STERLING TECHNICAL FIBERS

Acrylic Pulps and Fibers for Non-Asbestos Friction Materials

- General Information

    - Founded in 1957, Sterling Fibers specializes in the design and manufacturing of high performance fibers for the friction materials industry.
    - Health, safety and the environment are a priority for our business.
    - ISO 9001:2008 certified
    - Headquartered in Pace, Florida within the 1200 acres Sterling Industrial Park

- Technical Fibers

    - Acrylic fiber technology base
    - Engineered materials approach
    - High degree of technical support
    - Lower cost alternatives to aramid fibers for:
        - Non-asbestos friction materials
        - Non asbestos gaskets
        - Specialty papers and nonwovens
        - Fiber reinforced materials

- Sales and Technical Support

    - Sterling Fibers, Inc.
      5005 Sterling Way
      Pace, FL 32571 USA
      Tel: 800 342 3779 (toll free in USA) or Tel: 850 994 5311
      Fax: 850 994 2579
      Technical Support: Jim Hagerott jhagerott@sterlingfibers.com
      Customer Service: customerservice@sterlingfibers.com
      Website: www.sterlingfibers.com

Sterling Fibers, Inc.
5005 Sterling Way
Pace, FL 32571

TEL: (850) 994-5311 x618
FAX: (850) 994-2579
EMAIL: jhagerott@sterlingfibers.com

Technical Fact Sheet

Acrylic Fibers and Pulps for the Friction Material Industry

Sterling Fibers is the technology leader for a variety of engineered fibers and pulps designed specifically to provide innovative solutions for all of the various requirements and processes in the NON-ASBESTOS friction material industry, as summarized in the table below:

Application	Function	Product Form	Products Available
Automotive Disc Pads / Truck Blocks / Linings (Dry Mixed)	Combined Preform Strength / Mix Homogeneity / Friction Stability	Dry Pulp	CFF® V110-1, CPF 200 series
Automotive Disc Pads / Truck Blocks / Linings (Dry Mixed)	Mix Homogeneity Processing	Dry Pulp	CFF® V125-1
Automotive Disc Pads / Truck Blocks / Linings (Dry Mixed)	Short Fiber Processing / Reinforcement	Dry Pulp / Fiber Blends	CPF 400 series
Friction Papers	Paper Web Formation / Binding / Controlled Paper Porosity	Wet Pulp	CFF® 111-3 CFF® 500 series
Roll Linings / Segments / Wet Resin Mixes	Processing / Crack Resistance / Fracture Toughness	Short Cut Staple Fiber	CTF 395, CTF 525

Sterling Fibers, Inc.
5005 Sterling Way
Pace, FL 32571

TEL: (850) 994-5311 x618
FAX: (850) 994-2579
EMAIL: jhagerott@sterlingfibers.com

CFF® V110-1 Fibrillated Fiber is our flagship product for friction materials. It is a dry, high surface area acrylic (PAN) pulp used for combined mix homogeneity and preform strength in non asbestos disc pad, truck block, railway and industrial formulations. It offers equal performance to aramid pulp at a lower cost when used as a processing aid. CFF® V110-1 has been commercially available since 1988 and tens of millions of pounds have been used world wide. Extensive customer dynamometer and vehicle tests have demonstrated the excellent frictional stability of formulations containing these PAN fibers, and have resulted in increasing usage in both OEM and aftermarket formulations.

CPF 200 Series Fibers are composite blends of acrylic materials which are less fibrillated, lower cost alternatives to CFF® V110-1 and are used for preform strength in non asbestos disc pad and truck block applications. They are used mainly in formulations that may be easier to preform than standard formulations. CPF 200 Series products are chemically identical to CFF® V110-1 pulp.

CFF® V125-1 Fibrillated Fiber is a specially designed pulp which is smaller in both diameter and length. It has been specifically designed as a processing aid to prevent mix segregation in dry mix formulations for direct powder molding processes.

CPF 400 Series Fibers are special blends of acrylic pulp and reinforcing fibers. The fibers and pulp have been blended in such a way that the short cut staple fibers will not ball in dry mixed formulations when introduced into the Littleford or Lodige mixer. Blends with acrylic staple, melamine, and fiberglass are currently available. The process has also been demonstrated with carbon, basalt, and aramid short cut fibers. This technology could be extended to virtually any short cut staple reinforcing fiber where balling is a problem. Previous to the development of CPF 400 technology, compounders were limited to the use of very short fibers of about one millimeter or less, the use of aramid or acrylic pulps, or the use of controlled strand integrity fiber bundles.

CFF® 111-3 Fibrillated Fiber is a high surface area acrylic pulps used in wet-laid friction papers. The amount of refining is controlled to permit excellent control and design of sheet porosities, as well as high binding efficiency with various short reinforcing fibers, including carbon, rayon, and aramid.

CTF 525 Short Cut Staple Fiber is a high tenacity, high modulus second generation acrylic fiber used to improve crack resistance and fracture toughness in friction materials. Fiber lengths of 1.5 mm, 3 mm and 6 mm are available. CTF 525 exhibits excellent adhesion to phenolic resins and splits / fibrillates to absorb crack energy.

CTF 395 Short Cut Staple Fiber is an economical acrylic fiber used for reinforcement in roll linings, segments, and wet resin mixes. It can be provided in a range of fiber lengths from one millimeter to 10 millimeters.

CFF® 500 Series Fibers are high molecular weight homopolymer polyacrylonitrile (PAN) fibers with superior mechanical properties and excellent thermal and environmental resistance compared to typical synthetic fibers, but with the high surface area and branched structure of our conventional acrylic pulps.

IMPORTANT NOTICE

Sterling Fibers, Inc.
5005 Sterling Way
Pace, FL 32571

TEL: (850) 994-5311 x618
FAX: (850) 994-2579
EMAIL: jhagerott@sterlingfibers.com

Technical Fact Sheet

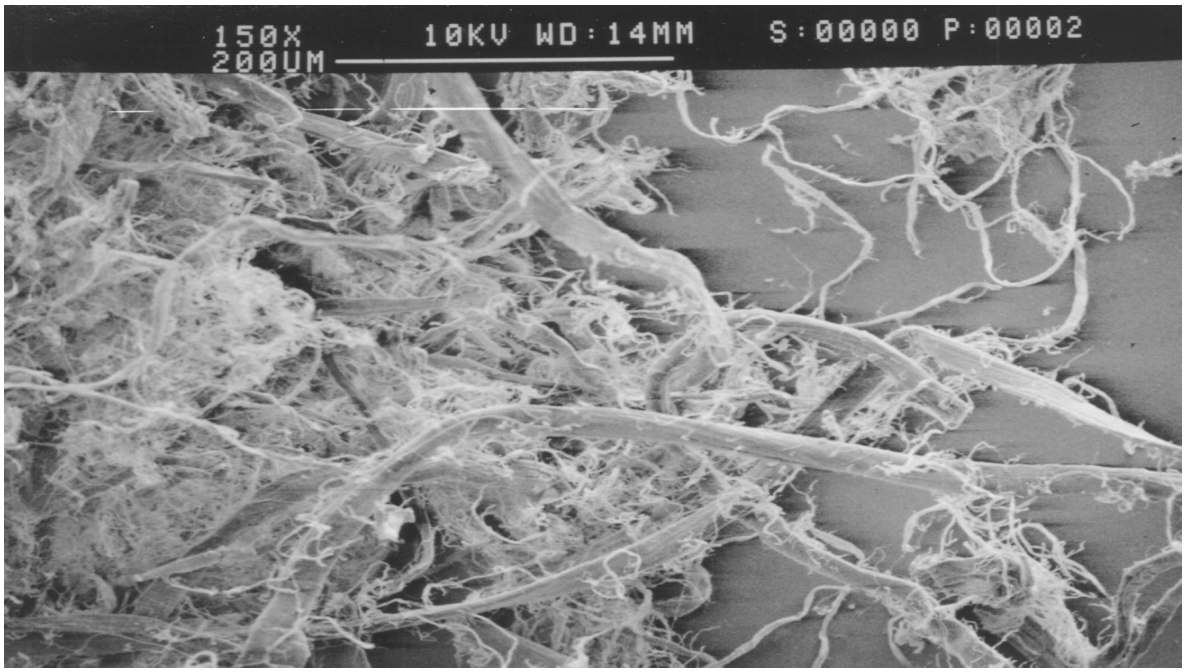
CFF® V110-1 Fibrillated Acrylic Pulp

General Description

The use of organic pulp to improve processing of dry mix asbestos free brake formulations became particularly important with the commercialization of non asbestos friction materials. Sterling Fibers has engineered a unique fiber that has both a high degree of fibrillation as well as a carefully controlled fiber length. This special fiber architecture provides the needed green strength for processing dry mixed friction materials.

CFF® V110-1 fibrillated fiber is being used commercially as a processing aid in the production of disc pads, truck blocks, and rail blocks as a direct replacement of aramid. CFF® V110-1 offers equal performance to aramid pulp at a lower cost when used as a processing aid. CFF® V110-1 has been commercially available since 1988 and tens of millions of pounds have been sold world wide. Extensive customer dynamometer and vehicle tests have resulted in increasing usage in both OEM and aftermarket formulations.

Photo Micrograph of CFF® V110-1



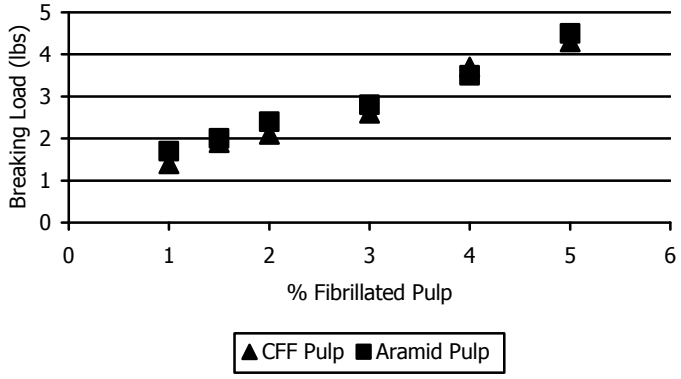
Sterling Fibers, Inc.
5005 Sterling Way
Pace, FL 32571

TEL: (850) 994-5311 x618
FAX: (850) 994-2579
EMAIL: jhagerott@sterlingfibers.com

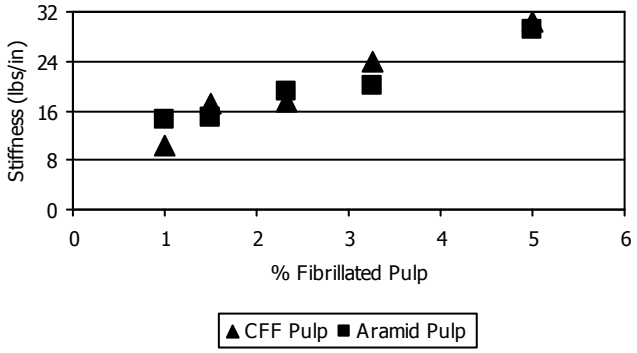
Typical Physical Properties

Canadian Standard Freeness	225 - 325 ml
BET Surface Area	50 m^2/g
Typical Fiber Length	6.5 mm
Appearance	Fine white pulp
Moisture Regain	2 %
Char Yield at 500 ^oC	65 %
Charge	Slightly Anionic (1/4 of aramid)
Specific Gravity	1.17
Modulus	6.0 GPa
Strength	450 MPa
Moisture Resistance	Excellent
Hydrocarbon Resistance	Excellent
Solvent Resistance	Good
Effect of Age	None
UV (Sunlight) Resistance	Excellent

Disc Pad Preform Strength
CFF Pulp vs. Aramid Pulp



Disc Pad Preform Stiffness
CFF Pulp vs. Aramid Pulp



IMPORTANT NOTICE

Sterling Fibers, Inc.
5005 Sterling Way
Pace, FL 32571

TEL: (850) 994-5311 x618
FAX: (850) 994-2579
EMAIL: jhagerott@sterlingfibers.com

Technical Fact Sheet

CPF 200 Series Acrylic Processing Aids

General Description

CPF 200 Series technology was developed in response to the friction materials industry needs for lower cost materials. CPF 200 series processing aids are composite materials based on acrylic fiber chemistry. This is a patented technology which can be specifically engineered to meet an individual customer's requirements.

Comparison of Preform Properties, 3% Fiber

Property	Unit	CFF® V110-1	CPF 207	CPF 205
Mix Bulk Density	lbs/ft^3	26.9	27.1	27.3
Preform Strength	lbs	1.91 +/- .09	1.76 +/- .16	1.55 +/- .06
Preform Stiffness	lbs/in	40 +/- 3	37 +/- 2	34 +/- 1
Thickness	in	.995 +/- .003	.992 +/- .003	.989 +/- .003
Recovery	%	5.2 +/- .2	5.4 +/- .2	5.3 +/- .2
Appearance	-	High integrity preform, no cracking or crumbling, good uniformity	High integrity preform, no cracking or crumbling, good uniformity	High integrity preform, no cracking or crumbling, good uniformity
Chemical Composition	-	AN/VA	AN/VA	AN/VA
Additives	-	None	None	None
Ease of Opening	-	Good	Good	Good
Dust Suppression	-	Good	Good	Good

Sterling Fibers, Inc.
5005 Sterling Way
Pace, FL 32571

TEL: (850) 994-5311 x618
FAX: (850) 994-2579
EMAIL: jhagerott@sterlingfibers.com

Technical Fact Sheet

CFF® V125-1 Fibrillated Acrylic Pulp

General Description

CFF® V125-1 is a fibrillated acrylic pulp with similar surface area to CFF® V110-1, but with a reduced average fiber length and smaller fiber diameter. This highly fibrillated structure contributes to mix uniformity, improved particle retention, and dust suppression in dry mix formulations. Due to its shorter fiber length, CFF® V125-1 pulp provides a lower increase in mix bulk volume relative to CFF® V110-1 or aramid pulp.

Comparison of CFF® Fibrillated Fiber Properties

Typical Properties	Units	CFF® V110-1	CFF® V125-1
Canadian Standard Freeness	ml	250	400
Fiber Length	mm	6.5	5
Fiber (Trunk) Diameter	micron	25	16
BET Surface Area	m^2/g	50	50
Screen Fineness (14 mesh)	%	40	<10
Fluff Volume, Minimum	ml	375	340
Moisture Content	%	2	15
Finish Level	%	0	0
Additive	%	0	0
pH	-	7	7
Chemical Composition	-	AN/VA	AN/VA
Appearance	-	Fine White Pulp	Fine White Pulp

Sterling Fibers, Inc.
5005 Sterling Way
Pace, FL 32571

TEL: (850) 994-5311 x618
FAX: (850) 994-2579
EMAIL: jhagerott@sterlingfibers.com

Technical Fact Sheet

CPF 402 Fiber Blend

The Blend Concept

Mixing typical short-cut staple fibers into dry blended compounds, such as non-asbestos friction formulations, is not possible because these fibers tend to entangle with each other leading to fiber balls and an inhomogeneous mix. Sterling Fibers has developed a unique process to intimately blend short staple fiber with acrylic pulp. The pulp fibrils become wrapped around the staple fiber, and these prevent staple fibers from entangling during mixing and eliminate the fiber balling problem.

General Description

Chemical composition: 33 wt% fibrillated acrylic fiber
67 wt% 6mm high strength acrylic fiber

Blend density: 1.18 g/cm^3
Moisture regain: < 4%

Component Properties

	Pulp	Staple
Length (mm)	5 - 8	
Melting Point (°C)	200*	
Tensile Strength (MPa)	300	1100
Modulus (GPa)	2.5	11
Density (g/cm^3)	1.18	

* - Does not melt, but instead carbonizes.

Sterling Fibers, Inc.
5005 Sterling Way
Pace, FL 32571

TEL: (850) 994-5311 x618
FAX: (850) 994-2579
EMAIL: jhagerott@sterlingfibers.com

Technical Fact Sheet

CPF 403 Fiber Blend

The Blend Concept

Mixing typical short-cut staple fibers into dry blended compounds, such as non-asbestos friction formulations, is not possible because these fibers tend to entangle with each other leading to fiber balls and an inhomogeneous mix. Sterling Fibers has developed a unique process to intimately blend short staple fiber with acrylic pulp. The pulp fibrils become wrapped around the staple fiber, and these prevent staple fibers from entangling during mixing and eliminate the fiber balling problem.

General Description

Chemical composition: 33 wt% fibrillated acrylic fiber
67 wt% melamine fiber

Blend density: 1.32 g/cm^3
Moisture regain: < 4%

Component Properties

	Acrylic	Melamine
Length (mm)	5 - 8	3 - 8
Melting Point (°C)	200*	370*
Tensile Strength (MPa)	300	260
Modulus (GPa)	2.5	7
Density (g/cm^3)	1.18	1.40

* - Does not melt, but instead carbonizes.

Sterling Fibers, Inc.
5005 Sterling Way
Pace, FL 32571

TEL: (850) 994-5311 x618
FAX: (850) 994-2579
EMAIL: jhagerott@sterlingfibers.com

Technical Fact Sheet

CFF® 111-3 Wet Fibrillated Acrylic Pulp

General Description

CFF® 111-3 fibrillated pulp is a high surface area acrylic pulp used in friction papers. This pulp is available in a 30% nominal solids form which can easily be redispersed in water using conventional hydropulper equipment. It can then be processed on a variety of equipment including rotoformers, cylinder machines, and Fourdrinier machines. The contributions of this product include water dispersibility, mechanical binding characteristics, excellent environmental resistance, adhesion to phenolic resins, and higher thermal stability than cellulose. Papers with a wide range of properties can be prepared by using either the fibrillated fiber alone, in combination with acrylic staple, or in combination with other fibers, pulp, or organic particles. In addition to excellent mechanical strength, this acrylic pulp also has higher temperature resistance and char yield compared to cotton linters.

Relative Performance of CFF® 111-3 Pulp and Cotton Linters

Binder Fiber	Char Yield (%) of Fiber at 500 ^{0}C	Tensile Strength of Paper (lbs/in)
CFF® 111-3	70	5
Cotton Linters	13	0.5

Strength Retention of Acrylic Paper made with CFF® 111-3 Pulp After Exposure to Various Automotive Fluids

	Air (125 ^{0}C)	Nitrogen (180 ^{0}C)	Transmission Fluid (125 ^{0}C)	Motor Oil (125 ^{0}C)	Gasoline (23 ^{0}C)
Retention of Tensile Strength (%)	110	85	105	100	98

Sterling Fibers, Inc.
5005 Sterling Way
Pace, FL 32571

TEL: (850) 994-5311 x618
FAX: (850) 994-2579
EMAIL: jhagerott@sterlingfibers.com

Technical Fact Sheet

CTF 525 High Strength Technical Fiber

General Description

CTF 525 technical fiber is a high molecular weight polyacrylonitrile (PAN) homopolymer with superior mechanical properties and excellent thermal and environmental resistance compared to typical synthetic fibers. It has been found that CTF 525 technical fiber increases toughness in phenolic composites at low fiber concentrations. This can be used in NAO friction materials to reduce cracking, such as that found at rivet holes. CTF 525 fiber can be provided in a wide range of fiber lengths from 0.25 mm to greater than 15mm.

Environmental Stability

CTF 525 fiber has excellent chemical and environmental resistance. It is not attacked by micro-organisms and has superior resistance to weathering and sunlight. CTF 525 fiber is insoluble in common organic solvents, and has excellent resistance to dilute alkalis and most acids. However, fiber degradation will occur under hot, concentrated alkaline conditions.

Typical Physical Properties

Color	cream
Cross section	round
Density	1.18 g/cm^3
Length	0.5 - 10 mm
Diameter	12 µm (0.0005 in)
Denier	1.2 dtex (1.1 denier)
Tensile strength	1100 MPa (160 ksi)
Modulus	13.8 GPa (2 Msi)
Elongation	12%
Shrinkage at 180°C	5%
Moisture content	< 4%
Dielectric Constant	2.8 @ 1MHz
Dissipation Factor	8.7 x10^{-4}@1MHz
Thermal Expansion	2x10^{-4} / °C
Surface charge	anionic

Sterling Fibers, Inc.
5005 Sterling Way
Pace, FL 32571

TEL: (850) 994-5311 x618
FAX: (850) 994-2579
EMAIL: jhagerott@sterlingfibers.com

Technical Fact Sheet

CTF 395 Acrylic Short Cut Staple Fiber

General Description

CTF 395 short cut acrylic staple has been specifically designed to increase the strength and toughness of liquid resin based brake and clutch products such as roll linings, extruded clutch facings and railroad blocks. In these applications the key issues are strength and toughness of both the in process and cured parts, with particular emphasis placed on the toughness or crack resistance. This fiber can be provided in a range of lengths from one to ten millimeters.

Physical Properties of NAO Wet Resin Friction Material Containing 6mm CTF 395 at Different Weight Percents

CTF 395 Weight %	Flexural Strength (KSI)	Properties Modulus (MSI)	Punch Shear Strength (KSI)	Fracture Toughness GI_C (in-lbs/in^2)
0	2.49 +/- .24	.21 +/- .03	2.6 (Rupture)	1.68
2	2.81 +/- .24	.21 +/- .01	3.0 (Yield)	2.61
4	3.16 +/- .24	.24 +/- .01	3.2 (Yield)	4.15

Relative Strength and Toughness Improvements in Model Roll Linings Containing 10% CTF 395 at Different Fiber Lengths

	No Fiber	3mm Fiber	6 mm Fiber	9 mm Fiber
Flexural Strength	1.0	2.2	3.5	3.0
Crack Resistance	1.0	3.2	4.2	2.8

Sterling Fibers, Inc.
5005 Sterling Way
Pace, FL 32571

TEL: (850) 994-5311 x618
FAX: (850) 994-2579
EMAIL: jhagerott@sterlingfibers.com

Technical Fact Sheet

CFF®500 Series High Performance Fibrillated Fibers

General Description

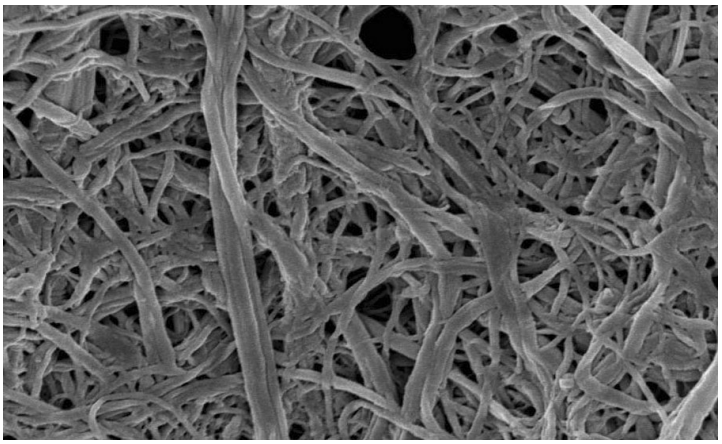
CFF® 500 series fibrillated fibers are produced from high molecular weight homopolymer polyacrylonitrile (PAN) fibers with superior mechanical properties and excellent thermal and environmental resistance compared to typical synthetic fibers, but with the high surface area and branched structure of our conventional acrylic pulps. In many applications, CFF® 500 series fibrillated fibers can be an economical alternative to aramid for demanding processing and reinforcement applications, such as: gaskets, specialty wet-laid papers / nonwovens, filtration media, pulp molded speaker cones, friction materials, concrete, and autoclaved cement boards.

It has also been found that CFF® 500 series fibrillated fibers increases toughness in phenolic composites at low fiber concentrations. This can be used in NAO friction materials to reduce cracking, such as that found at rivet holes.

In dry mix mixing and in sheeter gasket / solvent mixing, CFF® 500 series also prevents the fiber balling and pilling seen with short-cut fibers.

CFF® 500 series fibrillated fibers can be provided in a wide range of fibrillation levels from a CSF of 600 to less than 50, as either wet or dry pulp.

SEM Photomicrograph Showing the High Surface Area CFF® 500 Series Structure



Sterling Fibers, Inc.
5005 Sterling Way
Pace, FL 32571

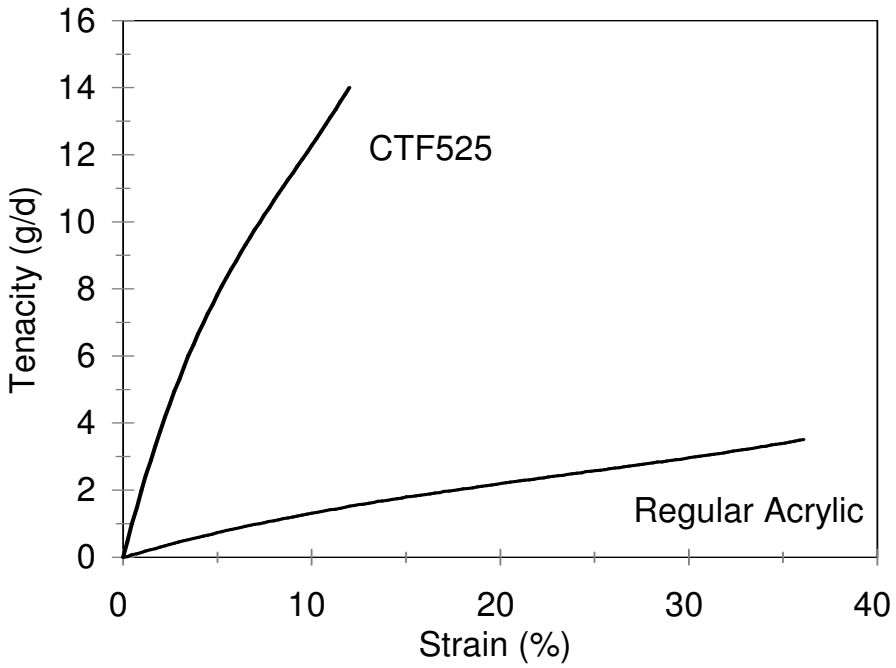
TEL: (850) 994-5311 x618
FAX: (850) 994-2579
EMAIL: jhagerott@sterlingfibers.com

CFF® 500 Series Fibrillated Fibers

CFF® Fibrillated Fiber Type	Product Form	Nominal Solids,%	Max. /Typical Length, mm	Nominal Degree of Freeness, CSF, ml
506-3	Wet Crumb	30	5.5	600
510-1	Dry Pulp	98	5.5	250
511-3	Wet Crumb	30	5.5	250
514-3	Wet Crumb	30	4.5	50

CFF® 500 Series Fibrillated Fibers are produced using CTF 525 precursor fibers. Two of the outstanding properties of this precursor fiber are the high modulus and tensile strength, and the low thermal shrinkage compared with conventional acrylic fibers. The properties of this precursor fiber, which is also available in short-cut lengths ranging from 0.5 mm to 25 mm, are shown in the following charts and tables.

Stress-Strain Behavior of CTF 525 versus Conventional Acrylic Fiber



IMPORTANT NOTICE

Sterling Fibers, Inc.
5005 Sterling Way
Pace, FL 32571

TEL: (850) 994-5311 x618
FAX: (850) 994-2579
EMAIL: jhagerott@sterlingfibers.com

CFF® 500 Series Fibrillated Fibers

Typical Physical Properties

Color	cream
Cross section	round
Density	1.18 g/cm^3
CSF ml	600- 50
Length	3-6 mm
Tensile strength	1100 MPa (160 ksi)
Modulus	13.8 GPa (2 Msi)
Elongation	12%
Shrinkage at 180°C	5%
Moisture content	< 4%
Dielectric Constant	2.8 @ 1MHz
Dissipation Factor	8.7 x10^{-4}@1MHz
Thermal Expansion	2x10^{-4} / °C
Surface charge	anionic

Environmental Stability

CFF® 500 series fibrillated fiber has excellent chemical and environmental resistance. It is not attacked by micro-organisms and has superior resistance to weathering and sunlight. CFF® 500 series fibrillated fiber is insoluble in common organic solvents, and has excellent resistance to dilute alkalis and most acids. However, fiber degradation will occur under hot, concentrated alkaline conditions.

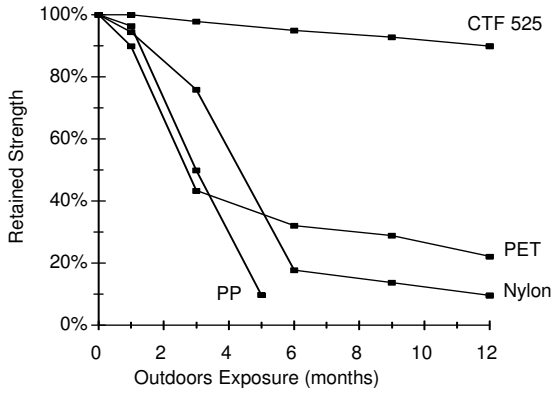
Chemical Resistance

Environment	Strength Retention
150°C air, 20hrs	95%
200°C air, 8hrs	90%
80°C water,24hrs	95%
150°C steam, 20hrs	95%
23°C conc. H_2SO_4, 60hrs	100%
23°C 10% NaOH, 60hrs	95%
80°C 10% NaOH, 20hrs	80%

Steam Resistance

CFF® 500 series fibrillated fiber is also more resistant to short term steam exposure than standard acrylics, so that CFF® 500 papers, cement boards containing CFF® 500 fiber, etc. can be autoclaved. Acrylic fibers are not recommended for applications requiring long term exposure to steam.

Weathering Resistance



Sterling Fibers, Inc.
5005 Sterling Way
Pace, FL 32571

TEL: (850) 994-5311 x618
FAX: (850) 994-2579
EMAIL: jhagerott@sterlingfibers.com