



CFF FIBRILLATED FIBERS OR PULP MOLDED SPEAKER CONE APPLICATIONS

1. Overview

Speaker cones manufactured using pulp molding techniques, where a wood pulp or cotton linter slurry is refined and then pulled under vacuum onto a shaped screen account for about 98 % of the world's production of speaker cones. But cones molded from a slurry of wood fibers are very susceptible to moisture. Free-air resonance can shift 10 percent from a dry to a highly humid environment. Depending on the beating of the wood pulp, cones may exhibit low tensile and tear strength, as well as low stiffness. Also, variations in body weight can occur that severely effect the acoustical response of the cone.

Polypropylene and aramid, alternative synthetic fibers and pulps which are currently being used, can help eliminate some of these problems. Polypropylene pulp has excellent moisture resistance, but does not bond well to resins and softens at temperatures which can be encountered in an automobile interior causing cone and sound distortion. Aramid pulp provides excellent mechanical binding and good temperature resistance. However, it has a high moisture regain and does not bond well to resins while its very high cost makes it uneconomical. In addition, it does not provide any additional bonding when hot pressed.

CFF acrylic pulp offers a number of unique advantages in specialty paper applications including the development of new pulp molded speaker cones. CFF fibrillated fiber was developed to serve as a high efficiency binder in addition to providing other engineering attributes to papers, speaker cones, filter media, nonwovens, pulp molded products and specialty composites.

Sterling's CFF® acrylic pulp is an excellent alternative choice to aid in the solution of speaker cone manufacturing problems to improve performance and variation. CFF fibrillated fiber is a synthetic pulp produced from a polyacrylonitrile (PAN) copolymer which can be used to produce speaker cones with improved moisture resistance, dimensional stability at varying humidities, temperature resistance, batch-to-batch uniformity, resistance to UV radiation, exceptional wet strength, as well as excellent chemical resistance, resin adhesion and lower cost compared to aramid pulps.

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. The presence of submicronic, fine diameter microfibrils in a synthetic fiber is unique. BET surface area can be as high as 45-50 m²/g.



SEM Photomicrograph - CFF Fibrillated Fiber

CFF wet pulps are being used in wet laid paper processes for interlocking other organic and inorganic fibers as well as various powders, such as aramid, carbon, etc. CFF 106-3 pulp has a Canadian Standard Freeness (CSF) of 600 ml and a typical length of 6.5 mm. CFF 111-3 pulp has a CSF of about 250 ml and a typical length of 6.5 mm. These materials are supplied at about thirty percent solids and are available in commercial quantities. CFF 114-3 pulp has a freeness of 60 ml and a length of about 4.3 mm and is also supplied as a wet pulp. Other freenesses between 650 and 50 ml can also be supplied.

CFF Pulp Type	Solids Content, %	CSF, ml	Max./Typical Fiber Length, mm
106-3	30	600	8.0/6.5
111-3	30	250	8.0/6.5
114-3	30	60	6.0/4.3

CFF is now being used by several speaker cone companies worldwide on a commercial basis. Typically about 20-30 percent of CFF pulp is used either with cellulosic pulps or a blend of cellulosic pulps and glass or other short synthetic fibers. These acrylic pulps enhance physical and mechanical performance, provide better acoustical /frequency response, reduce the moisture adsorption, and improve the wet strength. CFF wet pulp contains no size or surface finish. Cones containing CFF acrylic pulp can be hot pressed to improve surface smoothness, increase strength, reduce porosity, etc. CFF 111-3 is the most commonly used pulp because of its good balance of properties.

Some of the features that CFF pulps bring to pulp molded speaker cones include:

1. **Cleaner /crisper sound**
2. **Improved Damping / Smoother acoustical response curve**
3. **Decreased porosity of the conepaper with a resultant increase in sound pressure level output.**
4. **Ten times the binding / holding efficiency of cellulose pulps- enables synthetic short-cut fiber content of 40% or more**
5. **Increased bulk with no decrease in Young's modulus that increases bending stiffness.**
6. **Reduced moisture absorption**
7. **Outstanding dimensional stability vs. relative humidity**
8. **Increased mechanical strength and stiffness- superior wet strength**
9. **Higher use temperature vs. thermoplastic or cellulose fiber/ pulp**
10. **Good dispersion and wet processing**
11. **Excellent lot-to-lot uniformity**

The advantages of adding CFF acrylic pulp to standard speaker cone pulps (bleached kraft, unbleached kraft, cotton linters) to modify properties such as tensile strength, sheet porosity, etc. as well thermal bonding as a substitute to solvent dipping, are demonstrated in Table 1 and Table 2. These Tables summarize the properties of the cellulose and acrylic pulps used, and compares the handsheet properties of 100% cellulose, 50/50 cellulose/acrylic blends with and without hot pressing.

As the data indicate, large increases in both the dry tensile strength and wet tensile strength (16 hour soak at room temperature) can be obtained with the use of acrylic pulp. Because of the high degree of fibrillation of the CFF® 111-3 pulp used in these evaluations, the porosity is also decreased.

In summary, the use of CFF acrylic pulps, either alone or in combination with cellulose, cotton linters, or other organic/inorganic powders and fibers, permits the engineering and manufacturing of a new family of speaker cones and components. In addition to the CFF pulps used as examples in this technical note, it is possible to provide products with customer specific properties of CSF and fiber length. It is possible to also provide CFF wet pulp packaged in sealed plastic bags with a predetermined dry weight to meet a specific customer requirement and permit precise package weight to be added to the hydropulper for controlled speaker cone weights.

2.0 Using CFF Acrylic Pulp in Molded Speaker Cone Production

2.1 Pulp Packaging and Storage

CFF acrylic pulp is supplied for production use as a wet crumb containing about 30 % solids (70 % water). CFF acrylic pulp is packaged in plastic lined boxes with a net weight dry of 80 pounds (36.4Kg). Both the net weight wet (pounds) and the net weight dry (pounds) is marked on the package. CFF acrylic pulp samples for use in development are normally supplied in plastic bags having a dry weight of 0.5kg. The solids content is printed on the label.

It is very important not to allow the wet pulp to dry out before cone molding, since this makes dispersion into the slurry difficult and can reduce the paper cone strength. After removing CFF pulp from the plastic bag, the bag must be resealed by tying or taping it closed. Also, if the plastic bag is punctured or torn, the CFF should be transferred to a new bag.

2.2 Determination of Acrylic Pulp Weight to be Added

The amount of CFF acrylic pulp to be used with the cellulose pulp is based on the dry weight of the acrylic of the

cellulose pulp. CFF pulp is supplied wet, with about 30 percent solids content, so that the correct amount of wet acrylic pulp to be used for a specific formulation can be calculated from:

$$\text{Amount of wet CFF pulp to add} = \text{CFF dry weight needed} / \text{CFF solids content of wet pulp}$$

For example, if the formulation required 5 kg of CFF pulp based on a dry weight basis, and the solids content was 30%, the correct amount of wet pulp taken from the package would be:

$$\text{Wet Pulp needed} = 5 \text{ Kg} / 0.30 = 16.7 \text{ Kg}$$

The solids content of a box of CFF acrylic pulp is determined by the information on the label.

$$\text{Solids Content} = \text{Net Weight Dry} / \text{Net Weight Wet}$$

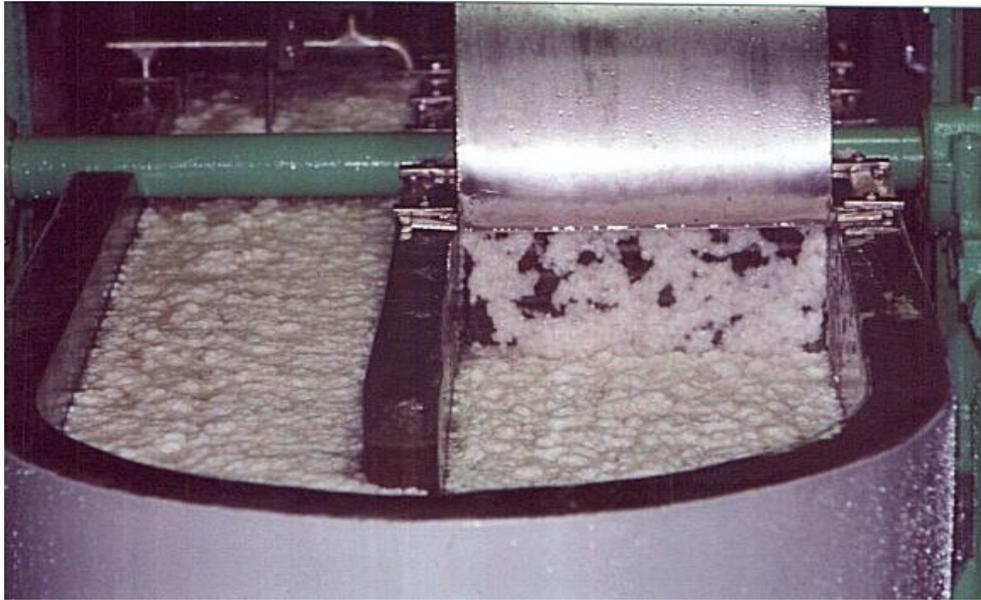
For a box with a net weight dry of 80 pounds, and a net weight wet of 281 pounds, the solids content would be $80 / 281 = .285 = 28.5\%$.

3.0 Dispersion of CFF Acrylic Pulp With Cellulose Pulp In Conventional Beaters

One key to successful use of our acrylic pulp is good dispersion in the slurry. Pulps are supplied wet (30 % solids) and can be dispersed in the types of beaters used in the speaker cone industry. However, dispersion may require different techniques than used with wood pulp. Engineered Fibers Technology can provide mixing recommendations as well as technical and processing assistance during either the laboratory, pilot machine or production scale development of speaker cones containing CFF acrylic pulps.

CFF acrylic pulp should be added to the cellulose pulp after the cellulose pulp has been beaten following the standard time normally used to obtain the desired freeness level. After the wood pulp has been beaten, the CFF acrylic pulp should be added as follows:

1. Raise the beater roll about 5 turns above the last setting used for beating the cellulose pulp.
2. With the beater pulp circulating, slowly add the CFF pulp to the beater in small hand fulls (about 50 gram) until all of the CFF has been added.
3. Allow the beater to run for about 30 minutes to open and mix the CFF pulp.



Blending of wood pulp and CFF Fibrillated in Production Beater

4. Remove a small sample (25-50 ml) of blended slurry from the beater and place in a 1000 ml graduate cylinder. Fill cylinder to the 1000 ml mark with water.
5. Holding hand over top of cylinder, invert and shake the cylinder 5 to 10 times to disperse the sample pulp.
6. Check pulp quality by holding the graduated cylinder in front of a light source. The CFF pulp and wood pulp should appear well dispersed with no fiber clumps or pills.
7. If dispersion is not good and pills are still visible, allow the beater to run for an additional 15 minutes and recheck the dispersion.
8. After dispersion is complete, add the remaining components, such as dye, waterproofing agents, etc. that are normally added at the end of the beating cycle and complete normal mixing.

A Sterling Technical Fibers Representative would be happy to discuss the application of CFF pulp in speaker cones with you in more detail.

TABLE 1 – COMPARISON OF PULP PROPERTIES

PULP	CSF, ml	MAXIMUM LENGTH, in.	TYPICAL LENGTH, in.
UNBLEACHED KRAFT	755	---	---
BLEACHED KRAFT	656	---	---
COTTON LINTERS	730	.24	.10
CFF 111-3 ACRYLIC PULP	250	.32	.28
CFF 114-3 ACRYLIC PULP	60	.28	.24

TABLE 2 – EFFECT OF CFF PULP MODICATION TO SPEAKER CONE PAPERS

Base Sheet	CFF 111-3 Fibrillated Fiber (%)	Pressed	Basis Weight, gm/ft²	Caliper, Mils	Frazier Air Porosity	Dry Tensile Strength lbs./in.	Wet Tensile Strength lbs./in.
Unbleached Kraft	.0	No	10.8	18	22.4	3.1 ± .2	0.13 ± .01
	50	No	9.3	14	1.1	10.0 ±.1	2.3 ±.1
	50	Yes	9.3	5	0	12.9 ± .1	4.5 ± .1
Bleached Kraft	0	No	10.4	15	2.8	8.8 ±.2	.37 ±.09
	50	No	9.4	13	0.6	11.8 ±.8	3.3 ± 0.1
	50	Yes	9.4	5	0	13.7 ± .6	4.3 ±.3
Cotton Linter	0	No	9.0	18	89.8	1.8 ±.1	.08 ± .01
	50	No	10.0	13	2.0	8.9 ±.7	4.0 ± .17
	50	Yes	10.0	6	0	9.7 ±.4	4.6 ±.24

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