Sudaglass Fiber Technology

What is Basalt Continuous Filament?

Overview

- **Man-made fiber made from melted Basalt Rock**
- **Made using only crushed basalt, no added chemicals**
- **Produced by methods similar to fiberglass production**
- **Tensile strength is in-between E-Glass and carbon fiber**
- **Heat resistance is in excess of asbestos without carcinigenic issues**
- **Cost is more than E-Glass, but less than S-Glass, much less than carbon fiber**
- **Limited supply today, but in medium-term all that market is ready to pay for.**

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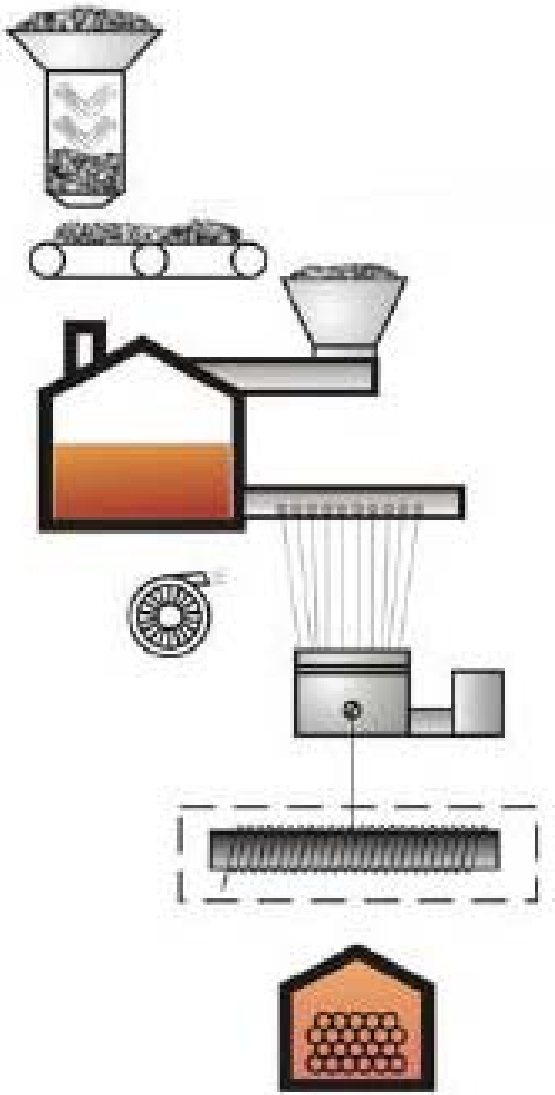
How is it manufactured?



Natural Basalt Volcanic Rock is:

- Mined and crushed to gravel size
- Fed into a special furnace for melting
- Drawn from a “bushing” made from platinum and rhodium
- Cooled by mist of water and sizing
- Wound onto high-speed winders
- Dried in ovens
- Reprocessed into rovings, yarns, and chopped fiber

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Not Invented Here!

- **Technology was developed by research bureaus in the Soviet Union in 1960-1980. Tens of millions of dollars were spent on development.**
- **Originally a “black” program for military and aerospace applications**
- **First application reportedly for ICBM re-entry nose cones**
- **Known to be used in 1980’s for blast shields for mobile missile launchers**
- **Very limited production, solely for military use**

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Where Is It Made Today?

- **Original military production was in Georgia and Khazakstan. (very limited)**
- **Today plants are in operation in Russia, Ukraine, Georgia, and China (PRC)**
- **World production today is in range of 5,000-8,000 metric tons per year.**
- **Production from these plants will double within 18 months**
- **<u>US production is coming soon!</u>**

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Why Should You Care?

- **Basalt Fibers will become a standard industrial product over the next few years**
- **Basalt Fibers are an inexpensive alternative to costly materials for demanding applications**
- **Basalt Fibers have thermal properties that exceed asbestos!!**
- **Basalt Fibers have no health or environmental issues, can be recycled.**

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Why Am I So Sure You Will Be Using Basalt Fibers in the Future?

- **Raw material cost for Basalt Fiber is less than $5/ton if the plant is located near the basalt quarry**
- **Fiberglass (E-Glass) raw material cost exceeds $300/ton**
- **There is no real limit on expansion of production of Basalt Fiber except capital cost of building plants**
- **The only environmental issue that affects Basalt Fiber production is the need to burn fuel to melt the rock**
- **There is no possibility of running out of the raw material (crushed basalt rock) for making Basalt Fiber**

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Comparative Properties

Tensile Strength

Fiber Type	Tensile Strength, M Pa
E-Glass	2,500
S-Glass	4,500
Basalt	4,840
Kevlar	3,300
Carbon	2,000-7,000

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Comparative Properties

Elastic Modulus

Fiber Type	Modulus, G Pa
E-Glass	71
S-Glass	87
Basalt	89
Kevlar	128
Carbon	225-300 +

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Comparative Properties

Elongation at Break

Fiber Type	Elongation, %
E-Glass	5.3
S-Glass	4.3
Basalt	3.2
Kevlar	2.5
Carbon	1.7

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Comparative Properties Temperature Range

Fiber Type	Maximum Application Temp	Maximum Sustained Application Temp	Minimum Application Temp
E-Glass	650 C 1,200 F	480 C 900 F	-60 C -76 F
S-Glass	875 C 1,600 F	845 C 1,550 F	
Basalt	980 C 1,800 F	850 C 1,560 F	-260 C -435 F
Carbon		500 C 930 F	

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Other Interesting Properties of Basalt Fiber Products

- Excellent sound absorption attenuation
- Does not absorb or wick water like fiberglass
- Does not conduct electricity, no fields induced when exposed to RF radiation
- Transparent to RF and Microwave radiation
- Highly resistant to nuclear radiation
- Very high acid and alkali resistance
- Not subject to biologic contamination

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Roving

Basic output of Basalt furnaces is roving.

Each orifice (tip) in the bushing produces one filament.

Bushings range from 200-800 tips, so this number of filaments is wound onto the winder as a unit. These filaments are not twisted together, but form a flattened bundle.

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Roving

From the winder, the roving is reprocessed into more complex products.

It can be combined into rovings with greater number of filaments.

The rovings can be twisted to form yarns.

Complex yarns may have rovings twisted in different directions to balance the twisting properties of the yarns.

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Roving

The individual filaments produced can range from 6-microns to 23 microns in diameter.

Rovings come in a multitude of weights, usually measured in:

TEX (grams per 1,000 meters) or

DENIER (grams per 8,000 meters) or

YIELD (yards per pound)

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Roving

Readily available rovings range from 68-4,800 Tex

(8-600 Denier, yield 7,300 -104)

Rovings are available in various size spools, generally 6-35 lbs.

Core sizes can be custom ordered to fit existing machinery.

Spools can be outside or inside pull

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Roving

Basalt filaments are coated in various sizings as part of the production process.

Many different sizings are available to match different uses.

Common sizings include silane (epoxy compatible) and PVAC. Others available on special order.

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Chopped Fiber

Roving can be further processed by chopping to various lengths

Typical lengths are 3 mm to 100 mm.

Uses include:

- **polymer reinforcement**
- **concrete reinforcement**
- **needle-punching into non-woven mats**

Compatibility with Existing Equipment

In general, equipment that handles fiberglass roving or chopped fiber can be used to process basalt fibers with only minor adjustments.

Filament Diameter—Size Does Matter

- **Basalt filaments are crystalline solids.**
- **Fiberglass filaments are amorphous solids.**
- **This has important implications for filament properties.**

Since the filaments go from liquid to crystalline in less than a meter while they are being drawn, smaller diameter filaments have a more consistent crystallization structure than larger ones.

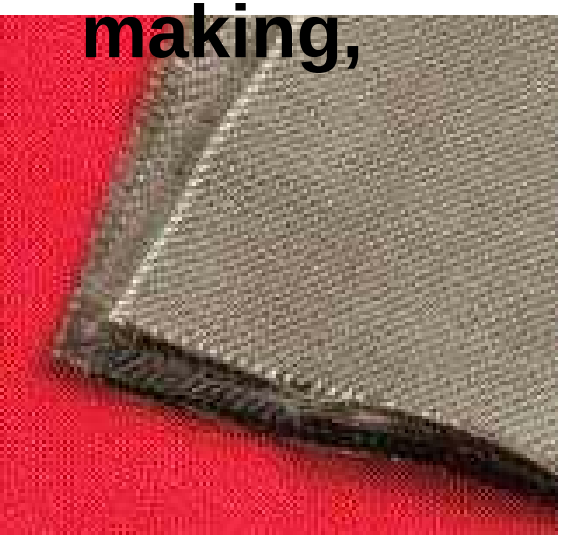
Published tensile strength numbers should be interpreted as applying to 9-micron filaments.

Basalt Filament Engineered Products

Fabrics

Basalt rovings and yarns can be woven into a variety of fabrics. Generally, filaments of 9-micron or smaller are used in weaving fabrics.

Fabrics are used for polymer reinforcement, fire curtains, thermal barriers, concrete panel making,



protective garments, structural fabrication, ballistic protection, filtration.

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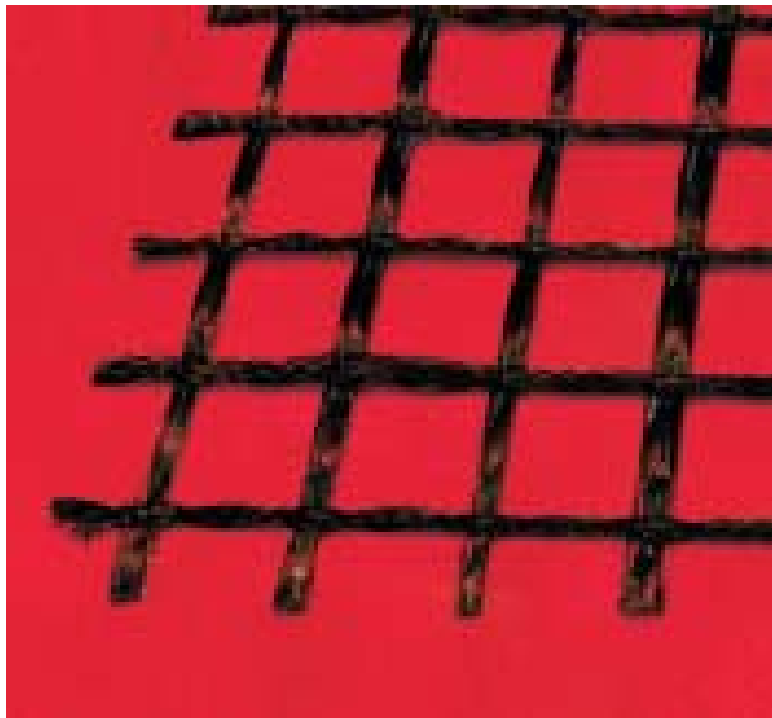
Basalt Filament Engineered Products

Meshes

Basalt filaments are available in reinforcing meshes ranging from light-weight scrims to heavy GeoGrid, used in reinforcing asphalt and concrete pavings.



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Basalt Filament Engineered Products

Non-Woven Mat

Basalt filaments can be needle-punched into felts or mats that have excellent insulating and heat-blocking characteristics.

Basalt Filament Engineered Products

Basalt filaments can be combined with various polymers or other binders to produce lightweight structural members with exceptional strength.

These products are stronger than steel with immunity to corrosion.

Basalt Filament Engineered Products

Unlike steel or carbon fiber based composites, basalt composites do not conduct electricity or create electrical fields when exposed to RF radiation.

They are also transparent to RF and microwave energy.

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Projected Uses of Basalt Filaments in Naval Shipbuilding

1. **Replacement of asbestos for thermal control.**

Virtually any requirement that was formerly satisfied with asbestos materials can safely accomplished with basalt fiber.

This includes high-temperature insulation, fire-proofing, fire protection for personnel, fire protection for structural members, and friction surfaces.

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Projected Uses of Basalt Filaments in Naval Shipbuilding

2. Ballistic protection and anti-fragmentation.

Basalt filaments have not yet been proven for anti-small arms fire. Testing continues on this front.

Basalt products have shown excellent results in protecting against fragments from explosive munitions.

There is potential for light-weight, effective protection for combat personnel

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Projected Uses of Basalt Filaments in Naval Shipbuilding

3. Structural reinforcement in high RF radiation environments.

Because magnetic fields are not induced when basalt fibers are exposed to RF, it can be used to replace fiberglass in this application, with much higher strength and higher temperature tolerance.

Steel and carbon fiber are not suitable in this application.

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Projected Uses of Basalt Filaments in Naval Shipbuilding

4. Structural elements, such as rails, decks, partitions

Basalt combined with the right polymer matrix allows the manufacturing of light-weight structural elements than can reduce weight, resist corrosion, and remain invisible to enemy radar.

Critical weight can be eliminated high in the ship structure without sacrificing strength.

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Projected Uses of Basalt Filaments in Naval Shipbuilding

5. Applications in high nuclear-radiation environments

Basalt products can be used in critical insulation, shielding, and structural applications in or near nuclear reactors.

Basalt has a natural resistance to damage by nuclear radiation.

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Projected Uses of Basalt Filaments in Naval Shipbuilding

6. Sound deadening and absorption

Basalt products have a superior natural ability to absorb and attenuate sounds.

Basalt mat products can be used to sound-proof noisy systems for military needs.

They can also be used to make crowded environments more livable in crew areas.

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Projected Uses of Basalt Filaments in Naval Shipbuilding

7. Replacing fiberglass and carbon in boats.

Basalt fibers cost a fraction of carbon fiber.

Basalt does not absorb or wick water, which leads to delamination, a constant problem with fiberglass.

Any composite material that requires constant or long-term exposure to water will benefit from basalt filaments.

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Projected Uses of Basalt Filaments in Naval Shipbuilding

8. Replacing steel reinforcement in concrete for on-shore facilities near salt water.

Basalt rebar and reinforcing mesh does not corrode. Spalling from corroded reinforcing steel is the leading cause of concrete failure in high-moisture and salt-air environments.