Science.
Applied to Life.™

3M™ Nextel™ Ceramic Textiles, Fibers and Composites

Pushing the limits.

High performance materials for extreme environments

3M™ Nextel™ Ceramic Fibers, Textiles and Composites

Take your imagination to the next level.

Throughout recorded history – from the bronze and iron age, right up to our present age – human progress has been greatly influenced and defined by the advancement of material science.

Each step forward in our ability to understand and manipulate the materials found in nature has pushed back the boundaries of what is possible and has extended our reach into places our ancestors could only dream of.

One of humankind's oldest material technologies – ceramics – continues to evolve for use in a wide range of demanding applications and harsh environments. In general, ceramics are hard, wear resistant, electrically and thermally insulative and capable of surviving extremely high temperatures. These and other intrinsic properties are the reason why advanced ceramic materials – such as 3M™ Nextel™ Ceramic Textiles, Fibers and Composites – are helping customers around the world push the boundaries of what is possible.

Built to survive

3M™ Nextel™ Ceramic Fibers and Textiles are high-performance, high-temperature materials made of continuous polycrystalline metal oxide fibers with a filament diameter of 8 to 14 µm. These versatile materials meet the most demanding thermal, mechanical and electrical performance requirements of many industrial, petrochemical, and aerospace applications.

Nextel ceramic textiles exhibit excellent dimensional stability and low thermal conductivity, as well as non-porous and non-hygroscopic characteristics. They retain their flexibility even at continuous temperatures of up to 2372°F (1300°C).

Due to their continuous form, high strength and flexibility, Nextel ceramic fibers can be processed using conventional textile technology such as weaving and braiding. Nextel ceramic textiles are semi-finished products offered in the form of rovings, yarns, sewing threads, fabrics, tapes and braided sleevings. Nextel ceramic fibers and textiles are also increasingly used in the development of continuous-fiber reinforced composite materials, including Ceramic Matrix Composites (CMCs), Polymer Matrix Composites (PMCs), and Metal Matrix Composites (MMCs).

Discover how the performance and unique properties of Nextel ceramic fibers and textiles can help in your applications. Key benefits include:

- Temperature resistance up to 2372°F (1300°C)
- High strength and stiffness
- Thermal shock resistance
- Fire resistance
- Chemical resistance
- Electrical resistance at elevated temperatures
- Abrasion and impact resistance

3M™ Nextel™ Ceramic Fabrics 312 and 440 are used for a variety of high temperature sealing and heat shielding applications, performing beyond the limits of conventional high temperature textiles such as aramids, carbon, quartz and glass. They are oxidation resistant, chemically inert, lightweight, flexible, flame resistant, and electrically insulating at high temperatures. As such, they are an excellent choice for applications such as door seals, rotary kiln seals and furnace linings.

Physical properties

3M™ Nextel™ Ceramic Fiber 312, 440, 610 and 720 Typical Properties

(Not for specification purposes)

Property	Units	Nextel 312	Nextel 440	Nextel 610	Nextel 720
Chemical Composition	wt. %	62.5 Al_2O_3 24.5 SiO_2 13 B_2O_3	70 Al_2O_3 28 SiO_2 2 B_2O_3	>99 Al_2O_3	85 Al_2O_3 15 SiO_2
Melting Point	˚C	1800	1800	2000	1800
Continuous Use Temperature (40% fiber strength retention)[1]	˚C	1200	1300	—	—
Continuous Use Temperature (Single Filament ≤1% strain)[2]	˚C	—	—	1000	1150
Filament Diameter	µm	8 – 12	10 – 12	11 – 13	12 – 14
Denier/Nominal Filament Count	g/9000 m	600 / 400 900 / 400 1200/750 1800 / 750 3600 / 1375	1000 / 400 2000 / 750	1500 / 400 3000 / 750 4500 / 1125 10000 / 2550 20000 / 5100	1500 / 400 3000 / 750 10000 / 2550
Tex/Nominal Filament Count	g/1000 m	67 / 400 100 / 400 133 / 750 200 / 750 400 / 1375	111 / 400 222 / 750	167 / 400 333 / 750 500 / 1125 1111 / 2550 2222 / 5100	167 / 400 333 / 750 1111 / 2550
Crystal Size	nm	<500	<500	<500	<500
Crystal Phase		Distorted Mullite+ amorphous	γ-Al_2O_3 + amorphous	α-Al_2O_3	α-Al_2O_3 + Mullite
Density	g/cc	2.8	3.0	3.9	3.4
Refractive Index		1.57	1.61	1.74	1.67
Filament Tensile Strength (25.4 mm gauge)	MPa ksi	1630 236	1840 267	2800 406	1940 281
Filament Tensile Modulus	GPa msi	150 22	190 27	370 54	250 36
Thermal Expansion 212-2012°F (100-1100˚C)	ppm/˚C	3.0 77-212°F (25-500˚C)	5.3	8.0	6.0
Dielectric Constant @ 9.5 GHz	3a 3b	2.7 4.8	2.8 5.0	4.7 6.9	3.8 6.2
Loss Tangent @ 9.5 GHz	3a 3b	0.003 0.004	0.001 0.001	0.002 0.002	0.001 0.001
Specific Heat @ 743°F (395˚C)[4]	cal/g/˚C	0.46	0.51	0.38	0.58

[1] Tested at room temperature after 100 hours soak.
[2] Tested under 69 MPa after 1000 hours.
[3a] As per standard IEC 61189-2-721: AF-20 (312), BF-20 (440), DF-19 (610) and EF-19 (720) heat clean fabrics were used to run dielectric data using cavity method.
[3b] Test data after Air part subtracted.
[4] Test ran on fibers heat treated at 950˚C for 1 hour.

Harnessing the power of advanced ceramics

Excellent thermal shielding

3M™ Nextel™ Ceramic Textiles feature excellent resistance to thermal shock and can be fabricated into high temperature thermal insulation.

High thermomechanical integrity

Nextel ceramic textiles retain greater strength and flexibility at higher temperatures than other refractory textile materials.

High electrical resistance

Nextel ceramic textiles' high electrical resistance at elevated temperatures make it an excellent choice for high temperature electrical insulation applications.

Low shrinkage

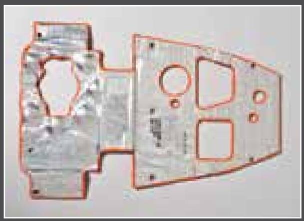
Nextel ceramic textiles exhibit very low shrinkage, providing excellent dimensional stability.

Non-hygroscopic

The smooth, non-porous surface of Nextel ceramic textiles only gains 0.08% of its weight after several hours exposure to 100% humidity.

Aviation

3M™ Nextel™ Ceramic Textiles, Fibers and Composites are found in nearly every commercial jetliner in the world, and are widely used in many military aircraft applications. That's because Nextel ceramic textiles can withstand extremely high temperatures and are extraordinarily durable, yet are also flexible and lightweight, meeting stringent FAA criteria for aircraft firewalls. They are also used as structural reinforcements in advanced metal and polymer composite materials for load-bearing applications.



Firewalls, fan cowls, engine struts and other jet engine components need to withstand a great deal of stress from high temperatures, punishing vibration and – above all – the threat of flame. If a fire should occur, firewalls made of Nextel ceramic fabrics have proved to meet the FAA's 2000°F (1093°C) 15 minute flame penetration requirement – at a lighter weight and with easier maintenance than metal shields. Nextel products are also used for high temperature sealing, electrical insulation for aircraft wiring, and as structural reinforcement for ceramic matrix composite (CMC) exhaust components.

According to FAA fireproofing regulations, commercial engine cowlings must be capable of withstanding a flame of 2000°F (1093°C) for 15 minutes without flame penetration. Nextel ceramic textiles help manufacturers exceed this requirement.

Outer space

3M™ Nextel™ Products have long been used on spacecraft for heat shielding and impact protection, in applications ranging from door seals, gaskets and gap fillers to tiles for the space shuttle. For example, blankets sewn from Nextel textiles protect the Delta II rocket engine from the plume of the solid boosters, and whipple shields made with Nextel fabrics defend the International Space Station and satellites against impact by micrometeorites and space debris.

Photo courtesy of Deutsches Zentrum für Luft- und Raumfahrt e. V.

WHIPOX® reinforced with Nextel ceramic textiles is used as re-usable thermal protection for the SHEFEX (Sharp Edge Flight Experiment) project. The resulting material is light weight and resistant to the extreme temperatures of re-entry 2,912°F (1,600°C).

Photo courtesy of Thermostatic Industries, Inc.

Nextel ceramic fabrics have been sewn into blankets to protect the liquid fueled engine of the Delta II rocket from the plume of the solid propellant boosters. These materials can be formed into blankets or other configurations to meet the needs of a wide range of applications.

Designed to protect spacecraft against collisions with micro-meteorites, the stuffed Whipple shield – produced at both the Johnson Space Center in Houston, Texas and the NASA Marshall Space Center in Huntsville, Alabama – utilizes Nextel ceramic fabrics for their durability and light weight.

Applications

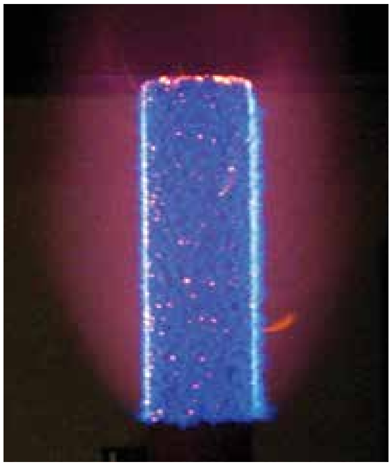
High temperature industrial

3M™ Nextel™ Ceramic Fabrics 312 and 440 are used in a variety of high temperature sealing and heat shielding applications, such as door seals, rotary kiln seals and furnace linings. They meet the toughest thermal, mechanical and electrical performance requirements, performing beyond the limits of common high temperature textiles such as aramids, carbon, quartz and glass. They are also oxidation resistant, chemically inert, lightweight, flexible, flame resistant, and electrically insulating at high temperatures.

Infrared Gas Burners

3M™ Nextel™ Ceramic Fabrics combine fast heat transfer with high temperature resistance and shock resistance, making them ideal for gas-fired infrared heating solutions, such as barbecues, broilers and fireplaces. When used as water heater burners, they produce 85% lower NOx emissions than conventional flame burners.

Photos courtesy of Innovative Thermal Systems, LLC.



The flexibility, high temperature stability and permeation uniformity of Nextel fabrics enables simpler fabrication in various burner shapes, including circular, ovals, flat and more.

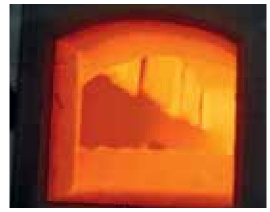
Furnace Linings

3M™ Nextel™ Ceramic Fabrics prevent the erosion of ceramic bulk fiber modules. This helps to reduce dust, which can contaminate products and may be a concern for operators and nearby personnel. Reducing erosion of insulation structures may also help reduce maintenance costs and time.

Photo courtesy of Insulcon B.V.

Zone Dividers

Nextel ceramic fabrics can be used as textile separators in heat treating furnaces operating at extremely high temperatures.



Photos courtesy of Insul.Tecno Group Srl.

Photo courtesy of Thermostatic Industries, Inc.

Heat Shields

3M™ Nextel™ Ceramic Fabrics, Woven Tapes and Braided Sleevings can be sewn and converted into an endless number of forms, including heat shields to protect specific areas, pads for assisting the transportation of high-temperature material, ropes for use as gasket material, or even as ties for securing an object within a high-temperature location.

Door Seals and Gaskets

Float glass furnaces typically require very tight temperature control and temperature uniformity. These requirements demand reliable door seals. The seals shown at right were made using a Nextel ceramic fabric, braided over a core of insulation. A typical seal must withstand numerous thermal and mechanical loading cycles. During each cycle, there is a possibility for wear as the seal presses against the surfaces. Seals made with Nextel fabric remain flexible at high operating temperatures, thereby extending the lifetime of the seal.

Seals with complex geometry (e.g. tadpole gaskets) made with Nextel ceramic fabrics can be used where uneven flanges and surfaces are present. The seals can be attached to metal or refractory surfaces by bolting or metal strapping, or by welding.

Photos courtesy of Thermostatic Industries, Inc.

Photo courtesy of Garnisch GmbH.

Photo courtesy of Schniewindt GmbH & Co. KG.

Covering for high temperature resistant wire and cable

3M™ Nextel™ Ceramic Yarns / Braider Packs are useful for electrical applications, offering excellent electrical insulation properties as well as heat protection – for thermocouples and other critical wiring systems in extreme environments.

Petrochemical industry

Used in applications such as process heaters and furnace reformers, 3M™ Nextel™ Ceramic Textiles can provide improved temperature resistance to internal and external tube seals and expansion joints. Nextel ceramic textiles can also be used as heat shields for radiant coils to help prevent coke formation and reduce premature aging of the tube surface. They are oxidation resistant, chemically inert, lightweight, flexible, flame resistant, and electrically insulating at high temperatures.

- Heat resistant up to 2372°F (1300°C)
- Good dynamic thermal and mechanical insulation properties
- Low shrinkage (less than 3% over 15 hours at 2372°F (1300°C))
- Resistant to corrosion and abrasion
- Long life in high temperature environments
- No residual acids or chlorides to leach out and cause etching of metal

Photo courtesy of Flextech Engineering, Inc.

Tube Seals

Engineered to operate at temperatures 900°F–2372°F (482°C–1300°C), tube seals made from 3M™ Nextel™ Ceramic Fabrics 312 and 440 maintain their shape in environments found in process heaters and furnace reformers, while helping to prevent the formation of harmful emissions. Because they are flame resistant, they are also a safety measure against potentially damaging flames from a draft fan failure.

Photo courtesy of Insul. Tecno Group Srl.

Expansion Joints

Expansion joints in petrochemical facilities are typically subject to extreme temperatures, high pressures, vibration and exposure to aggressive chemicals. Nextel ceramic textiles are manufactured to survive these kinds of harsh operating conditions, to help ensure equipment reliability and extend service life.

Photo courtesy of Insulcon B.V.

Heat Shields

Nextel ceramic fabrics are used in applications such as radiant coils, to help decrease the formation of coke, while helping to prevent premature aging of the tube skin.

Applications

Composites

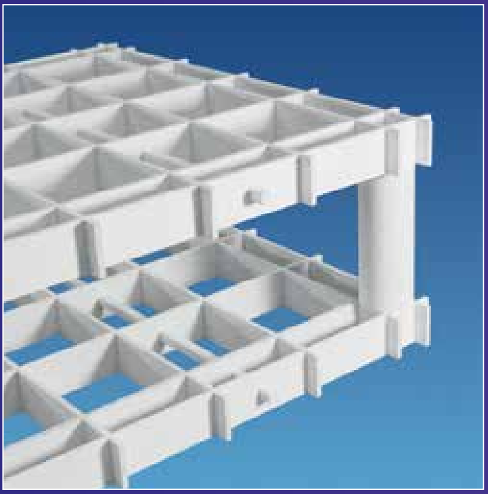
3M™ Nextel™ Ceramic Fibers are used as structural reinforcements in a variety of metal, ceramic and polymer composites, making them stiffer and stronger while imparting other useful characteristics.

Ceramic Matrix Composite (CMC)

Because of their strength, light weight, creep resistance and ability to withstand higher temperatures, ceramic matrix composites are being used in an increasing number of demanding applications such as jet engines, gas turbines and industrial furnaces to replace metals and metallic alloys. CMCs reinforced with 3M™ Nextel™ Ceramic Fibers enable the production of components with complex geometries that are resistant to oxidation and thermal shock.

Photo courtesy of Composites Horizons, Inc.

Photo courtesy of Composites Horizons, Inc.



(Photo courtesy WPX Faserkeramik GmbH)

Ceramic Matrix Composites based on Nextel ceramic fibers are being used in high temperature metal treating environments as a charge carrier support to help mitigate oxidation issues.

(Photo courtesy WPX Faserkeramic GmbH)

CMCs made with Nextel ceramic fibers offer low thermal capacity and good thermal heat permeability as protective tubes and kiln rollers.

Polymer Matrix Composite (PMC)

Strong, lightweight and stiff, PMCs reinforced with 3M™ Nextel™ Ceramic Fibers are ideal for use in a wide range of aviation applications, including radomes, ducting and other structural components. They offer very high compressive strength and are electrically non-conductive and electromagnetically transparent.

Because of their electromagnetic transparency, PMCs made with Nextel ceramic fibers are ideal for applications such as aircraft radomes.

Polymer based composites reinforced with Nextel ceramic fibers are designed for applications requiring strength and stiffness combined with electrical non-conductivity and electromagnetic transparency, such as structural aircraft components, rotor blades and radomes.

Metal Matrix Composite (MMC)

Metal matrix composites reinforced with 3M™ Nextel™ Ceramic Textiles enable the production of high performance components that are half the weight of steel or cast iron, but with equal or better strength and stiffness. As such, they can be used in a variety of automotive applications, either as complete components or as reinforcing inserts into other materials. For example, MMCs using Nextel ceramic textiles have been used in aluminum disc brake calipers and pushrods, to significantly reduce component weight, while maintaining desired stiffness.

Made from continuous alpha alumina fibers, 3M™ Nextel™ Ceramic Fiber 610 works especially well in aluminum matrix composites.

Metal matrix composite brake calipers employing Nextel ceramic textiles are half the weight of steel or cast iron, but with equal or better strength and stiffness.

3M™ ACCR (Aluminum Conductor, Composite Reinforced) is an advanced type of power transmission cable that employs a proprietary 3M metal matrix composite technology to significantly increase ampacity, compared to conventional steel cable. With less sag under heat load, ACCR has also proven to be especially effective for use in long span applications, such as river crossings.

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