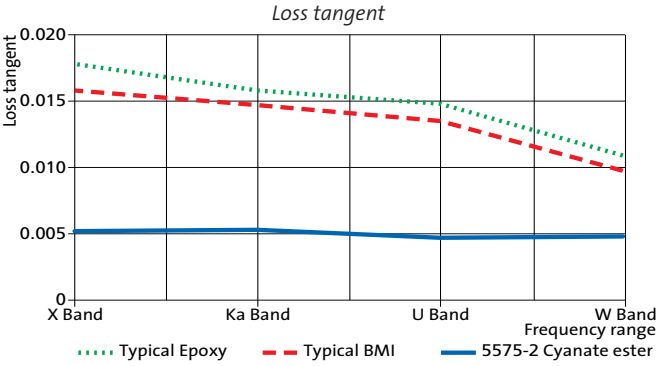
- **Source of information: 36th International SAMPE symposium and exhibition, "Novel cyanate ester based products for high performance radomes applications", S.C. SPEAK, H. SITT, R.H. FUSE, April 15-18, 1991.**

Reinforcement: Astroquartz® II fabric.
Astroquartz® II fabric is woven from 9 micron Quartzel® yarn.
Astroquartz® is a registered trademark of JPS Glass Fabrics.

Dielectric constant



Loss tangent



Nota: X Band: 8 - 12 Ghz Ka Band: 20 - 40 Ghz U Band: 40 - 60 Ghz W Band: 75 - 100 Ghz

- **Source of information: FiberCote Industries**

Reinforcement: Astroquartz® II.

	Dielectric constant X Band (9.375 GHz)	Loss tangent X Band (9.375 GHz)
Electrovue®	3.0	0.0010
V 376 Cyanate ester	3.2	0.0050
E 761 - Epoxy (120°C)	3.3	0.0090
E 746 - Epoxy (177°C)	3.6	0.0120
V 341 Polybutadiene	3.1	0.0010

Electrovue® is a registered trademark of FiberCote Industries.

- **Source of information: Bryte Technologies, Inc.**

Reinforcement: Astroquartz® III.
Testing method: cavity guide @ 10 GHz

	Dielectric constant 10 GHz	Loss tangent 10 GHz
EX-1522 – Toughened Epoxy	3.4	0.0060
EX-1515 – Toughened Cyanate Ester	3.2	0.0040
BTCy-1A– Toughened Cyanate Ester	3.1	0.0040
BTCy-2– Toughened Cyanate Ester	3.0	0.0010

Comparison on virgin filaments

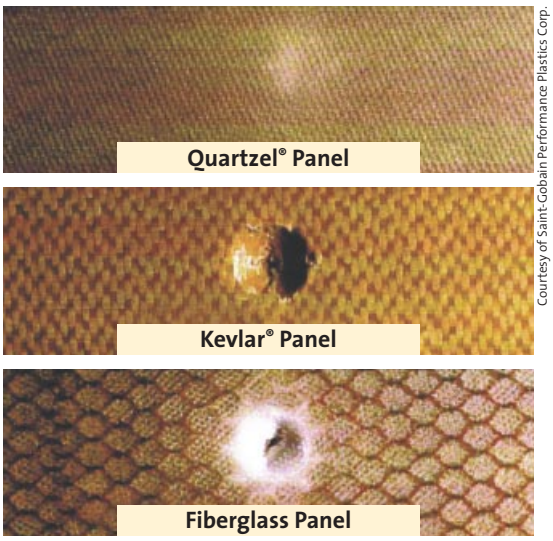
	Tensile strength (MPa)	Tensile modulus (GPa)	Elongation to failure (%)
Quartzel®	6 000	78	7.7
E Glass	3 400	73	4.5
D Glass	2 500	55	4.5
R or S Glass	4 400	86	5.1

Comparison on impregnated strand tensile test

Resin: Epoxy. Strength and modulus are calculated on fiber cross section.

	Density	Tensile strength (MPa)	Tensile modulus (GPa)
Quartzel®	2.20	3 600	78
E Glass	2.60	2 400	72
D Glass	2.14	1 650	55
Kevlar®	1.44	3 400	125
Spectra® 1000 PT	0.97	3 000	172

Kevlar® is a registered trademark of Dupont.
Spectra® is a registered trademark of Allied Signal Corp.



Courtesy of Saint-Gobain Performance Plastics Corp.

Hail impact
Above pictures show the damage of a simulated hail strike that punctures both fiberglass and Kevlar®, but leaves only an impact mark on Quartzel®. Tests have shown that Quartzel® radomes can resist puncture at up to 3 times the impact energy of fiberglass radomes.

Comparison on unidirectional composite with an epoxy resin system

	Unit	Quartzel®	E Glass	D Glass	Kevlar® 49	Spectra® 1000 PT
Compressive strength	MPa	1 000	1 000	850	200	69
Interlaminar shear strength	MPa	74	72	70	35	20
Flexural strength	MPa	1 200	1 200	1 000	600	200
Flexural modulus	GPa	35	35	25	35	38

Values on unidirectional composite with cyanate ester resin system

Fiber: Quartzel® Silica Roving C9 667 QS16 (33)(300 20E QS16). Resin: YLA RS-3C.

	Fiber direction	Silica roving	Standard
Tensile strength	[0°]	1 471 MPa	ASTM D3039
Tensile modulus	[0°]	45.3 GPa	ASTM D3039
Tensile strength	[90°]	50 MPa	ASTM D3039
Compressive strength	[0°]	838 MPa	ASTM D3410
Compressive modulus	[0°]	45 GPa	ASTM D3410
Interlaminar Shear Strength	[0°]	86.5 MPa	ASTM D2344

Source of data: YLA INC - USA.

Values on 8 Harness fabric with cyanate ester resin system

Resin: 954-2A system. Fabric Style: 581. Room temperature Data.

0° Tensile Strength (MPa)	0° Tensile Modulus (GPa)	90° Tensile Strength (MPa)	0° Compressive Strength (MPa)	0° Compressive Modulus (GPa)	0° Flexural Strength (MPa)
655	22	606	524	23.4	764

Source of data: CYTEC FIBERITE.

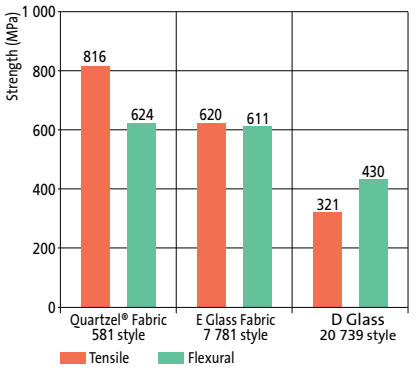
Quartzel® technical data

Mechanical properties (ctd)

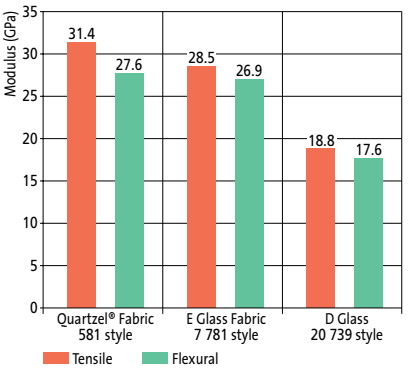
Comparison on composites made from Quartzel® fabric, with epoxy resin system

Resin: EPON 828. Fabric Style: 581. Fiber Volume fraction: 60%.

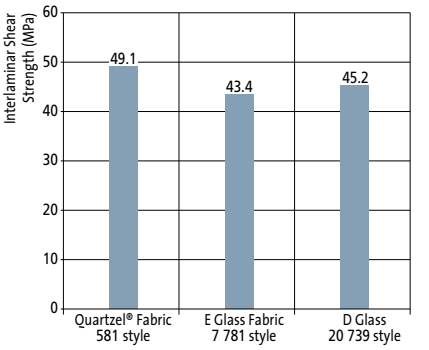
Strength



Modulus



Interlaminar Shear Strength



Comparison on composites made from Quartzel® fabric, with BMI resin system

Resin: F 650 Bismaleide Resin – Hexcel Corp. Fabric: Astroquartz® II 581 Style. Fiber Volume fraction: 55%.

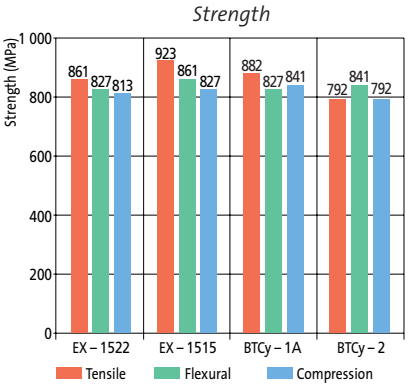
		Unit	Room Temperature	93°C	177°C
Tensile	Strength	MPa	672	622	529
	Modulus	GPa	28.9	28.2	24.1
Compressive	Strength	MPa	453	419	371
	Modulus	GPa	28.9	28.2	24.1
Flexural	Strength	MPa	555	–	494
	Modulus	GPa	23.2	–	21.8
Interlaminar Shear	Strength	MPa	46.9	47.5	–

Source of information: HEXCEL, Advanced Composites Handbook, Table 107.BG.

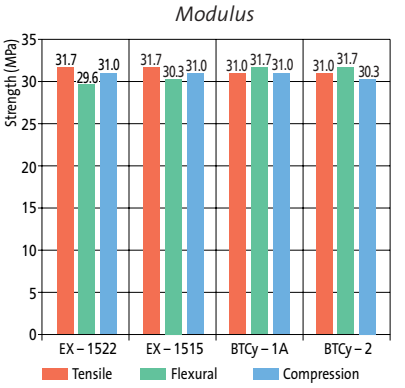
Comparison on composites made from Quartzel® fabric, with epoxy/cyanate ester

Fabric Style: Astroquartz® III 4581 Style. Fiber Volume fraction: 60%.

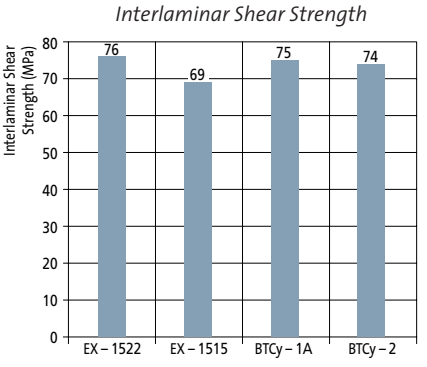
Strength



Modulus



Interlaminar Shear Strength



EX-1522: Toughened Epoxy.
EX-1515: Toughened Cyanate Ester.
BTCy-1A: Toughened Cyanate Ester.
BTCy-2: Toughened Cyanate Ester.

Source of information: Bryte Technologies, Inc.

The testing methods used for the above data are as follows:

- Tensile Strength — ASTM D3039
- Compression Strength — ASTM D695, Boeing modified
- Flexural Strength — ASTM D790
- Interlaminar Shear Strength — ASTM D2344

Quartzel® is recognized for its outstanding thermal properties. It is used at higher temperatures than standard fiberglass textiles.

The softening point of silica is 1 700°C.

Standard Quartzel® is used in the 600°C – 1 050°C temperature range.

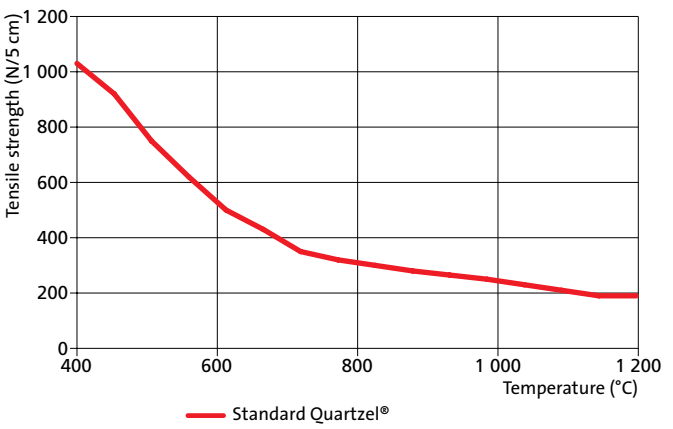
Above 1 600°C, Quartzel® starts to sublimate. Sublimation is an endothermic reaction which energy consumption during reaction allows temperature reduction. Quartzel® is used as an ablative material in atmospheric re-entry applications or in missiles.

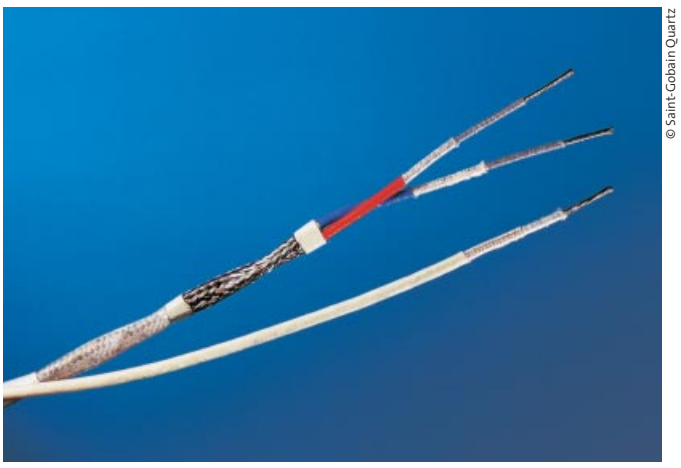
Quartzel® is often used in conjunction with phenolics or silicon resins.

Quartzel® fuselage fire barrier under test at C.E.A.T. (Toulouse – France)

Tensile strength versus temperature

Quartzel® 8 Harness fabric tensile strength after one month of thermal exposure





High temperature resistance cable

Flame test results in accordance with FAA advisory Circular 20-135

Quartzel® HT1 fabric (8HS Satin - 230 g/m²) passed the FAA flame test 1 093°C ± 66°C (2 000°F ± 150°F) for 15 minutes. No burn through took place.

The maximum backside temperature was 429°C (804°F).

The Quartzel® fabric is able to withstand flame penetration for the 15 minutes time duration. After removing the sample from the mounting stand, the sample was examined for further damage. After physical examination, the Quartzel® fabric was determined to be very pliable revealing no brittleness. The sample was first bent over one inch diameter rod, then folded completely over, and in both cases showed the flexibility to return to its original shape with no sign of damage or deformation. The kapton film on the backside of the sample showed charred discoloration, but remained intact. (Data courtesy of Hi Temp Insulation Inc.)

Fabric flexibility after exposure to temperature

• *Angle measurement on a fabric after thermal exposure*

After thermal cycle, fabric samples size 10 cm x 2 cm are bonded on horizontal support (2 cm x 2 cm). Then the 8 cm "free length" of the fabric flexes under its own weight. The fabric angle relative to the horizontal plane is recorded.

A high angle means good handling characteristics after thermal exposure.

Cycle	Standard Quartzel®	Quartzel® 4	Continuous ceramic fibers
1 month – 1 200°C	5°	75°	35°
1 month – 1 150°C	10°	75°	75°
1 month – 1 100°C	15°	75°	75°

• *Bending of a fabric after thermal exposure*

A fabric sample is exposed at 1 200°C for 30 days. Then the fabric is bent over a 1 mm rod.

Quartzel® 4 has very few broken filaments compared to ceramic fibers and standard Quartzel®.

Thermal properties (ctd)

Shrinkage

Unlike leached silica Quartzel® fabrics have virtually no shrinkage. Typical shrinkage measured after 1 000 hours at 1 000°C is less than 1.5%.

Courtesy of EADS LV

Atmospheric Reentry Demonstrator heat shield.
This resin impregnated Quartzel® fabric whistands temperatures of 2 000°C reached during reentry due to atmospheric friction.

Ablative properties

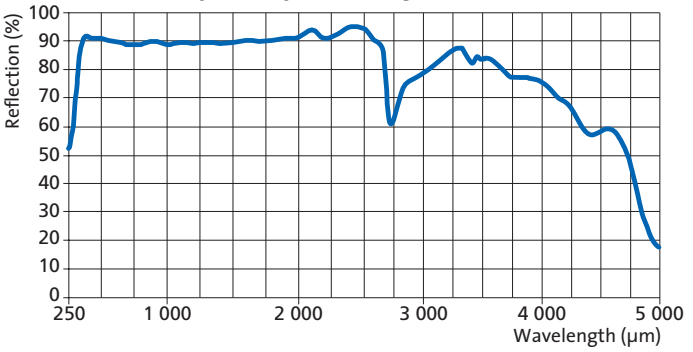
For more specific information concerning ablative characteristics of silica at different temperatures and atmospheres, we recommend the following paper "Journal of the American Ceramic Society", Heur and Lou, Vol 73, n° 10, pp 2796.

© Saint-Gobain Quartz

Quartzel® Heat Collar

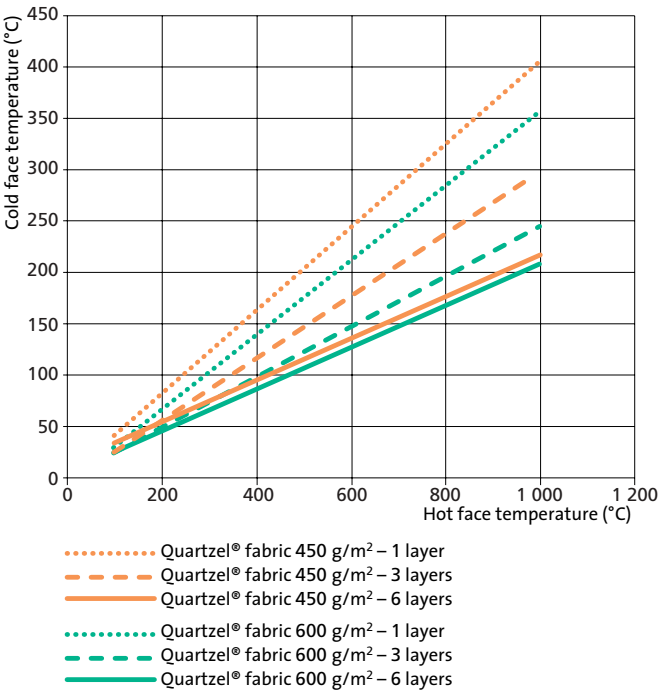
Reflective properties

Reflection of Quartzel® rigid silica

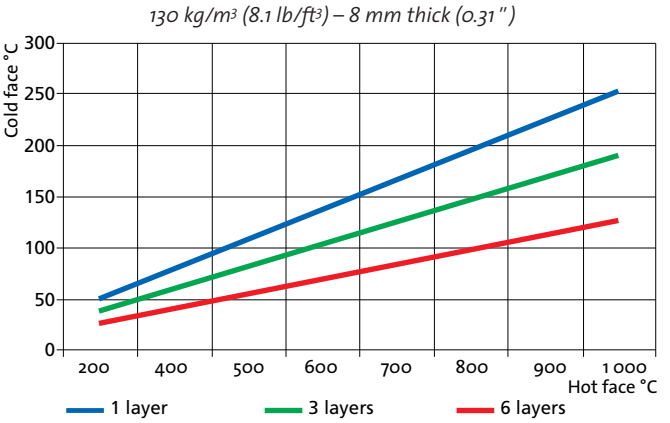


Hot face / Cold face thermal data

Test conditions: hot face versus cold face temperature tests were conducted on samples of one through 6 layers of Quartzel® 450 g/m² and 600 g/m² fabrics. The hot face of the fabric is set in a controlled heated zone. Temperature measurement on the cold face is performed with a thermocouple at 5 mm from the fabric. The temperature was recorded after the cold face had reached a steady state.

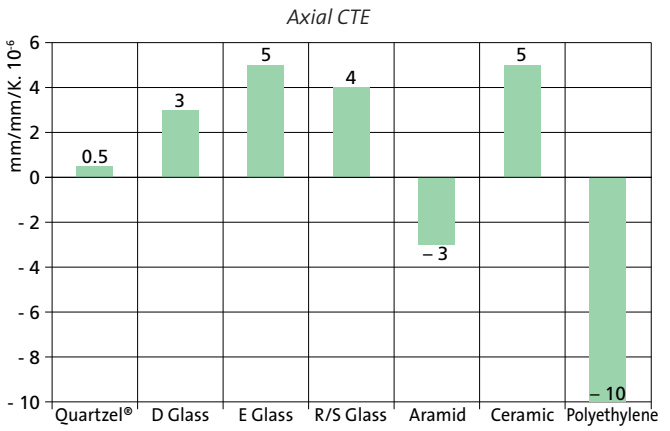


Quartzel® Needle Punched Felts Hot Face / Cold Face
130 kg/m³ (8.1 lb/ft³) – 8 mm thick (0.31 ")

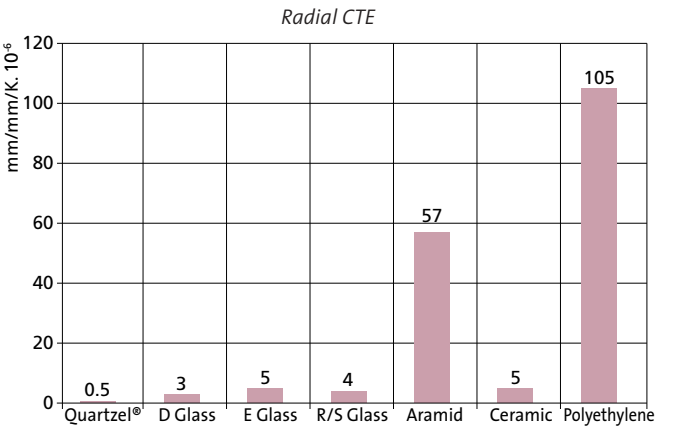


Quartzel® rigid silica has a dual role of insulation and reflection in IR heating. It plays a significant role in fast response and energy saving, reducing the cost of ownership of the system.

Coefficient of Thermal Expansion comparison



Quartzel® has the lowest Coefficient of Thermal Expansion of mineral fibers.



Organic fibers are anisotropic and the large difference in the axial and radial Coefficient of Thermal Expansion can cause many problems in composites.

Chemical properties

Fused silica is well known for its chemical resistance especially in acidic environment.

Quartzel® fibers have the intrinsic chemical inertness of bulk fused silica.

For this reason fused silica containers and equipment are widely used in laboratories.

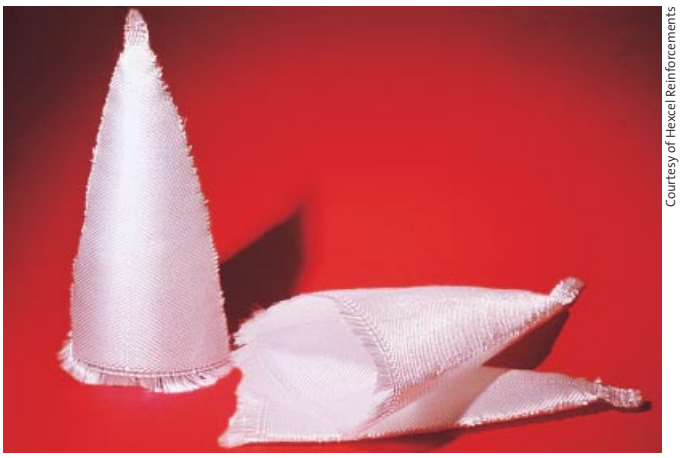
Applications for Quartzel® chemical resistance include:

- Filtration media for laboratory analysis,
- Filtration of hot acidic gases,
- Reinforcement for acid resistant composites. If there is a crack, the fiber is not attacked by the chemical media.

Textile presentations available

- Woven fabrics with a wide range of thicknesses and weaving styles (plain weave, satin weave, twill, leno,...).
- Woven tapes with similar styles as described above.
- Woven shapes or preforms.
- Screen fabrics.
- 3D woven shapes or knitted preforms.
- Braids with diameters ranging from 1 to 300 mm.
- Continuous strand mats, approximately 300 g/m².
- Sewing threads coated with PTFE or uncoated.
- Veils with capabilities from 10 g/m² up to 200 g/m².
- Packings.

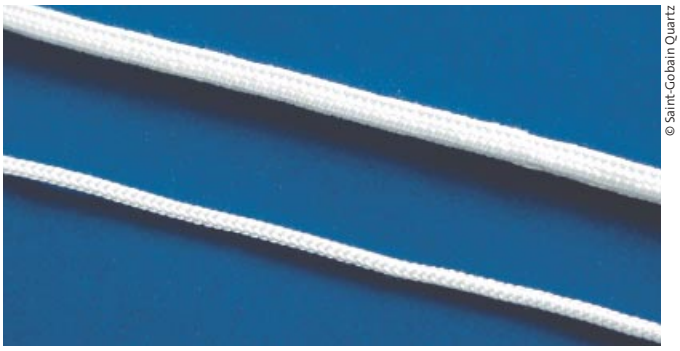
The majority of these products are available from our customers. Contact our sales department for further information.



Woven preform for radome manufacturing

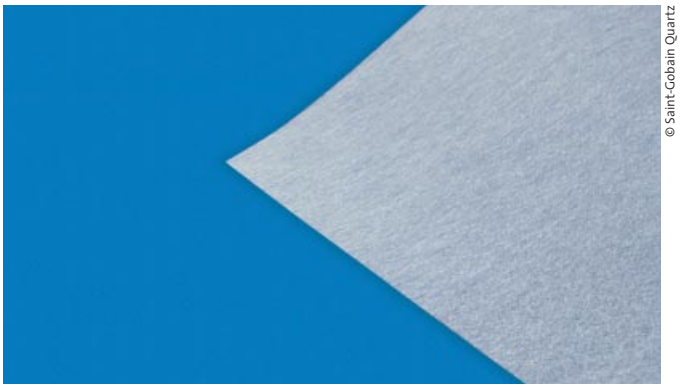
Quartzel® Tape

Quartzel® Braid

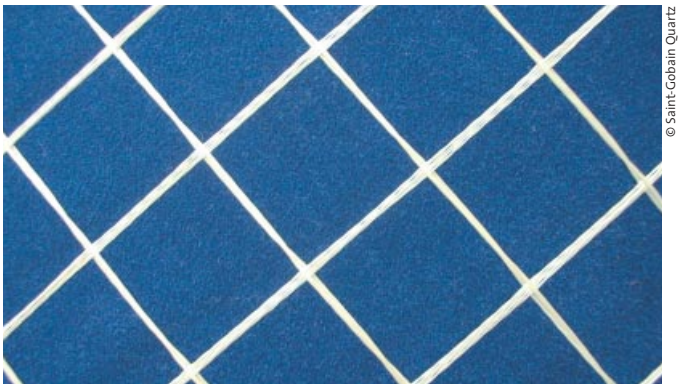


Quartzel® Packing – Top: 10 x 10 mm square section
Bottom: 5 mm round section

Quartzel® Fabric



Quartzel® Veil



Quartzel® Screen Fabric

Quartzel® bare filament, as drawn, needs a protective surface coating called sizing so it can be further processed.

Quartzel® fibers are sized at the filament level before being assembled into a strand.

The sizing has numerous functions:

- To enhance textile processability at the forming, twisting and plying levels, as well as conversion into fabric, woven tapes, braids, knitted structures...
- To lubricate the yarn to reduce filament to filament friction and yarn to contact surfaces friction.
- To give the yarn integrity, which means good cohesion.
- To improve wet out of the fiber by resins for composite applications.
- To enhance chemical compatibility of the fiber with the matrix for better structural performance.

9 microns yarn with QS13 sizing, 12.5 microns Quartzel® 4 with QS1318 sizing, 14 microns with QS1318 sizing

Quartzel® is available with the following sizings:

- **QS13:** Multipurpose high performance direct size, recommended for most textile processes and composite applications.

  QS13 has an excellent compatibility with epoxy and phenolics, it can also be used with vinyl ester and polyimides.

  More limited data is available on use with thermoplastic resin systems, however good results have been obtained with PEEK, PPS, PBT and PES.

- **QS1318:** Multipurpose high performance direct size, recommended for most textile processes and composite applications. It is an improved version of QS13 in terms of textile processability and ageing, and has the same resin compatibility as QS13.

- **QS16:** QS16 has excellent compatibility with cyanate ester resins. It combines excellent mechanical performance and dielectric transparency.

  QS16 can also be used with epoxy systems.

Quartzel® 4 QS1318 is a new product developed for high temperature applications. It replaces Quartzel® HT1.

Quartzel® Yarns

Quartzel® yarns are assemblies of many fused quartz continuous filaments which are gathered into strands (forming package), then twisted with varying levels of twist and ply.

Quartzel® yarns are used in numerous textile processes:

- Beaming,
- Weaving,
- Braiding,
- Texturizing,
- Stretch breaking (spun yarn),
- Knitting,
- Multiple winding.

Quartzel® Yarn

Yarn nomenclature (Example for the same product)

Based on ISO 2078	
	Quartzel® silica yarn C9 33x4 S150 QS13
C	Continuous filament
9	Filament diameter in micron, can be **9** or **14** microns
33	Yield (or linear density) in tex (= g/1 000 m) of input yarn
x4	Number of ends in the plied yarn (plied yarn case only, otherwise nothing)
S150	Twist direction (**Z** or **S**) and twist level (**150** is this case) in turn/m. Standard twists are **Z20** for single yarns and **S150** for plied yarns
QS13	Sizing reference

Based on US customary system	
	Quartzel® silica yarn 300 2/4 QS13 4Z 3.8S
300	Yardage of the base strand (**300** x hundred yards per pound). Can also be **125**
2	Number of base strands used to make the strand at drawing level. It is either **1** or **2** base strands
4	Number of assembled strands of the plied yarn. It is **0** if the yarn is a single yarn
QS13	Sizing reference
4Z	Twist level (turns/inch) and twist direction (**Z**) of the single yarn
3.8S	Twist level (turns/inch) and twist direction (**S**) of the plied yarn

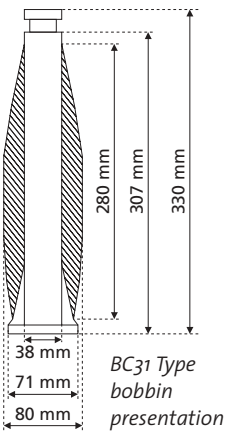
Standard yarn products

Sizing	ISO 2078 nomenclature	US customary system	Nominal linear density	
			tex	100 x yard/lb
QS13	C9 17 Z20 QS13	300 1/0 QS13 0.5Z	17	300
	C9 17x2 S150 QS13	300 1/2 QS13 4Z 3.8S	33	150
	C9 33 Z20 QS13	300 2/0 QS13 0.5Z	33	150
	C9 33x2 S150 QS13	300 2/2 QS13 4Z 3.8S	67	75
	C9 33x4 S150 QS13	300 2/4 QS13 4Z 3.8S	133	37
	C9 33x8 S150 QS13	300 2/8 QS13 4Z 3.8S	267	18
	C9 33x2x2 Z160 QS13*	300 2/2/2 QS13 5.9Z 10.2S 4.0Z*	133	37
	C9 33x2x3 Z160 QS13*	300 2/2/3 QS13 5.9Z 10.2S 4.0Z*	205	24
	C9 33x2x4 Z160 QS13*	300 2/2/4 QS13 5.9Z 10.2S 4.0Z*	272	18
	C14 40 Z20 QS13	125 1/0 QS13 0.5Z	40	125
	C14 80 Z20 QS13	125 2/0 QS13 0.5Z	80	62
	C14 80x2 S150 QS13	125 2/2 QS13 4Z 3.8S	160	31
	C14 80x4 S150 QS13	125 2/4 QS13 4Z 3.8S	320	15
QS1318	C9 17 Z20 QS1318	300 1/0 QS1318 0.5Z	17	300
	C9 17x2 S150 QS1318	300 1/2 QS1318 4Z 3.8S	33	150
	C9 33 Z20 QS1318	300 2/0 QS1318 0.5Z	33	150
	C9 33x2 S150 QS1318	300 2/2 QS1318 4Z 3.8S	67	75
	C9 33x4 S150 QS1318	300 2/4 QS1318 4Z 3.8S	133	37
	C14 40 Z20 QS1318	125 1/0 QS1318 0.5Z	40	125
	C14 80 Z20 QS1318	125 2/0 QS1318 0.5Z	80	62
	C14 80x2 S150 QS1318	125 2/2 QS1318 4Z 3.8S	160	31
QS16	C9 17 Z20 QS16	300 1/0 QS16 0.5Z	17	300
	C9 17x2 S150 QS16	300 1/2 QS16 4Z 3.8S	33	150
	C9 33 Z20 QS16	300 2/0 QS16 0.5Z	33	150
	C9 33x2 S150 QS16	300 2/2 QS16 4Z 3.8S	67	75

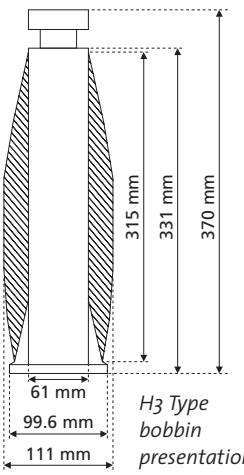
* Uncoated sewing thread.

Quartzel® yarn packaging

- BC31 biconical support (approximately 136 g),
- Nominal weight: 1 kg,
- Each package protected by a perforated polyethylene bag,
- 20 packages per carton, dimensions in mm: L 485 x W 385 x H 345,
- Full pallet built up: 4 levels of 6 cartons, 480 kg net weight, pallet dimensions in mm: L 1 200 x W 1 000 x H 1 530.



BC31 Type bobbin presentation



H3 Type bobbin presentation

Saint-Gobain Quartz has initiated a textile quality upgrading program. H3 bobbin will be gradually introduced to replace BC31.

Sewing thread products

Yarn reference	Nominal yield (in tex)	Typical breaking strength (in DaN)	Typical breaking strength (in pounds)	Approx. diameter (in mm)	Typical PTFE content (in %)
Quartzel® PTFE coated sewing thread Q18	250	11.2	25	0.43	20
Quartzel® PTFE coated sewing thread Q24	340	15.6	35	0.51	20

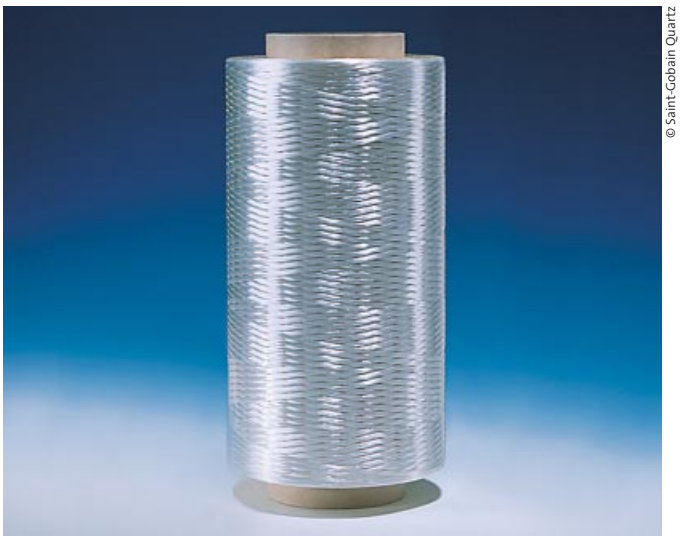
Quartzel® Sewing Thread coated with PTFE (Polytetrafluoroethylene)

Quartzel® Rovings

Quartzel® rovings are assemblies of fused quartz continuous filaments combined into strands (or ends), then assembled with no intentional twist.

Quartzel® rovings are used in a large variety of textile processes:

- Weaving: fabrics (woven or knitted),
- Filament winding,
- Unidirectional prepregging,
- Pultrusion.



Quartzel® Roving

Roving nomenclature (Example for the same product)

Based on ISO 2078	
	Quartzel® silica roving C9 667 QS13 (33)
C	Continuous filament
9	Filament diameter in micron, can be **9** or **14** microns
667	Yield (or linear density) in tex (= g/1 000 m) of the roving
QS13	Sizing reference
(33)	Yield (or linear density) in tex (= g/1 000 m) of the input ends in the roving. In this example, the roving has 20 ends (667/33)

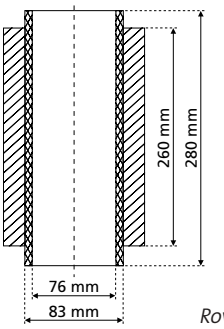
Based on US customary system	
	Quartzel® silica roving 300 20E QS13
300	Yardage of the base strand (**300** x hundred yards per pound) Can also be **125**
20E	Number of ends in the roving
QS13	Sizing reference

Standard roving products

Sizing	ISO 2078	US customary system	Number of ends	Nominal linear density	
				tex	yard/lb
QS13	C9 267 QS13 (33)	300 8E QS13	8	267	1 858
	C9 400 QS13 (33)	300 12E QS13	12	400	1 250
	C9 667 QS13 (33)	300 20E QS13	20	667	750
	C14 640 QS13 (80)	125 8E QS13	8	640	775
	C14 960 QS13 (80)	125 12E QS13	12	960	520
	C14 1600 QS13 (80)	125 20E QS13	20	1 600	310
QS16	C9 267 QS16 (33)	300 8E QS16	8	267	1 858
	C9 400 QS16 (33)	300 12E QS16	12	400	1 250
	C9 667 QS16 (33)	300 20E QS16	20	667	750

Quartzel® roving packaging

- Outside pull type bobbins, inside tube diameter 76 mm,
- 2.5 or 1 kg nominal weight per package protected by a perforated polyethylene bag,
- Exterior carton dimensions in mm: L 197 x W 188 x H 296.



Roving presentation

Quartzel® Chopped Strands

Quartzel® chopped strands are produced from fused quartz fibers which are chopped to a pre-determined length.

Quartzel® chopped strands are used in the following applications:

- Blending with elastomeric resins such as rubber, silicon or phenolics for ablative materials,
- Compounding with thermoplastic resins for injection moulding or compression moulding,
- Veils production,
- Wet laid mats.

Quartzel® Chopped Strands

Chopped strands nomenclature (Example for the same product)

Based on ISO 2078	
	Quartzel® silica chopped strands C9 33- 6 mm QS13
C	Continuous filament
9	Filament diameter in micron, can be **9** or **14** microns
33	Yield (or linear density) in tex (= g/1 000 m) of the input ends
6 mm	Chopping length, usually **6** or **12**, **3** and **20** mm also available
QS13	Sizing reference

Based on US customary system	
	Quartzel® silica chopped strands 300 6 mm QS13
300	Yardage of base strand (**300** x hundred of yards per pound). Can also be **125**
6 mm	Chopping length, usually **6** or **12** mm, **3** and **20** mm also available
QS13	Sizing reference

Standard chopped strands products

Sizing	ISO 2078 nomenclature	US customary system
QS13	C9 33- 6 mm QS13	300 6 mm QS13
	C9 33- 12 mm QS13	300 12 mm QS13
	C14 80- 6 mm QS13	125 6 mm QS13
	C14 80- 12 mm QS13	125 12 mm QS13

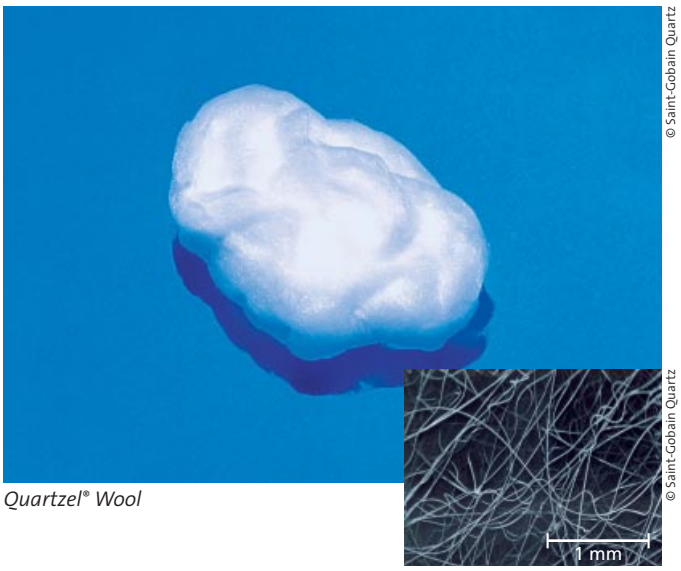
Chopped strands packaging

- Chopped strands are packed in a polyethylene bag, then put in a carton, 5 kg net weight per carton,
- Carton dimensions in mm: L 260 x W 260 x H 260,
- Full pallet built up: 3 levels of 16 cartons, 240 kg net weight,
- Pallet dimensions in mm: L 1 200 x W 1 200 x H 920.

Quartzel® Wool

Quartzel® wool is made from pure fused quartz fiber: amorphous, continuous, tangled, white, odorless, with no volatile component and no shot.

Length, shape and arrangement of fibers give the wool its curly appearance preventing compression of the padding and improves its desired insulating properties.



Quartzel® Wool

SEM picture of Quartzel® Wool

Applications

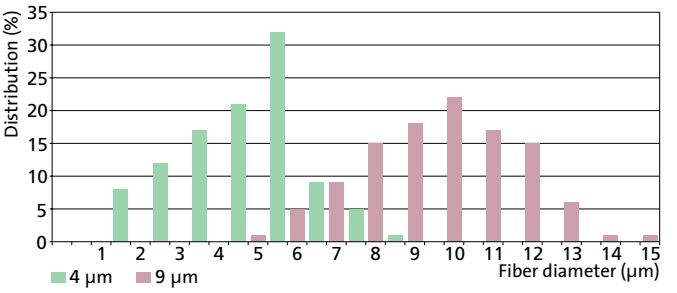
- Thermal protection systems for launchers.
- Ablative material for military and aerospace markets (rocket nozzles, space reentry vehicles).
- Filtration of hot acidic liquids and gases.
- Furnace closures and insulation.
- Asbestos replacement.
- High temperature insulation for semiconductor industry.
- Catalytic support for heavy duty vehicles catalytic converters.

Properties

Quartzel® wool has the properties of pure silica glass:

- high temperature use (1 050°C long term, higher temperature possible in case of short term exposure),
- resistance to thermal shocks,
- low thermal conductivity,
- high electrical resistivity,
- low dielectric constant,
- good chemical resistance.

Typical fiber diameter distribution



Available products and standard presentation

- **9 microns Quartzel® wool (coarse)**

  3 presentations are available:

  Reference: 9 µm Quartzel® wool - 500 g roll
  9 µm Quartzel® wool - 2 x 250 g roll with interpolated sheet
  9 µm Quartzel® wool - 50 g package

  The interpolated sheet allows easy separation of 2 layers of 250 g wool.

Presentation	Weight per roll (bag)	Approximate dimensions before rolling and pressing (mm)	Quantity per carton	Carton dimensions (mm)
Standard	500 g	L 3 700 x W 600 x H 150	12 x 500 g = 6 kg	L 1 330 x W 650 x H 650
With interpolated sheet	2 x 250 g	L 3 700 x W 600 x H (2 x 75)	12 x 500 g = 6 kg	L 1 330 x W 650 x H 650
50 g bags	50 g	–	6 x (20 x 50 g) = 6 kg	L 1 330 x W 650 x H 650

- **4 microns Quartzel® wool (fine)**

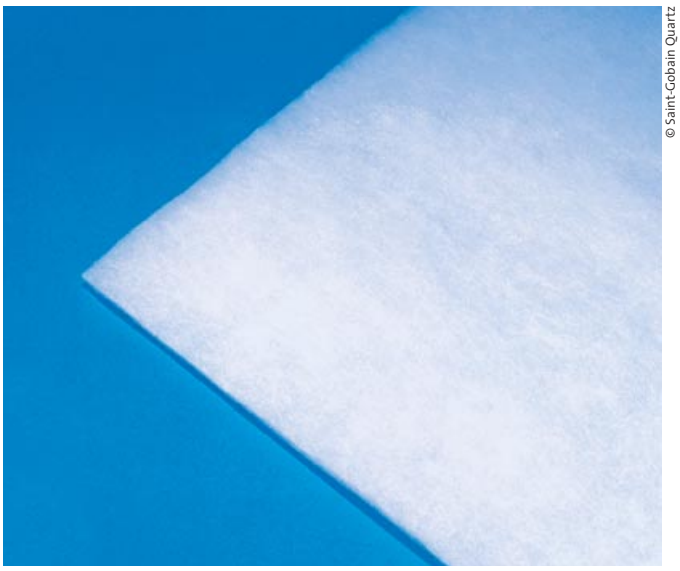
  4 microns wool is available in 1 kg, 1 lb, 50 g and 10 g bags.
  Carton dimensions for 10 kg in 1 kg packages are L 1 330 x W 650 x H 650 mm.

- **2 microns Quartzel® wool (ultrafine)**

  2 microns wool is available in 1 kg, 1 lb, 50 g and 10 g bags.
  Carton dimensions for 10 kg in 1 kg packages are L 1 330 x W 650 x H 650 mm.

Low density felt

Quartzel® low density felts are produced from 9 microns Quartzel® wool. The wool is impregnated with an organic binder, and the density of the resulting product is increasing from a few kg/m³ to approximately 10-20 kg/m³ (0.62-1.25 lb/ft³). The impregnated wool is called felt.



© Saint-Gobain Quartz

Quartzel® Felt

Applications

- High temperature insulation in aircraft engine environment. Quartzel® felts are very often used between 2 welded foils of refractory alloys.
  Quartzel® felts are recognized for their superior insulation performance / weight ratio, good resistance to vibrations, high life cycle.
- Domestic and industrial catalytic heaters. Felts are used as a support for the catalyst. Good mechanical integrity after long term temperature exposure, short time to start the heaters are the key advantages for this market.
- Furnace closures and insulation.
- Asbestos replacement.

Available products

Felts are available in binder.

Maximum size is 3.5 x 1 m.

Felts are easy to handle and to cut to appropriate size.

Felts can be cut according to customer's requirements (cutouts in rectangular shapes, example 1 000 x 500 mm).

New product

Felts can also be supplied with mesoporous coating to increase the specific surface up to 80 m²/g.

Standard presentation

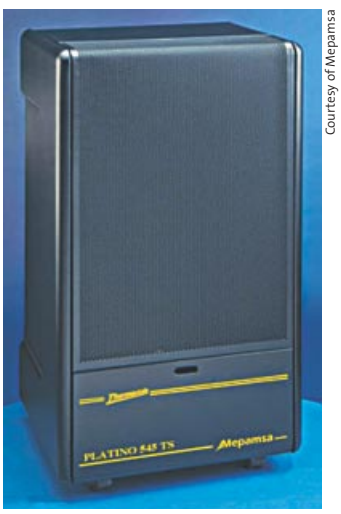
Areal weight (g/m²)	Approximate density (kg/m³)	Approximate thickness in mm / in inches (without pressure)	Organic binder available	Max. dimension available (m)	Quantity per carton	Carton dimensions (mm)
65	10-20	6 mm / 0.24"	PVA*	3.5 x 1.0	15 x 3.5 m² = 52.5 m²	L 1 330 x W 650 x H 650
80	10-20	8 mm / 0.31"	PVA*	3.5 x 1.0	15 x 3.5 m² = 52.5 m²	L 1 330 x W 650 x H 650
100	10-20	11 mm / 0.43"	PVA*	3.5 x 1.0	15 x 3.5 m² = 52.5 m²	L 1 330 x W 650 x H 650

* Polyvinyl Alcohol

Thermal conductivity data

40 kg/m³ and 90 kg/m³ data have been obtained by compressing standard felts in the testing equipment.

Temperature		90 kg/m³ (5.6 lb/ft³)		40 kg/m³ (2.5 lb/ft³)		17 kg/m³ (1.06 lb/ft³)	
°C	°F	W.m⁻¹.K⁻¹	Btu.in/(ft².hr.°F)	W.m⁻¹.K⁻¹	Btu.in/(ft².hr.°F)	W.m⁻¹.K⁻¹	Btu.in/(ft².hr.°F)
100	212	0.037	0.256	0.041	0.284	0.062	0.429
150	302	0.042	0.291	0.055	0.381	0.079	0.547
200	392	0.048	0.332	0.068	0.471	0.098	0.678
250	482	0.054	0.374	0.085	0.588	0.128	0.886
300	572	0.061	0.422	0.108	0.748	0.169	1.170
350	662	0.069	0.478	0.133	0.921	0.216	1.495
400	752	0.078	0.540	0.163	1.128	0.270	1.869
450	842	0.089	0.616	0.197	1.364	0.332	2.298
500	932	0.101	0.699	0.235	1.627	0.400	2.769
550	1 022	0.116	0.803	0.277	1.918	0.475	3.288
600	1 112	0.133	0.921	0.325	2.250	0.578	4.002
650	1 202	0.157	1.087	0.382	2.645	0.688	4.763
700	1 292	0.190	1.315	0.454	3.143	0.813	5.628
750	1 382					0.944	6.535
800	1 472					1.093	7.567



Courtesy of Mepamsa

Catalytic heater using Quartzel® felt as a catalytic support

Quartzel® Felts

Needle punched felt

Quartzel® needle punched felt is manufactured from chopped Quartzel® fibers.

Quartzel® fiber is homogeneous, continuous, amorphous, ultra pure fused quartz.

Quartzel® needle punched felts can be used at elevated temperature up to 1 200°C.

Chemical composition: Silica content ≥ 99.95%

Applications

- Industrial ovens insulation.
- Aircraft engine insulation.
- Glass oven heating up and repairs.
- Ceramic fibers or asbestos replacement.
- Thermal insulation in optical fiber manufacturing.

Available products

- Filament diameter: 9 to 14 microns.
- Density range: 130 kg/m³ (8.10 lb/ft³).
- Lower densities are available upon request.
- Areal weight: 1 000 g/m², 200 g/m².
- Thickness: 2 to 12 mm ± 10% thick.
- Width: 1 m (39.4").
- Roll length: 25 m (27.3 yd).

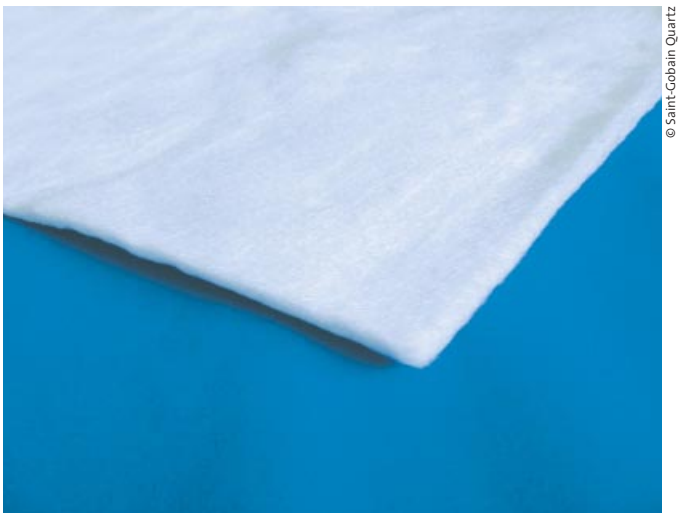
Also available in tubular shapes.

Shrinkage

The following data have been obtained after one hour heat treatment.

Temperature		Shrinkage
°C	°F	%
600	1 112	0.0
1 000	1 832	0.0
1 200	2 192	0.3
1 300	2 372	0.5

Tubular Quartzel® needle punched felt



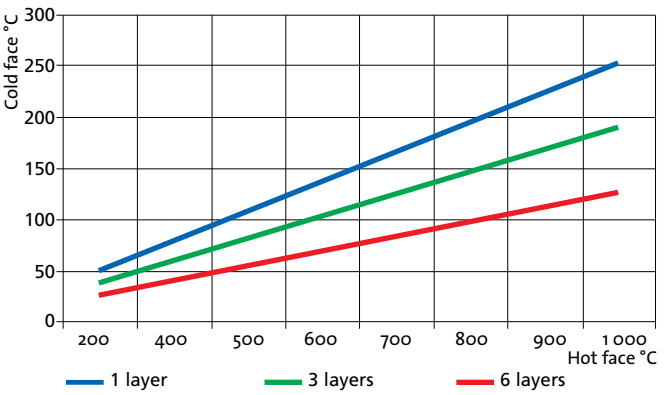
Quartzel® Needle punched felt

Thermal conductivity

Measured on 130 kg/m³ density (8.1 lb/ft³)

Temperature		Thermal conductivity	
°C	°F	W.m⁻¹.K⁻¹	Btu.in/(ft².hr.°F)
400	752	0.075	0.52
500	932	0.107	0.74
600	1 112	0.146	1.01
700	1 292	0.182	1.26
800	1 472	0.225	1.55
900	1 652	0.271	1.88
1 000	1 832	0.328	2.27
1 100	2 012	0.380	2.63
1 200	2 192	0.435	3.01

Quartzel® Needle Punched Felts Hot Face / Cold Face
1 000 g/m² – 8 mm thick



Saint-Gobain Quartz is launching a new and innovative photocatalytic substrate made from Quartzel® needle punched fibers. Quartzel® photocatalytic substrates have high photocatalytic efficiency and can be used in air purification applications such as:

- building air treatment: hotels, restaurants, bars, supermarkets, airports...
- domestic: air purifiers, refrigerators, cooking air treatment...
- industry: odor treatment generated by processes such as paint...
- transportation: VOC treatment, air conditioning.
- food industry: smell reduction.

This product is the result of Saint-Gobain research in the domain of environment friendly materials, such as BIOCLEAN® self-cleaning glass.

Quartzel® Photocalytic Substrates

Air Titan air purifier

Available products

Saint-Gobain Quartz current standard product has an areal weight of 200 g/m², a thickness of 2 mm and a specific surface of 40 m²/g.

Specific presentation can also be customized per customers requirements.

Why are Quartzel® photocatalytic substrates used in photocatalytic applications?

The excellent UV transmission of Quartzel® fibers (Quartz is used for fiber optics) brings the light in the mass of the material, allowing an efficiency in the volume rather than in the surface provided by other solution. This product has very high surface exchange capabilities compared to honeycombs.

What is photocatalysis?

The combined action of UV light and TiO_2 decomposes organic materials into basic molecules such as CO_2, H_2O and reduces the odors as a result. Systems based on activated carbon only absorb pollutants and shall be changed frequently, whereas photocatalysis is a chemical reaction, and is continuous process.

Main characteristics

- High substrate purity (SiO2 ≥ 99.99%).
- High specific surface.
- Excellent light transmission in UV range.
- Neutralize the harmful pollutants, reduce strong tobacco odors and dissipate unpleasant smells.
- Decontaminate viruses and bacteria.
- No sodium (does not poison catalyst).
- Low pressure drop.
- Excellent stability with time.
- Light and compact solution compared to activated carbon.

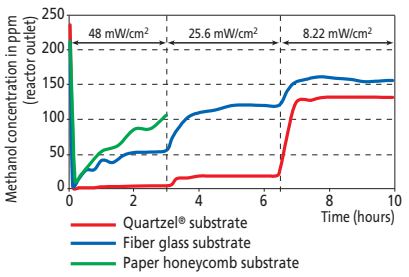
Tests conditions

The efficiency of Quartzel® photocatalytic substrates has been measured in a testing cell containing a 47 mm diameter and 2 mm thick needle punched Quartzel® substrate at room temperature (23°C). UV lamp spectrum is 365 nm.

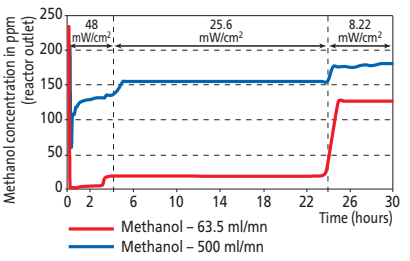
Efficiency of Quartzel® photocatalytic substrate vs other substrates

Quartzel® offers the best efficiency available today, thanks to the high surface exchange capabilities.

Reactor inlet = 250 ppm of Methanol at 63.5 ml/mn with different illumination power

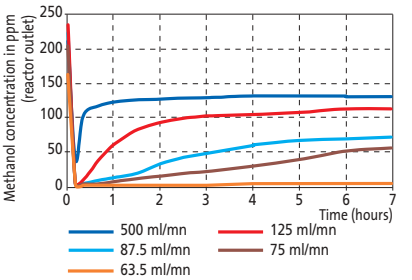


Efficiency versus time for different flow inlet (250 ppm of methanol) and UV power



Efficiency versus time with different flows

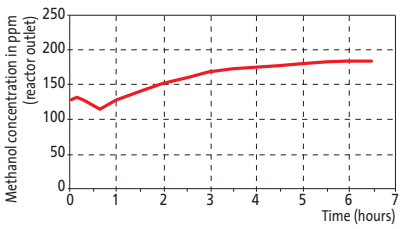
Lamp power = 48 mW/cm²
Reactor inlet of 250 ppm of Methanol



Efficiency under UV > 400 nm (sun UV light simulation)

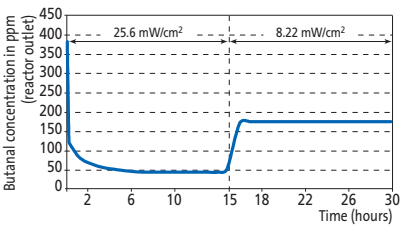
Quartzel® is also efficient under sunlight exposure conditions.

Reactor inlet = 250 ppm of Methanol at 63.5 ml/mn – P = 0.2 mW/cm²



Technical data with Butanal
Efficiency versus time for different lamp powers

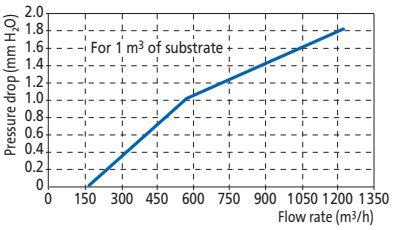
Reactor inlet = 350 ppm of Butanal at 63.5 ml/mn



Technical data: pressure drop

The pressure drop of Quartzel® substrate is minimal.

It is recommended to use a pre-filter to avoid dust built-up on the substrate.



Quartzel® Rigid Silica

Quartzel® Rigid Silica is manufactured by sintering ultra pure fused quartz fibers. Nominal density is 0.35 g/cm³. Quartzel® Rigid Silica is a high performance insulating material resisting up to 1 200°C (2 190°F). It can be used in infrared applications because of its good reflection properties, and has also proven experience in Semiconductor environment. We recommend flame glazing for a better surface finish, and long term resistance. Very large sizes are also available by using assembly techniques.

Main characteristics:

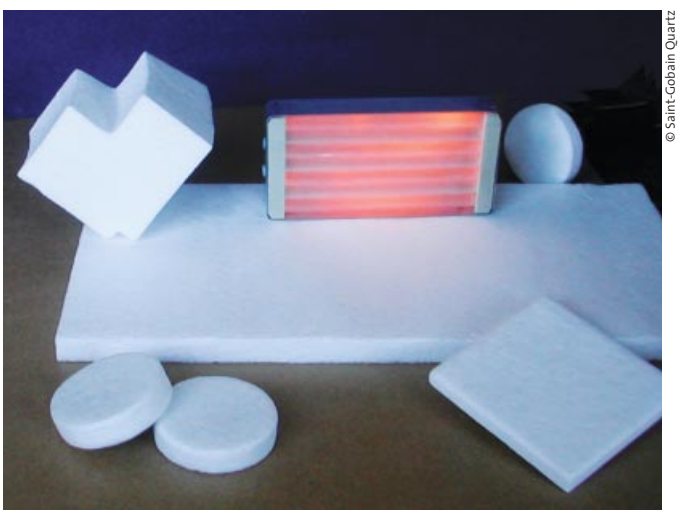
- High purity ($SiO_2 \geq 99.99\%$)
- Temperature up to 1 200°C (2 190°F)
- No loose fibers
- Glazed surface
- Good thermal insulation
- High reflection in IR
- Virtually no shrinkage
- High thermal shock resistance
- Ceramic fiber free

Applications:

- IR reflection in thermoforming / drying
- Insulation in semiconductor processes
- Insulation in industrial furnaces
- Filtration of hot gases
- Insulation in optical fiber processes
- Catalytic applications
- Airbag filters
- High Mach radome or re-entry materials

Technical data parameters:

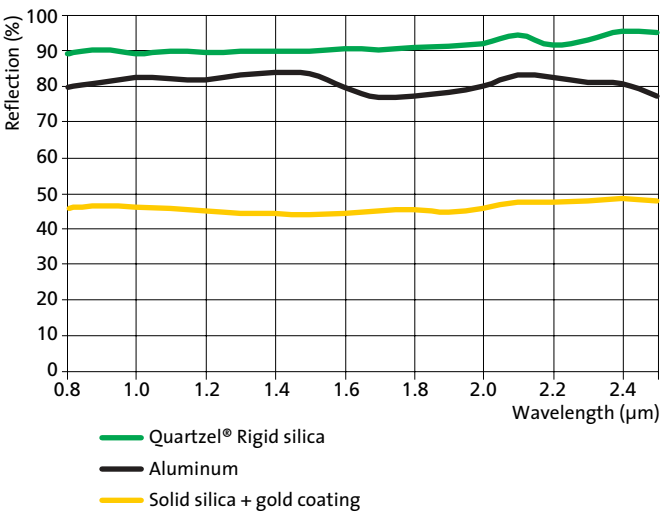
- Nominal density 350 kg/m³ (21.81 lb/ft³), higher density under development
- Thermal conductivity
- Shrinkage according to ENV 1094-7 (NFB 40-456):
  0.2% average and 0.5% max @ 1 100°C
  3.7% average and 5.4% max @ 1 300°C
- Machining tolerances: typically ± 0.5mm
- Specific surface: 0.5 m²/g
- Permeability: 0.02 Darcy



Quartzel® Rigid silica plates and shapes

Quartzel® Rigid silica shape

Comparative reflection of different materials

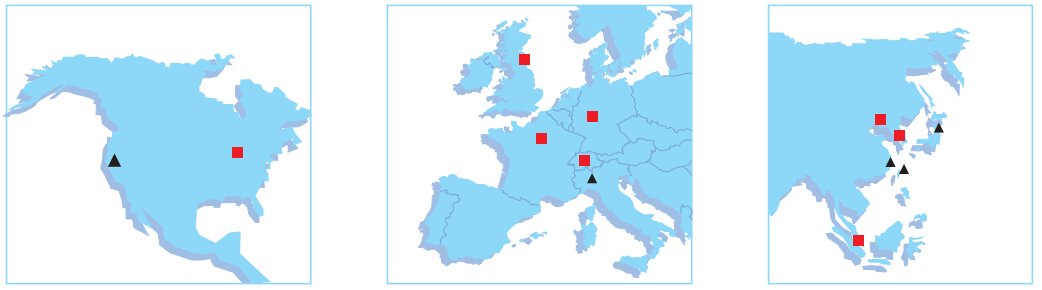


Dielectric properties:

- Dielectric constant: 1.31 @ 9.3 GHz – Density 412 kg/m³
- Loss tangent: 0.002 @ 9.3 GHz – Density 412 kg/m³

Thermal conductivity data

Temperature		Thermal conductivity	Thermal conductivity
°C	°F	$W.m^{-1}.K^{-1}$	$Btu.in/(ft^2.hr.°F)$
162	324	0.10	0.69
246	475	0.11	0.76
283	541	0.12	0.83
352	666	0.12	0.83
388	730	0.13	0.90
473	883	0.14	0.97
559	1 038	0.17	1.17
620	1 148	0.19	1.31
834	1 533	0.25	1.73
894	1 609	0.26	1.79
1 039	1 902	0.30	2.07



■ Production sites ▲ Sales offices

SALES OFFICES

EUROPE

France
Saint-Gobain Quartz S.A.S.
B.P 102 – 77793 Nemours Cedex
Tel: (33) (0)1 64 45 45 00
Fax: (33) (0)1 64 28 45 11
E-mail: quartz.sales.fr@saint-gobain.com

Germany
Saint-Gobain Quartz GmbH
Hüttenstrasse 10
D-65201 Wiesbaden
Tel: (49) (0)6 11 27 00 0*
Fax: (49) (0)6 11 27 00 27
E-mail: quartz.sales.de@saint-gobain.com

Italy
SEPR ITALIA SpA
Via Romagnoli 6 – 20146 Milano
Tel: (39) 02 472 140
Fax: (39) 02 472 188
E-mail: quartz.sales.it@saint-gobain.com

Switzerland
Saint-Gobain Quartz S.A.
Rue de la Colline 5
CH-1635 La Tour de Treme
Tel: (41) 26 919 82 92
Fax: (41) 26 919 82 95
E-mail: sales@sgquartz.ch

United Kingdom
Saint-Gobain Quartz PLC
P.O Box 6 – Wallsend
Tyne & Wear – NE28 6DG
Tel: (44) (0)191 262 5311
Fax: (44) (0)191 263 8040
E-mail: quartz.sales@saint-gobain.com

NORTH AMERICA

USA
Saint-Gobain Quartz USA
10300 Ormsby Park Place
Suite 450
Louisville, KY 40223-6185
Tel West: (1) 502-423-6341
Tel East: (1) 502-423-6342
Fax: (1) 502-423-6369
E-mail: quartz.sales@saint-gobain.com

ASIA

China
Saint-Gobain Quartz Co., Ltd
Room 1706, Ocean Tower,
550 Yan An Dong Road – Shanghai,
200001
Tel: (86) 21 6322 3618
Fax: (86) 21 6322 0911
E-mail: quartz.sales.china@saint-gobain.com

Japan
Saint-Gobain KK
3-7 Kojimachi, Chiyoda-ku
Tokyo 102-0083
Tel: (81) 3 3263 0282
Fax: (81) 3 3264 6010
E-mail: quartz.sales.jp@saint-gobain.com

Korea
Saint-Gobain Advanced Materials Korea Co., Ltd
13th Floor Dongshin Building
141-28, Samsung-Dong
Kangnam-Ku – Seoul 135-090
Tel: (82) 2 538 7367
Fax: (82) 2 538 7368
E-mail: sgacsel@unitel.co.kr

Taiwan R.O.C.
Saint-Gobain Advanced Materials Taiwan Co., Ltd
Suite 1203
147, ChienKwo North Road,
Section 2, Taipei
Tel: (886) 2 2503 4201
Fax: (886) 2 2503 4202
E-mail: sgactw@ms19.hinet.ne

SAINT-GOBAIN
QUARTZ

Saint-Gobain Quartz S.A.S.
B.P. 102
77793 Nemours Cedex
France
Tel: (33) (0)1 64 45 45 00
Fax: (33) (0)1 64 28 45 11
E-mail: quartz.sales.fr@saint-gobain.com

Visit our web site:
http://www.quartz.saint-gobain.com

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