STERLING TECHNICAL FIBERS FOR NON-ASBESTOS GASKETS

No one single fiber has been found which can act as a one-to-one replacement for asbestos in gasket formulations. Beater addition gaskets, compressed gaskets, resin impregnated papers and formed-in-place gaskets all use a blend of organic fibers in combination with inorganic fibers and/or fillers to tailor the performance to a particular application. The most common organic fibers used are cellulose and aramid pulps to aid in processing, as well as provide tensile strength, heat/crush resistance and fluid resistance. However, the use of cellulose pulp usually results in lower tensile strength, lower flexibility, sheet embrittlement and lower temperature resistance while aramid pulp results in high raw materials cost, and in many cases, poor die cutting and other manufacturing problems. In addition, aramid fiber may exhibit poor bonding to the latex and styrene-butadiene rubber or nitrile rubber matrices normally used in gasket sheet fabrication.

Sterling acrylic (polyacrylonitrile) pulps, fibers and fiber blends are a new addition to the selection list which can provide reduced cost, improved processability and gasket uniformity, greater gasket flexibility, higher tear strengths and improved thermal resistance, among other enhanced qualities. Provided in the form of fibrillated fibers, short/small diameter geometry microfibers, or with newly developed second generation acrylic polymer chemistry for higher heat and hydrolysis resistance, Sterling fibers offer engineering advantages combined with cost savings. All three types of fibers are being used commercially and can be provided in production quantities.

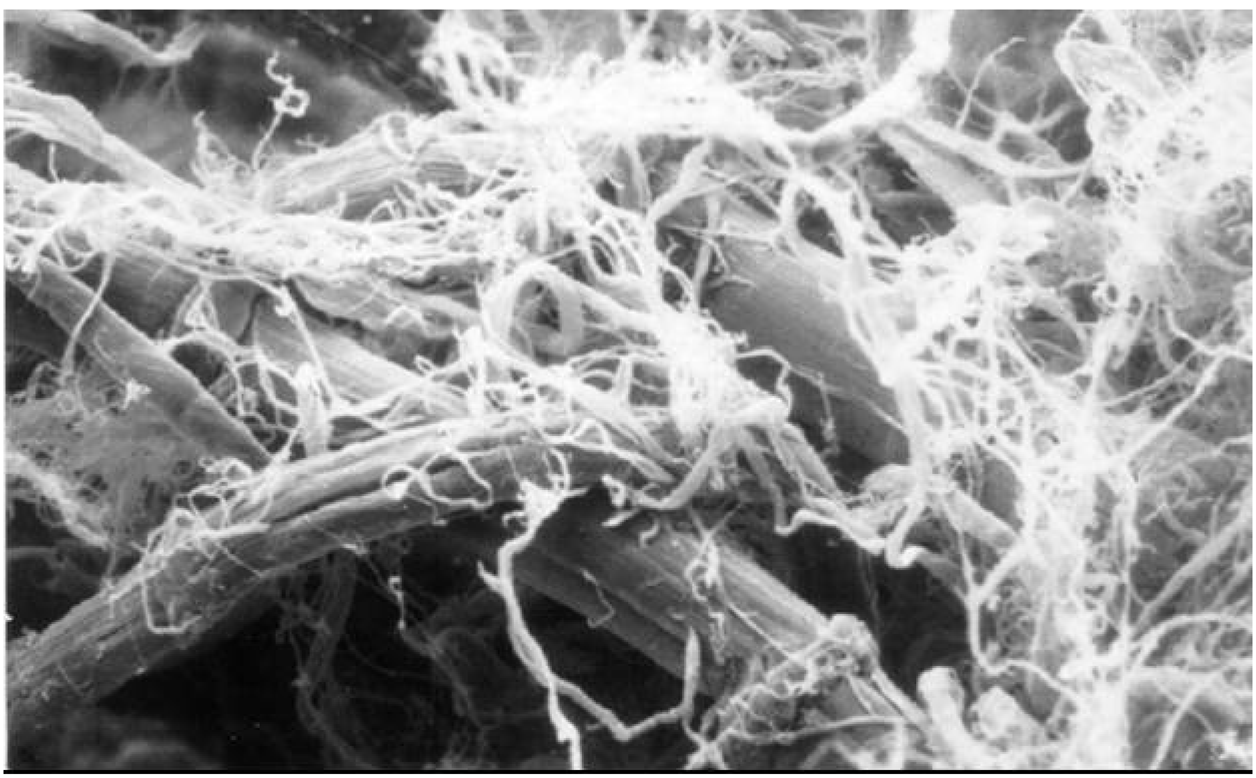
Sterling Technical Fibers for Non-Asbestos Gaskets			
Applications	**Description**	**Product Form**	**Products Available**
Beater Addition Gaskets, Resin Impregnated Papers	Acrylic pulp, wet, CSF = 600, 6.5 mm nominal length	Wet Pulp	**CFF 106-3 Fibrillated Fiber**
Beater Addition Gaskets, Resin Impregnated Papers	Acrylic pulp, wet, CSF = 250 ml, 6 mm nominal length	Wet Pulp	**CFF 111-3 Fibrillated Fiber**
Beater Addition, Compressed Sheet, Formed-in-Place Gaskets	Acrylic fiber, 10 micron diameter, 1-2 mm length	Short Cut Fiber	**CTF 311 Technical Fiber**
Beater Addition, Compressed Sheet, Formed-in-Place Gaskets	Higher heat resistant acrylic fiber, 12 micron diameter, 1-2 mm length	Short Cut Fiber	**CTF 525 Technical Fiber**
Compressed Sheet, Designed to Solve Mixing Problems in Some Processes Where Fiber Balling /Pilling Can Occur, or Where Use of Longer Fiber Is Desired.	Engineered Blend of CTF 525 Technical Fiber (3 mm) and CFF Pulp	Fiber Blend	**CPF 406 Fiber Blend**

Acrylic fibers have a specific gravity of 1.17 and a moisture regain of less than two percent. Acrylic fiber also has excellent environmental, chemical and solvent resistance. Acrylic fibers are insoluble in common organic solvents, including acetone, benzene, carbon tetrachloride, dichloroethane, naphtha, alcohol and automotive hydraulic and antifreeze fluids and lubricants, as well as gasoline and diesel fuel. They have excellent resistance to petrochemicals. A fluid resistance chart is presented in the appendix. The fibers withstand outdoor exposure and have outstanding UV resistance

Sterling acrylic fibers are composed of greater than ninety percent polyacrylonitrile (PAN) and a small amount of vinyl acetate monomer to form a random copolymer. The chemistry of these fibers is very similar to the chemistry of PAN fibers used as carbon fiber precursors.

CFF® acrylic pulps are provided as a wet crumb (about thirty percent solids). Wet CFF acrylic pulp disperses easily in water and can be used in all beater addition and papermaking processes. Normally, the pulp is dispersed in a hydropulper or refiner prior to the addition of other components to disperse any entangled fibers.

CFF acrylic pulp is a highly branched fibrillated fiber with a treelike structure. A wide range of fiber/fibril diameters is created in the fibrillation process ranging from about a ten micron main fiber with attached macrofibrils and fibrils to fine microfibrils of one micron or less. The high percentage of branched structure in these fibrillated fibers entraps and holds other components in the paper while the long fiber trunks provide good web and finished sheet strength. Thus gasket papers can be produced where the CFF pulp binds the other organic fibers, inorganic fibers and/or inorganic fillers without the use of any resinous binder. The presence of submicronic, fine diameter microfibrils in a synthetic fiber is unique. BET surface area is 45-50 m^2/g.



CFF FIBRILLATED FIBER FOR GASKET APPLICATIONS

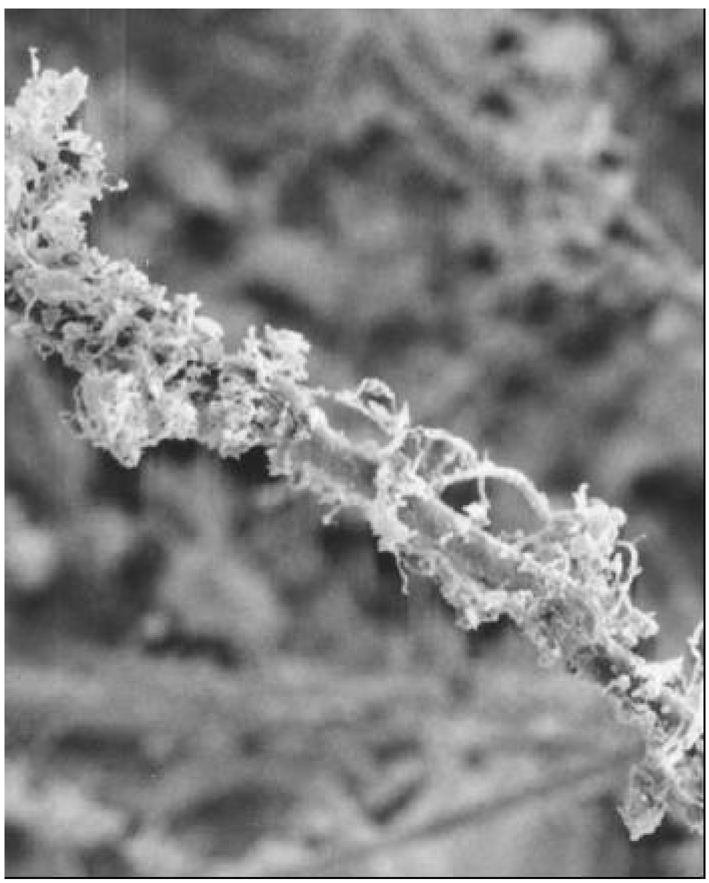
CTF Technical Fibers for gasket applications are short, small diameter microdenier fibers with an aspect ratio in the range of 100:1 to 150:1. The 1-2 mm length of the fibers permits better dispersion and processing compared to other fibers, and the high aspect ratio, combined with the good fiber-to-matrix adhesion obtained because of the nitrile groups on the surface insures good bonding to the matrix.

In addition to the excellent reinforcing effects obtained with microdenier CTF fibers, the fiber stiffness is optimum to obtain good load transfer and very high extensibility/flexibility in the finished gasket. In fact, the use of these fibers to obtain improved flexibility is patented.*

Also, the use of a few weight percent of these fibers in formed-in-place gaskets provides thixotropic performance and sag resistance during formation and installation, as well as high tear resistance and improved tensile strength in the gasket.

For beater addition and papermaking applications, CTF 311 and CTF 525 Technical Fibers can be provided in completely PULPABLE bags for direct loading into the hydropulper.

CPF 406 Fiber Blends have been developed based on a unique technology that eliminates the fiber balling that can occur when components, including fibers, are dry compounded prior to the addition of solvent in the production of compression gaskets. These blends also permit the use of longer short-cut fibers in compression / sheeter gaskets. These blends consist of 80 % CTF 525 Technical Fiber and 20% CFF pulp. In the blending process, CFF pulp essentially coats the short-cut CTF 525 and keeps the fibers from forming pills when mixed in a Littleford or similar mixer. The structure of CPF 406 is shown in the photomicrograph below:



CPF 406 FIBER BLEND FOR GASKET APPLICATIONS (CFF Pulp / CTF 525 Fiber)

**U.S. Patent 5272198 "Asbestos - Free Microdenier Acrylic Fiber Reinforced Material for Gaskets and the Like*

To illustrate the relative performance of organic fibers in a gasket formulation, a series of beater addition test sheets were prepared using the formulation shown in Table I and the formation/molding procedures listed in Table II. This formulation and gasket preparation procedure was selected to provide a representative model of the types of product mode in the industry. Kevlar 361 aramid pulp was selected as the basis of comparison because of its wide use. The other organic fibers were cellulose (unbleached Kraft), Kevlar 306 aramid pulp, CFF 106-3 acrylic pulp, CFF 111-3 acrylic pulp, CTF 311 Technical Fiber, and CTF 525 Technical Fiber. Each fiber was used for the total organic fiber content. Several combinations were evaluated as well to demonstrate engineering and cost advantages.

TABLE I ***Non-Asbestos Gasket Formula***
15 wt.% Organic Fiber/Pulp
70 wt.% Platey Talc (Pfizer —12-50)
15 wt.% NBR Latex Binder (Chemigum 260)
2 PHR Sulfur 4 PHR Zinc Oxide 1.5 PHR Butyl Zimate 2 PHR Agerite D Antioxidant
2 PHR Precipitation Regulator (TAMOL N)
5-10 PHR Precipitation Agent (ALUM)

	TABLE II ***Formation Procedure***
1.	Mix fiber, filler, cure agents and latex in D.I. H_2O using Waring blender on low speed. (2% solids mixture).
2.	Precipitate latex with alum while intermittently mixing.
3.	Dilute mixture to 1% solids, form into 12" x 12" sheet in papermaking sheet mold.
4.	Precompact sheet in press, partially dry in oven, press cure 20 minutes at 250°F. Pressure = 600-900 psi. Postcure in oven 20 minutes at 250°F.

Sheet density, tensile strength and elongation (flexibility), as well as crush extrusion were measured on all gaskets. All of these mechanical and thermal properties are fiber dependent. Tensile properties were measured using ASTM procedure D882; creep relaxation was measured using ASTM procedure F38, and crush extrusion was measured as the percentage area increase of a 20 mm diameter disc. The target for sheet density was 1.50 - 1.55 g/cm^2, which is representative of commercially manufactured beater addition gaskets. Close control of sheet density was also maintained since the mechanical and thermal properties are a function of density, and comparison of values at different densities is not valid. All gaskets had a nominal 0.82 mm thickness. Table III and the following pages illustrate the relative performance and cost of using these fibers.

TABLE III - RELATIVE FIBER PERFORMANCE

FIBER	COMMENTS
Aramid Pulp Kevlar 361 Kevlar 306	Currently used in non-asbestos gaskets, good performance, difficult cutting. High cost.
Cellulose Pulp Cellulose Fiber (Unbleached Kraft) Cellulose/Aramid Pulp Blend	Used in lower performance, lower temperature applications, causes embrittlement when blended with aramid. Low cost.
CFF Series 100 Fibrillated Fiber CFF 106-3 Acrylic Pulp CFF 106-3 Acrylic Pulp//Aramid Pulp Blend CFF 111-3 Acrylic Pulp	Fibrillated acrylic pulp with excellent mechanical binding for papermaking operations. Good tensile properties. Moderate temperature resistance. Excellent chemical resistance. Lower cost.
CTF Series 300 Technical Fiber CTF 311 Technical Fiber CTF 311 Technical Fiber/Aramid Blend CTF 311 Technical Fiber/CFF 106-3 Acrylic Pulp Blend	Microdenier fiber which provides high flexibility with tensile strength equal to aramid. Excellent aramid extender with good temperature resistance. Excellent chemical resistance. Lower cost.
CTF Series 500 Technical Fiber CTF 525 Technical Fiber CTF 525 Technical Fiber/Aramid Blend	Second generation acrylic polymer chemistry for higher heat and hydrolysis resistance. Good tensile properties. Moderate cost.

TABLE IV- RELATIVE PROPERTIES OF NON-ASBESTOS GASKETS USING VARIOUS PULPS AND FIBERS

Property	Units	Temp °C.	Kevlar 306 Pulp	Kevlar 361 Pulp	Cellulose (Wood) Pulp	CFF V106-3 Acrylic Pulp	CFF V111-3 Acrylic Pulp	CTF 311 Acrylic Fiber (1 mm Length)	CTF 525 Acrylic Fiber (1.5 mm Length)
Sheet Density	g/cm^3	23	1.53	1.51	1.52	1.53	1.54	1.54	1.54
Tensile Strength	KSI	23	3.1	2.6	2.4	2.4	2.1	2.6	3.5
Tensile Elongation	%	23	7.1	9.2	5.9	9.2	9.0	16.8	8.5
Creep Relaxation	%	150	43	43	__	48	48	48	44
Crush Extrusion	% Area Increase								
	10KSI	150	8	8	26	25	25	25	2
	20KSI	150	22	24	78	65	68	55	14
	10KSI	180	10	11	30	__	__	51	10
	20KSI	180	24	29	85	120	117	125	38

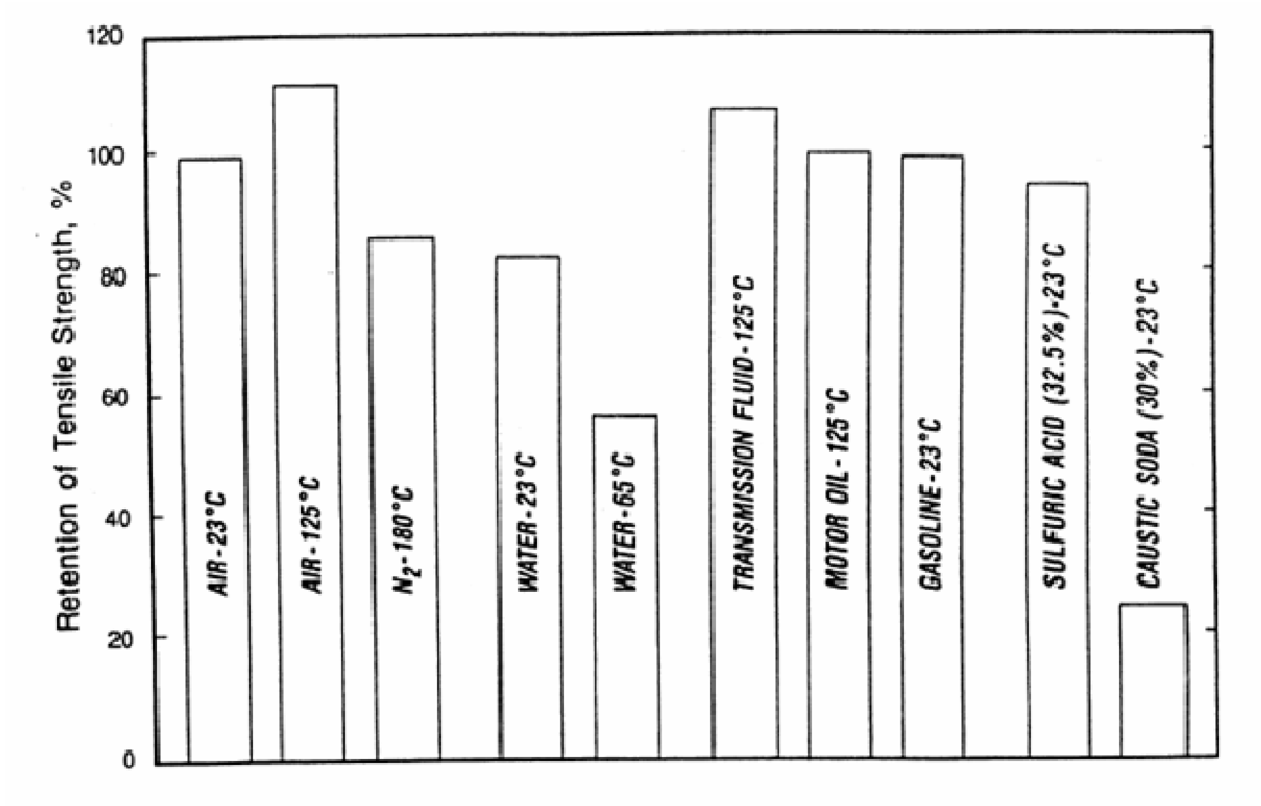
TABLE V- RELATIVE PROPERTIES OF NON-ASBESTOS GASKETS USING VARIOUS 50/50 BLENDS OF PULPS AND FIBERS

	Units	Temp °C.	Kevlar 361 Pulp Control	CFF V106-3 Acrylic Pulp / Kevlar 361 Pulp	CTF 311 Acrylic Fiber / Kevlar 361 Pulp	CTF 525 Acrylic Fiber / Kevlar 361 Pulp
Sheet Density	**g/cm^3**	**23**	**1.51**	**1.50**	**1.52**	**1.52**
Tensile Strength	**KSI**	**23**	**2.6**	**2.5**	**3.1**	**3.4**
Tensile Elongation	**%**	**23**	**9.2**	**9.8**	**12.4**	**8.0**
Creep Relaxation	**%**	**150**	**43**	**45**	**44**	**43**
Crush Extrusion	**% Area Increase**					
	10KSI	**150**	**8**	**17**	**16**	**4**
	20KSI	**150**	**24**	**45**	**41**	**16**
	10KSI	**180**	**11**	**__**	**27**	**8**
	20KSI	**180**	**29**	**70**	**92**	**32**

CFF acrylic pulps, CTF Technical Fibers and CPF Fiber Blends have been engineered in several product forms to meet the needs of the gasket industry by providing enhanced performance and lower cost. Used alone or in combination with other organic and inorganic fibers, they permit new opportunities in the formulation of non-asbestos beater addition and compressed gaskets

APPENDIX- FIBER CHEMICAL/ ENVIRONMENTAL RESISTANCE

CHEMICAL AND ENVIRONMENTAL PROPERTIES OF ACRYLIC FIBERS	
Long Term Stability	**Excellent**
Resistance to Sunlight (UV)	**Excellent: Durable up to 5 years outdoors**
Resistance to Insect Attack	**Excellent: Not attacked by moths**
Resistance to Biological Agents (Mildew, Fungus, etc.)	**Excellent: Does not support growth of mildew, fungi, etc.**
Resistance to:	
Moisture/water	**Excellent: Durable in boiling water for extended periods.**
Hydrocarbons	**Excellent: engine oil, brake fluid, lubricating oil, transmission fluid**
Gasoline	**Excellent**
Ethylene Oxide, Antifreeze	**Excellent**
Nonpolar Solvents	**Excellent: alcohols, aldehydes, ketones**
Polar Solvents	**Dissolves in DMF, DMAC, DMSO**
Weak Acids	**Excellent**
Strong Organic Acids	**Good**
Strong Inorganic Acids	**Dissolves in concentrated HNO_3, H_2SO_4**
Weak Alkalis	**Good**
Strong Alkalis	**Yellow; degrades-hot**
Steam	**Partially hydrolysed or plasticized**



Strength retention of 100% CFF paper after thirty-day exposure in various environments

STEAM RESISTANCE OF CTF TECHNICAL FIBERS

Exposure Time, Hours		CTF 300 Type			CTF 500 Type	
	Modulus, g/den	Tenacity, g/den	Elongation, %	Modulus, g/den	Tenacity, g/den	Elongation, %
0	41	3.4	35	167	9	11
24	-	3.0	35	98	8.5	16
72	41	3.2	35	77	8.5	16
192	-	2.6	41	68	8.2	16
264	-	-	-	61	5.1	19
312	-	-	-	29	4.2	42