Performance Properties of the Most Frequently Utilized Fibers and Yarns

Overview: **Y**arns and fibers are the basic building block from which fabrics are composed. As a company that develops fabrics to meet specific performance applications, Bally Ribbon Mills experience has demonstrated that, the process must begin with first understanding what our customers wish to accomplish. This, coupled with our knowledge of fibers, yarns and weaving technology, provides us with a keen ability to develop fabrics that meet specific application parameters. When working with one of our applications engineers, you will note that we always inquire as to the end use for the material you are looking for. This is because by our knowing what your intended use is, we can work with you to add value to the development process. Working with customers in this fashion for the past 80, plus years is a testament to the many applications and devices we have developed to solve problems brought to us by our customers. Typically, this problem solution process has evolved to address all of the following issues: Controlled elongation, controlled porosity, air permeation, self lubrication (reduced friction), abrasion resistance, high modulus, heat and light resistance, moisture and chemical resistance, 2D & 3D shapes, high-strength, lightweight, flexibility, flame resistance, corrosion resistance, bio-compatibility, shape retention, conductivity and static resistance, etc. What are your performance requirements?

Natural Fibers: Natural fibers are found in a raw state in plant and animal fiber. Natural fibers include **Hemp, Bamboo, Cotton, Wool, Silk** and fibers [P**olylactic Acid (PLA**), P**olyglutamic Acid (PGA) polymers**] made from renewable sources such as corn. Most natural fibers (hemp, wool, bamboo, cotton and wool) are spun from short (staple) fibers into a sliver, than made into roving and spun (entwined) to form a continuous, long fiber that may be woven, braided or knitted into a fabric. The resulting fabric usually has a "fluffy" appearance (unless finished, serged, or otherwise treated) that results from the short staple fibers from which they were produced. Silk, is a naturally spun, long polymer that are very similar to man made fibers. The resulting fabrics are shiny, smooth and have a much sot after hand. PLA and PGA are natural fibers that are polymerized by an industrial process.

Performance Properties of the Most Frequently Utilized Fibers and Yarns

Manmade Fibers: Manmade fibers are composed of long chain hydrocarbons. Most are synthesized as polymers from petroleum stocks. A typical manmade fiber begins life as a solid pellet, chip, or as flake. This pellet is heated to its melting point and fed to an extruder where it is forced, at a consistent speed, through a spinneret (like a showerhead) to form many long strands (like spaghetti), or filaments in a consistent thickness that solidify quickly in the cooler air. The filaments are then drawn and stretched, to orient the long molecules into an orderly arrangement. This drawing process gives the filament both its strength and elasticity. Filaments are than joined with other filaments into a fiber bundle to form a filament yarn. A monofilament is extruded as a single filament (fishing line). The resulting yarn is graded into deniers (see glossary) and used as yarn in the weaving, braiding, or knitting of fabric.

Nylon – A manufactured fiber in which the fiber forming substance is any long chain synthetic polyamide having recurring amide groups (-NH-CO-). Properties of nylon include excellent strength, flexibility, toughness, elasticity, abrasion resistance, washability, ease of drying, moisture absorption and resistance to attack from insects and microbes.

Polyester - A manufactured fiber in which the fiber forming substance is any long chain synthetic polymer composed of at least 85% by weight of an ester of dihydric alcohol and terephthalic acid. Polyester fibers have high strength, low moisture absorption, lightweight, resistant to shrinking and are quick drying. Polyester fibers have been used in the construction of medical implantable devices and are proven to be will tolerated en vivo.

Polyethylene – A manufactured fiber made of polymerized polyethylene units. It is often a monofilament, but is also available as continuous filament yarns and as staple fiber. Polyethylene fibers have a low specific gravity, extremely low moisture regain, and good resistance to mildew and insects. It has shown utility as a geotextile, in industrial applications and outdoor furniture. Polyethylene yarn cannot be dyed. It is colored by the addition of pigments and dyes to the melt at extrusion.

Performance Properties of the Most Frequently Utilized Fibers and Yarns

Polypropylene – A manufactured olefin fiber made from polymers, or copolymers of propylene. The resulting fiber has a high degree of crystallinity (72 to 75%), so it is very strong and resilient. It has excellent chemical resistance, and while its melt point is low compared to nylon and polyester (165°C) it is so light that it floats. It is also highly resistant to mechanical abuse. With low moisture absorption, it is useful as filtration media, protective clothing, outerwear and binding materials.

Rayon - A manufactured fiber composed of regenerated cellulose. It can be made to be quite lustrous and strong dependent upon the number and size of the filaments in the yarn. End uses are in clothing, tire cord, industrial products and in blends with other fibers to enhance functional and aesthetic qualities of the resulting fabric.

Fiberglass (e-glass, s-glass) – One may argue that fiberglass, a silica based material, is a natural fiber, but fiberglass must be highly processed before it can be useful as a yarn. Fiberglass is very brittle and difficult to work with. It does not absorb water and has very low elongation. Its most significant feature is its high strength when the fibers are in an oriented direction. Fiberglass is also very resistant to heat, flame (melts at 1121°C, or higher) and is resistant to attack by chemicals. All glass fibers have a very high (2.48 to 2.54g/cc) densities.

PEEK – Polyetheretherketone (PEEK) is a manufactured fiber with high temperature resistance that also processes easily and is very resilient. It is quite inert and has excellent surface release (low stick) properties that make it useful for food contact and for medical applications.

Carbon/Graphite Fiber – Carbon/Graphite fiber is a high tensile fiber that is made by heating rayon, polyacrylonitrile fibers, or petroleum residues to appropriate temperatures. They are typically over 90% carborized. At Bally Ribbon Mills we have woven Carbon/Graphite fibers into highly complex, engineered 2 and 3 dimensional shapes that have proven use in aerospace composite fabrics, sporting goods and racing auto frames used to form structural and weight bearing components. The resulting structures are lightweight, very strong, highly resistant to corrosion and have proven to be stealthy by their virtue of absorbing, rather then reflecting radar signals.

Performance Properties of the Most Frequently Utilized Fibers and Yarns

Performance Fibers: Performance fibers are manmade fibers that have been designed to meet one or more specific applications. They are the end result of costly research and are typically trademarked as belonging to the companies that developed them. Many fabrics designed and woven by Bally Ribbon Mills have been developed with these yarns, or a blend of these yarns to achieve specific performance at an appropriate price point in line with the application.

Polytetrafluoroethylene (PTFE) - is a fluorine-containing fiber characterized by its high chemical stability, moderate tensile strength, chemical inertness and high melting point. The fiber may be drawn as a filament yarn (Brown Teflon®), or slit from a membrane (slit film) and elongated (ePTFE) white available from Lensing and W.L. Gore & Associates. PTFE has a very low frictional coefficient giving it a slippery hand. PTFE finds use in release applications, as self-lubricating bearings, packaging (food and medical) and as filtration media for highly corrosive fluids.

Aramide – A manufactured fiber in which the fiber-forming material is a long chain synthetic polyamide having at least 85% of its amide linkages (-NH-CO-) attached directly to two aromatic rings. Aramide fibers have low flammability, high strength and high modulus. Aramide fibers have found use in protective clothing, ropes and webbing used in safety applications and used as protection from ballistics and projectiles. Nomex® and Kevlar® are two aramide fibers produced by the DuPont® Company that have found use as fibers demonstrating heat and fire resistance. Aramide yarns, as a fiber class, have high modulus and significant tensile strength. Other aramide fibers include Tarwon®, Technora® and Conex® brand fibers. Unfortunately most aramide yarns are effected by UV light which alters the natural color and degrades fiber strength upon prolonged exposure.

Polybenzimidazole (PBI) – A manufactured fiber in which the fiber forming substance is a long chain aromatic polymer having recurrent imadazole groups as an intricate part of the polymer chain. PBI is a high performance fiber with high chemical resistance and will not burn in air. It has no melting point and does not drip, or melt when exposed to

flame. The fibers retain their flexibility; dimensional stability and strength without becoming brittle even when exposed to extreme heat. It can be used in its raw state, or blended with other fibers (Kevlar®/PBI). PBI has high moisture regain, low modulus and comfort properties similar to cotton. These properties make PBI, and blends of PBI, very useful in safety and protective applications.

Vectran® - A manufactured yarn spun from liquid crystal polymer. These fibers have high-temperature resistance, high strength and modulus, high resistance to moisture and chemicals. Vectran® exhibits good property retention in hostile environments. An outstanding feature of this yarn is that it has very low creep. Therefore Vectran® excels in applications requiring minimal elongation.

Spandex®/Lycra® - A manufactured fiber in which the fiber-forming substance is a long chain synthetic polymer composed of at least 85% of segmented polyurethane. The fiber is lighter in weight, is more durable and more supple than conventional elastic thread, while offering two to three times the restraining power. The yarn does not suffer from deterioration from oxidation, it is not damaged by body oils, perspiration, lotions, or detergents. As such, this yarn finds utility in foundation garments, bathing suits, hose and stretch webbing.

Spectra®/Dyneema® - A manufactured fiber made from ultra-high molecular weight polyethylene. This remarkably durable material is one of the world's strongest and lightest fibers. The material is pound for pound, ten times stronger then steel, more durable than polyester, and, according to the manufacturers, has a specific strength that is 40% greater than aramid fiber. The fiber is used for ballistic and projectile protection, in helmets, as vehicle armor, sailcloth, lifting slings and cut resistant gloves. It is also resistant to degradation from UV light.

Ryton® - A manufactured yarn composed of polymers containing Polyphenylene Sulfide (PPS). This fiber has high temperature resistance (230° C) and good chemical resistance. It is also flame retardant. The fiber has demonstrated to be useful as bag filtration applications, liquid chemical filtration and as webbing used in highly toxic environments.

Performance Properties of the Most Frequently Utilized Fibers and Yarns

Metalized Yarns – These yarns are either yarn made from thinly drawn metals (gold, silver, nitinol, stainless steel, nickel, etc.) flexible enough to be woven, or yarns that have been metalized through the bonding of a metal to the yarn. Typical examples of metalized yarns are Silver (X- static® fiber) or Copper, etc. bonded to nylon. The DuPont Company manufactures a metal clad fiber called Aracon® fiber, in which a metal is directly bonded to an aramide fiber. Typical uses for metalized yarns include antimicrobal, static dissipation, shielding from electromagnetic force (EMF), shielding from radiation, shape retention and conductivity.

Reflective Yarns - Are manufactured yarns made from polymers that have minute glass beads distributed within the polymer. These glass beads, when exposed to light, reflect light back to its source. Other yarns are composed of polymers that have florescent materials distributed throughout the yarns. The florescent materials gather energy when exposed to a light source and give off (glow) this stored energy when the light source is removed. These yarns are used in reflective safety webbing, reflective barrier fabric strips and binding material on sportswear.

Specialty Yarns: In addition to the yarns and fibers listed above Bally Ribbon Mills has contacts at yarn manufactures that are able to combine, blend, spin and to otherwise formulate yarns to meet a specific application. Bally Ribbon Mills ships over 6 million lineal yards of fabric every month. Given our significant manufacturing capability and over 80 years in business, we have excellent sources for throwsters, twisters, spinners and fiber producers from which to discuss and acquire the materials to use in your development project. Should you feel that this service would be of benefit in your development project, please feel free to discuss this need with your Bally Ribbon Mills applications engineer.