



TOOTHBRUSH FILAMENT PROPERTIES

- Picks well in very high speed machines
- Special low friction finish
- Excellent diameter control
- Non-blocking
- Excellent bend recovery
- High stiffness
- Clean square cuts
- Convenient ten pound tote

Innovation, quality, and competitive price have been the hallmarks of [Monahan Filaments](#) toothbrush filaments. We are eager to work with you in product development and problem solving.

MFI toothbrush filaments are packaged to meet your requirements. Consistent wrap tightness, excellent bundle diameter control, no loose ends, and clean square cut surfaces ensure smooth feeding in your toothbrush machines. Our toothbrush filaments are available in hank length or cut into bundles and packed into ten pound tote boxes for efficient handling. Bundles and hanks are printed and color coded for ease of identification.

WYTEX® 6.12S has exceptionally high clarity and is specially processed to give superior bend recovery. See the Filament Properties section for stiffness modulus and bend recovery data. Capability and actual lot test data are available for Wytex® 6.12S.

PLYER® SK PBT polyester has greater wet stiffness than 6.12S. It offers a superior surface finish to aid in picking on today's very high speed toothbrush machines, and a significant cost savings advantage per brush over Nylon 6.12. See the Filament Properties section for stiffness modulus and bend recovery data. Capability and actual lot test data are also available for Plyer® SK.



PRODUCT SPECIFICATIONS

PRODUCT	AVAILABLE DIAMETERS	BUNDLE WRAP	BUNDLE DIAMETER	CUT LENGTH	HANK LENGTH
WYTEX® 6.12S	.006-.020"	PVC or Paper	1.94" ± .03"	1" and up	48"
PLYER® SK	.006-.020"	PVC or Paper	1.94" ± .03"	1" and up	48"

Tolerances

Filament Diameter Tolerance: ±3% on average of the specified diameter

Bundle Cut Length Tolerance: ±1/32" of the specified length

FILAMENT PROPERTIES

MFI produces toothbrush filaments in different materials, different sizes, different shapes, and in almost any color. The following table compares some of the properties in a general way, followed by definitions and by information in detail.

PRODUCT	Diameter (mil)	Specific Gravity	Melting Point (°F)	Bend Recovery (%)	Tensile Modulus (k-psi)	Typical Elongation (%)	Tensile Strength (k-psi)	Typical Ovality
WYTEX® 6.12S	7	1.06	410	95	490	50	55	1.01
PLYER® SK	6	1.26	430	94	520	50	55	1.01

PRODUCT	Relative Abrasion Resistance	Set Resistance	Water Absorption % Max	Retention of Stiffness in Water	Sun Light & UV Light Resistance	Hi-Temp Oxidation Resistance	General Chemical Resistance
WYTEX® 6.12S	7	1.06	410	95	490	50	55
PLYER® SK	6	1.26	430	94	520	50	55

The information contained herein is based on laboratory tests, published data, and current processing methods and is believed to be accurate. Specifications will be maintained as accurately as possible, but no warranties or guarantees are expressed or implied regarding the accuracy or the performance of these materials. Samples are available on request for specific tests.



PLYER® SK vs NYLON 6.12 TOOTHBRUSH FILAMENTS

Monahan Filaments developed Plyer® SK, a toothbrush filament that performs well, runs well, and costs much less per brush than filament made from Nylon 6.12. Plyer® SK is made from PBT resin. PBT is a widely used engineering thermoplastic that has excellent properties for toothbrush bristles.

Costs Less

Plyer® SK filament costs significantly less per brush. The density of Plyer® SK is about 25% higher than that of Nylon 6.12, but the cost per pound of filament is much lower. In addition, PBT has had greater long term price stability than Nylon 6.12.

Great Processing

Plyer® SK filaments have superior picking, trimming, and end rounding characteristics on very high speed toothbrush machines. It has an especially high surface lubricity. Trimmers must be sharp and properly adjusted to ensure good end rounding with Plyer® SK.

Consistent Stiffness

The reliable wet stiffness of Plyer® SK is another of its assets. Its dry stiffness modulus is about the same as Nylon 6.12. When wet, Plyer® SK retains its stiffness while Nylon 6.12 filament loses much of its stiffness. This explains why toothbrushes made with nylon filament feel hard when they are new. Plyer® SK filaments have more consistent performance wet or dry.

More Plaque Cleaning Surface

For equivalent stiffness under the wet conditions of tooth brushing, Plyer® SK requires a diameter of about one mil (.025 mm) less than that of Nylon 6.12 filament. This results in more Plyer® SK filaments of smaller diameter in a brush with the same stiffness as with Nylon 6.12. These extra Plyer® SK filaments, with significantly more surface area, may help clean teeth more effectively.

Satisfying Brush Life

Toothbrushes filled with Plyer® SK have a long brush life due to good bend recovery properties. Bend recovery failure is typically the reason that toothbrushes wear out. The results of bend recovery tests on Plyer® SK are comparable to those of Nylon 6.12 using smaller Plyer® SK filaments of equivalent wet stiffness.

Summary

Plyer® SK presents a great opportunity to produce excellent quality toothbrushes at a lower cost. Plyer® SK also provides satisfying brush life, more cleaning surface area, consistent stiffness, and exceptional processing characteristics on today's high speed toothbrush machines.



EFFECTS OF WATER ON FILAMENTS

Because of their chemical nature, most synthetic filaments do not absorb water to any appreciable extent, and as a result their physical properties are not affected by water. Nylon is an exception. The chemical bonds that give our Wytex® nylon its strength and high melting point also cause it to absorb significant amounts of water. Water acts as a plasticizer in Wytex® allowing the molecules to move more easily. This reduces the stiffness of nylon filaments.

Nylon 6.12 absorbs less water than other nylons but still loses much of its stiffness in water. Plyer® SK PBT absorbs almost no water and therefore is more consistent wet and dry.

TENSILE MODULUS AT VARIOUS HUMIDITIES (k-psi)

RELATIVE HUMIDITY	0%	50%	100%
WYTEX® 6.12	570	490	410
PLYER® SK	540	530	515

About the Test

Wytex fibers were conditioned in a desiccators (0% humidity), a climate controlled room (50% humidity), and a glass container with free water (100% humidity) for two weeks at 70°F. They were then tested on our Instron® tensile testing machine.

FILAMENT STIFFNESS

Tensile modulus is one of the factors that affect the stiffness of a filament. It is the ratio of force used to stretch a filament (stress) to the amount of stretch (strain) and is a property of the material. The higher the modulus, the stiffer the filament. A filament with a tensile modulus of 600 k-psi will be twice as stiff as a filament of the same size and shape with a tensile modulus of 300 k-psi. Different methods of measuring modulus give different values. Processing, additives, heat, sunlight, chemicals, humidity, and a host of other factors all affect tensile modulus. The stiffness of a filament also depends upon its length, size, shape, and the amount of water it absorbs.

INITIAL TENSILE MODULUS (k-psi)

7-mil WYTEX® 6.12	490
8-mil PLYER® SK	520

About the Test

The filaments were conditioned in a climate controlled room at 50% relative humidity and 72°F (22°C) and tested under the same conditions. Using an Instron® tensile testing machine, we measured the stress and strain of the filament and calculated the tensile modulus for the first few percent of strain. Thus we measured the "initial" tensile modulus. Tensile modulus is also known as elastic modulus or Young's modulus.



FILAMENT BEND RECOVERY

Most brushes wear out from abrasion or bend recovery failure. Toothbrushes fail in the bend recovery mode. Bend recovery failure results in the bristles becoming so bent or matted that they do not function or clean effectively. In a properly designed brush, this typically takes months.

Factors that influence bend recovery are severity of the bending, filament material, how the filament is made, length of time the filament is bent, length of time the filament is allowed to recover, temperature, diameter, and shape.

MFI uses a variety different tests to investigate these factors including a pinch bend recovery test (very sharp bend for a few seconds), a mandrel¹ bend recovery test (less sharp bend for a few minutes), and a set resistance test (slight bend for up to several days). The mandrel test is typically used to test toothbrush filaments.

The chart below shows the Mandrel Bend Recovery for MFI filaments. Wytex® 6.12S and Plyer® SK have high bend recoveries and both are excellent for severe applications like toothbrush filaments.

MANDREL BEND RECOVERY (%)

7-mil WYTEX® 6.12	96.0
8-mil PLYER® SK	95.5

About the Test

The DuPont¹ or mandrel method is relatively easy to do and gives very consistent results. The basic test involves winding ten turns of the filament on a 3/32" (2.4mm) diameter rod or mandrel. After the filament has been on the rod for four minutes, it is cut off and allowed to relax in a dish of water for one hour. The bend recovery is calculated based on the number of turns in the filament at the end of the recovery periods compared to the number of turns wrapped on the mandrel, expressed as a percentage.

¹ E. I. DuPont de Nemours, Bend Recovery of TYNEX® and HEROX® Nylon Filaments, *Technical Data Bulletin No. 5*, Plastics Department, Wilmington, DE, 1979

DEVELOPMENT CAPABILITIES

Full Cycle of Product Development

MFI has assembled the equipment for the full cycle of new product development.

Make Filaments

We make special custom engineered toothbrush filaments on our filament lines

Test Filaments

We test the toothbrush filaments for stiffness, bend recovery, and other filament properties.

Test Toothbrushes

We test toothbrush stiffness on our customized ISO 8627 Toothbrush Stiffness Tester, and toothbrush wear properties and brush life on our customized WT3 Ponzini Wear Test Machine.



LABORATORY CAPABILITIES

CAPABILITIES

- Filament Composition Analysis
- Filament Property Analysis
- Filament Additive Performance Analysis
- Filament Finish Analysis
- Color Analysis
- Custom Color Matching
- Metamerism Analysis
- Process Improvement
- Light Microscopy
- FDA/USDA Status

TESTING

- Filament Composition, Identification
- Softening and Melting Behavior
- Differential Scanning Calorimetry
- Fisher-Johns Melting Point
- Plastic Melt Flow Rate, Viscosity
- Moisture Content (to 0.01%)
- Antimicrobial Efficacy
- Heat Aging (dry or wet)
- Brush Wear
- Bend Recovery
- Gurley Stiffness
- Initial Tensile Modulus
- Tensile Strength, Elongation
- Abrasion Resistance
- Flex-fatigue Resistance
- Chemical Resistance
- Military Specifications (Mil Spec.)
- Controlled Temperature & Humidity

EQUIPMENT

- Perkin Elmer DSC6 Thermal Analysis System
- Fischer-Johns Melting Point Apparatus
- MacBeth Color Booth
- MacBeth Color Eye 3000 Spectrophotometer
- Atomic Absorption Spectrophotometer
- UV-Vis. Spectrophotometer
- Instron Tensile Tester Model 1101
- Gurley Stiffness Tester
- Brookfield Viscometer
- Leitz SM Binocular Microscope
- Stereo Microscope, Optical Comparator
- Video Microscope
- Controlled Environment Testing Room

EXPERTISE

- Chemical Engineering
- Plastics Engineering
- Chemistry
- Mechanical Engineering
- Industrial Engineering
- Quality Assurance Engineering
- Design, CAD
- Design of Experiments
- Statistics, SPC



NEW PRODUCT DEVELOPMENT

We are eager to work with you to develop new products. MFI has comprehensive laboratory facilities to develop and test filaments and toothbrushes.

We have a record of achievement in partnering with existing customers to develop new products from the concept stage through to successful commercialization.

New Materials

MFI is especially motivated to research and develop alternative plastic materials. We have experience in many materials and applications in many different filament markets. Ask about our alternate FDA approved materials:

- PBT polyester
- Nylon 6.10
- Custom engineered resins

Mixed Sizes

Filaments of different size can be mixed within the same filament bundle. Mixed diameters and sizes allow you to take advantage of small filaments designed for cleaning the gumline and between teeth while mixing them with larger sizes for sufficient stiffness and wear properties.

Mixed Colors

Filaments of two different colors may be mixed at different ratios in the same filament bundle. Color can be used to accent the tuft or to help distinguish filaments with a special function. MFI has over 60 different FDA (CFR 21 178.3297) approved colors

Mixed Filaments

Filaments with as many as two colors and three different sizes and shapes can be mixed within the same filament bundle.

Shaped Filaments

MFI has been producing many shapes, for many markets, for many years.

- Honeycomb shape: It has two hollow sections designed for flagging or feathering of the filament tips.
- Star shaped ribbed and grooved shape: The ribs are designed to help clean the gumline and between teeth. The grooves are designed to trap and deliver toothpaste to the teeth for efficient cleaning.
- Others and Custom engineered shapes

Antibacterial Filaments

We have experience in developing, producing and marketing antibacterial filaments for different markets.



DEFINITIONS

Specific Gravity is the weight of the material compared to an equal volume of water. The specific gravity of water is 1.00. Materials with specific gravities less than water float in water; those with specific gravities more than water sink. This property is useful in identifying the material. It is also useful in comparing the volume of filaments per pound. The lower the specific gravity, the higher the yield.

Melting Point is also useful in identifying the material. These values are typical values and actual melting points may vary by 20°F from these values. It should be kept in mind that each of these materials often soften and melt over a range of temperatures, and that the useful temperature limit of a filament is quite a bit lower than the melting point.

Tensile Modulus is a measure of the stiffness of the filament. The higher the modulus the stiffer the filament. Other names for tensile modulus are elastic modulus and Young's modulus.

Elongation refers to how much the filament will stretch before it breaks. A significant decrease in these values indicates that the filament is deteriorating usually due to UV, high temperature oxidation, or chemical attack.

Tensile Strength refers to how hard you can pull on the filament before it breaks. A significant reduction in tensile strength indicates deterioration of the material.

Bend Recovery is a filament's ability to return to its original position after being bent. Lack of bend recovery is a common mode of brush failure.

Abrasion Resistance is a filament's ability to resist being worn away. Abrasion is another mode of brush failure.

Ovality: No filament is perfectly round. Ovality is a measure of its out of roundness. It is calculated by measuring the largest and smallest diameters at a point along a filament and dividing the largest (called the d2) by the smaller (called the d1). Ovality generally increases with filament diameter. Certain colors and additives may affect ovality.

Set Resistance refers to a filament's ability to straighten completely after being moderately flexed for a long period. This differs from Bend Recovery which is a more severe bending for shorter periods.

Water Absorption and **Retention of Stiffness in Water** refer to the tendency of certain plastics to pick up and be plasticized by water. Some materials do not absorb water.

Sunlight, UV Light will result in the degradation of some polymers.

High Temperatures will cause some materials to degrade well below their melting points.

General Chemical Resistance refers to the ability of filaments to retain their important physical properties when exposed to certain chemicals. Ask about our Technical Bulletin on Chemical and Solvent Resistance.

The information contained herein is based on actual laboratory tests done by us and is believed to be accurate but no warranties are expressed or implied regarding its accuracy or as to the performance of these products. Samples are available for testing in specific applications.