

111-4
19019
32P

NASA Contractor Report 191539

Illustrated Glossary of Textile Terms for Composites

Christopher M. Pastore

*North Carolina State University
Department of Textile Engineering, Chemistry and Science
Raleigh, North Carolina*

Purchase Order L-18543D
September 1993



National Aeronautics and
Space Administration
Langley Research Center
Hampton, Virginia 23681-0001

N94-15484

Unclas

G3/24 0190199

(NASA-CR-191539) ILLUSTRATED
GLOSSARY OF TEXTILE TERMS FOR
COMPOSITES (North Carolina State
Univ.) 32 p

Introduction

This glossary has been developed in response to the need for better communication between textile manufacturers and composites engineers. The need for such a glossary has been under discussion for some time, and at a recent workshop on process control of textile composites held at NASA Langley, one of the principal action items identified was the creation of such a document. The need became apparent in this workshop which included both textile and aircraft manufacturers, when the difficulty in precise communication became obvious.

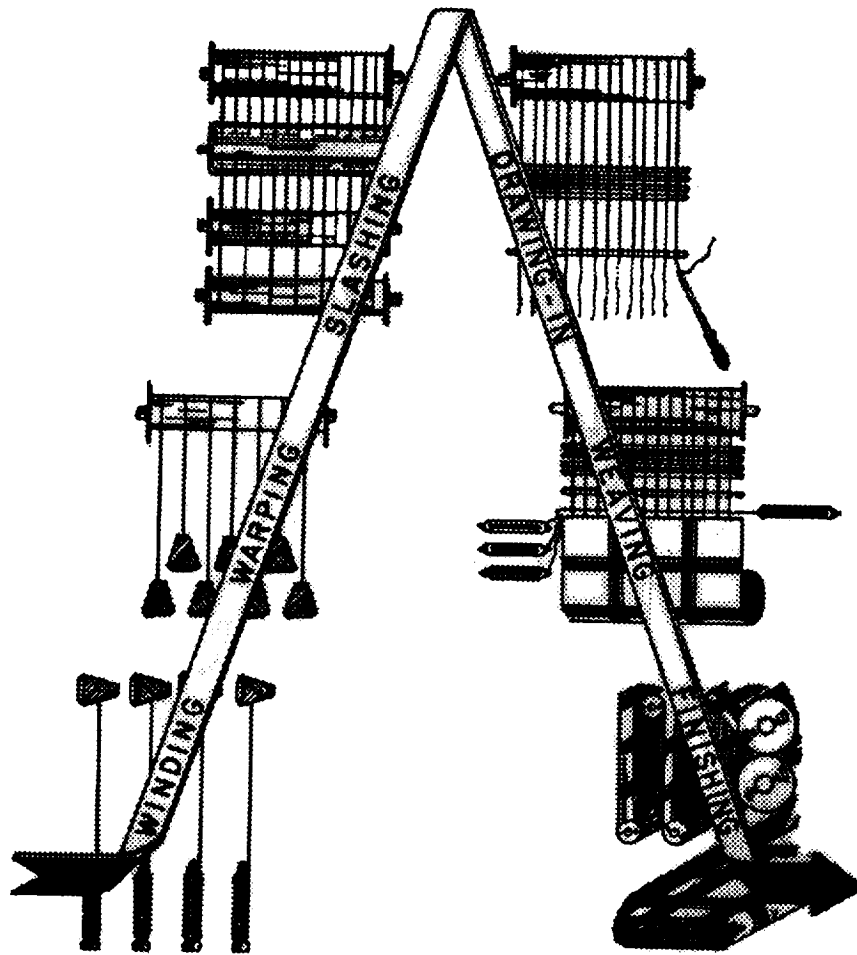
The terms in this glossary are those commonly used by the textile industry, and unlikely to be familiar to those educated in engineering and science. To ensure that a full range of terminology was employed, several sources were employed. Traditional textile dictionaries and textbooks, as well as terminology documents prepared by various government and industrial agencies were used as the starting point. Based on these documents, a rough draft was created and sent to a number of people working in the general area of textile composites (Appendix A). The industrial and government participants gave their feedback to the the document and this was incorporated into the final text.

The intention of this glossary is to allow the reader to identify terms used in the traditional textile industry, and understand their meaning. Illustrations are used to help clarify some of the more difficult to describe terms.

The terminology included in this document relate to various steps in the process, including fibers, yarns, fabrics, and finishing processes. Some composites terms are also included in this document, relating to matrix placement and composite defects. Where appropriate, illustrations have been incorporated.

There are many terms involved in the textile industry, principally because of the age of the industry (at least 3,000 years), and the numerous steps involved in forming a fabric. Archaic and specialty terms have been omitted from this glossary. Terms such as *retting*, *scrutching*, *scrooping* are not included. This document is not intended as a textile dictionary, but rather as a glossary of textile terms for composites engineering.

To realize the complexity involved in textile manufacturing, and thus the necessity for a large array of terminology, consider the relatively simple weaving process which has remained virtually unchanged for 300 years. In order to manufacture a simple woven cloth, it is necessary to convert a fiber (natural fibers are very short, approximately 1-3 cm) into a yarn for fabrication. This yarn must then be converted into a fabric, and the final fabric must be treated for handling. However, as it is very difficult to process these materials as they form, there are several operations which are required to make handling the material easier. Thus, the conversion of fiber to fabric takes on several steps in the process, as illustrated below. Because each of the processes illustrated is typically carried out by a different sub-industry of the textile world, there is a unique set of vocabulary for each process step. It should also be pointed out that the flow chart is greatly simplified. Each process may involve up to ten distinct process steps before conversion is complete.



Process Flow of Fiber-Yarn-Fabric Production Steps

A

Abraded Yarn A filament yarn in which filaments have been cut or broken to create a surface hairiness (fibrillation) to simulate the surface character of spun yarns. Abraded yarns are usually plied or twisted with other yarns before use. (see also hispidulous)



Abraded Yarn

Adherend A body that is held to another body, usually by an adhesive.

Adhesive Failure Rupture of an adhesive bond such that the separation appears to be at the adhesive-adherend interface.

Adhesive Strength Strength of the bond between an adhesive and an adherend.

Air-Bubble Void Air entrapment within and between the plies of reinforcement or within a bondline or encapsulated area; localized, and non-interconnected.

Air Forming A process in which air is used to separate and move fibers to fashion a web.

Air Jet Spinning A spinning system in which yarn is made by wrapping fibers around a core stream of fibers with compressed air. In this process, the fibers are drafted to appropriate sliver size, then fed to the air-jet chamber where they are twisted, first in one direction, then in the reverse direction in a second chamber. They are stabilized after each twisting operation.

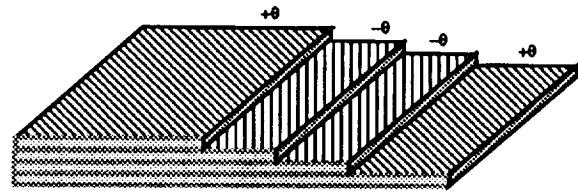
Air-Laid Nonwovens Fabrics made by an air-forming process. The fibers are distributed by air currents to give a random orientation with the web and a fabric with isotropic properties.

Alternating Twist A yarn in which the twist alternates between S-type and Z-type along the length of the yarn. Sometimes called "False twist."



Alternating Twist in a Yarn

Angle-Ply Laminate A laminate formed with fibers of adjacent plies oriented at alternating angles, e.g. $[\theta, -\theta]_n$.



Schematic of Angle Ply Laminate

Anisotropic Not having the same properties in every direction. In the plane of a fabric, it is related to a non-random distribution of fibers.

Areal Weight The weight of fiber per unit area (width x length) of tape or fabric. Typically expressed in either g/m^2 or oz/yd^2 .

Autoclave 1. An apparatus for carrying out certain finishing operation, such as pleating and heat-setting, under pressure in a superheated steam atmosphere. 2. An apparatus for polymerizing condensation polymers such as nylon or polyester at any pressure above or below atmospheric.

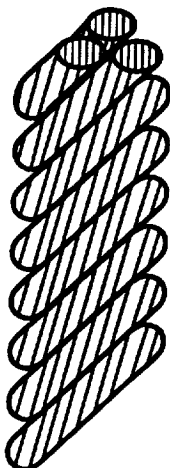
Automatic Press A hydraulic press for compression molding or an injection machine that operates continuously, being controlled mechanically, electrically, hydraulically, or by a combination of any of these methods.

Axial Yarn 1. A yarn running purely in the 0° direction of a fabric (warp direction). This yarn

has no intentional crimp. 2. The system of longitudinal yarns in a triaxial braid that are inserted between bias yarns.

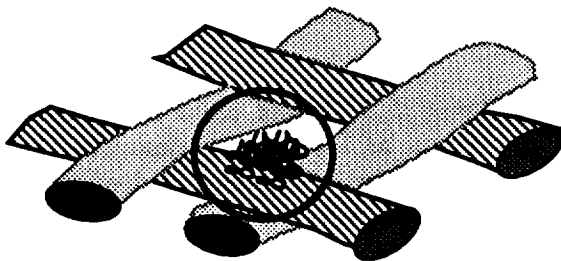
B

Balanced Twist In a plied yarn or cord, an arrangement of twist which will not cause the yarn or cord to twist on itself or kink when held in an open loop. A single ply is twisted in a particular direction (S or Z), and several plies are twisted together in the opposite direction (Z or S) so that the final yarn structure has no net residual torque.



Yarns with Balanced Twist

Balling Up A defect in which loose or frayed fibers form into a ball and are then woven into the fabric.



Balling Up Defect in Woven Fabric

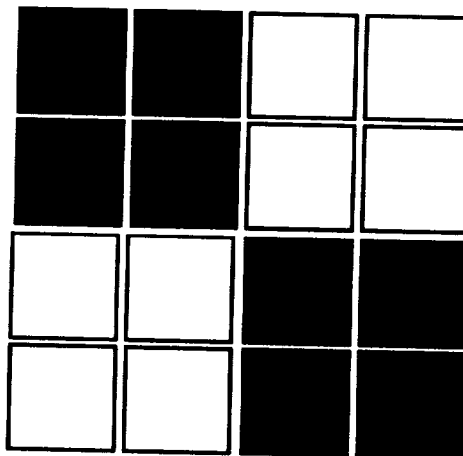
Ball Warp Parallel threads in the form of a twistless rope wound into a large ball. When wound mechanically with a quick traverse a ball warp may be made in the form of a large cylindrical package.

Ban Another name for a yarn creel.

Base Fabric In coated fabrics, the underlying substrate (q.v.).

Basket Stitch A knit construction in which purl and plain loops are combined with a preponderance of purl loops in the pattern courses to give a basket weave effect.

Basket Weave A variation of the plain weave in which two or more warp and filling threads are woven side by side to resemble a plaited basket. Fabrics have a loose construction and a flat appearance and are used for such things as monk's cloth and drapery fabrics.



Schematic of Basket Weave

Batting A soft, bulky assembly of fibers, usually carded. Battings are sold in sheets or rolls and are used for warm interlinings, comforter stuffings, and other thermal or resiliency applications.

Beaded Selvage A weaving defect at the selvage of excessive thickness or irregular filling loops that extend beyond the outside selvages.

Beam A cylinder of wood or metal, usually with a circular flange on each end, on which warp yarns are wound for slashing, weaving, or warp knitting.

Beating-Up The last operation of the loom in weaving, in which the last pick inserted in the fabric is "beat" into position against the preceding picks.

Bending Length A measure of fabric stiffness based on how the fabric bends in one plane under the force of gravity.

Bending Modulus Stress a specimen can withstand when bent a unit deflection. For fibers, the stress per unit of linear fiber weight required to produce a specified deflection of a fiber.

Bending Rigidity This measure of a material's resistance to bending is calculated by multiplying the material's weight per unit area by the cube of its bending length.

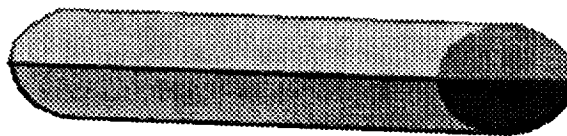
Bias Fabric A 2-D textile fabric that when oriented in the XY plane contains fibers that are aligned in a different direction, i.e., 45 to the X-axis.

Bias Filling A fabric defect in which the filling yarn does not run at a right angle to the warp. The principal cause is improper processing on the tenter frame.

Biconstituent Fiber A fiber extruded from a homogeneous mixture of two different polymers. Such fibers combine the characteristics of the two polymers into a single fiber.

Bi-directional Fabric A fabric which has reinforcing fibers in two distinct directions, e.g., in the warp (machine) direction and filling (cross) direction.

Bilateral Fibers Two generic fibers or variants of the same generic fiber extruded in a side-by-side relationship.



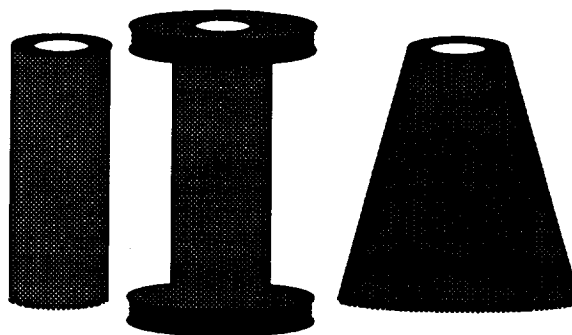
Bilateral Fibers

Binder An adhesive applied with a solvent, or a softenable plastic melted to bond fibers together in a web or to bind one web to another.

Binder Fibers Fibers that can act as an adhesive in a web because their softening point is relatively low compared with that of the other fibers in the material.

Blister A bulge resulting from separation of coating or laminating material from the base fabric.

Bobbin A cylindrical or slightly tapered barrel, with or without flanges, for holding slubbings, rovings, or yarns.



Bobbin for Holding Yarn

Bolt A roll or piece of fabric of varying length.

Bonded Fabric 1. A fabric containing two or more layers of cloth joined together with resin, rubber, foam, or adhesive to form one ply. 2. See Nonwoven Fabric.

Bonding 1. A process for adhesive laminating two or more fabrics or fabric and a layer of plastic foam. There are two methods: the flame method used for bonding foam and the adhesive method used for bonding face and backing fabrics. 2. One of several processes of binding fibers into thin sheets, webs, or battings by means of adhesives, plastics, or cohesion (self bonding).

Bonding with Binder Fibers Specially designed low melting-point fibers are blended with other fibers in a web, so that a uniformly bonded structure can be generated at a low temperature by fusion of the binder fiber with adjacent fibers.

Point Bonding The process of binding thermoplastic fibers into a nonwoven fabric by applying heat and pressure so that a discrete pattern of fiber bonds is formed. Also called *Spot Bonding*.

Print Bonding A process of binding fibers into a nonwoven fabric by applying an adhesive in a discrete pattern.

Spray Bonding A process of binding fibers into a nonwoven fabric involving the spray application of a fabric binder.

Stitch Bonding A bonding technique used for the fabrication of nonwovens in which the fibers are connected (bonded) by stitches sewn or knitted through the web. Also known as *Quilting*.

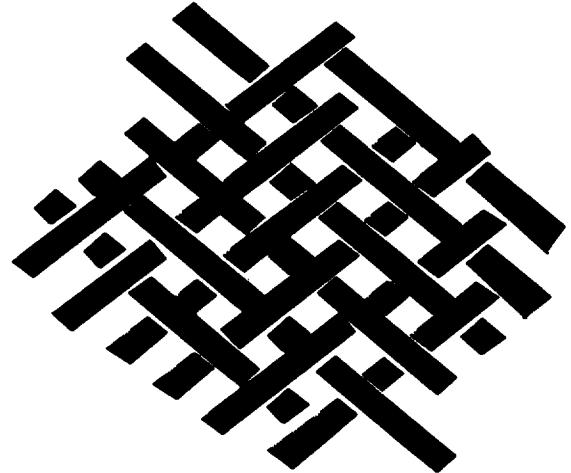
Bow The greatest distance, measured parallel to the selvages, between a yarn and a straight line drawn between the points at which this yarn meets the selvages. Bow may be expressed directly in inches or as a percentage of the width of the fabric at that point.

Box Loom A loom using two or more shuttles for weaving fabrics with filling yarns that differ in fiber type, color, twist level, or yarn size. The box motion is automatic, changing from one shuttle to another.

Box Mark A fine line parallel to the filling caused by shuttle damage to a group of filling yarns.

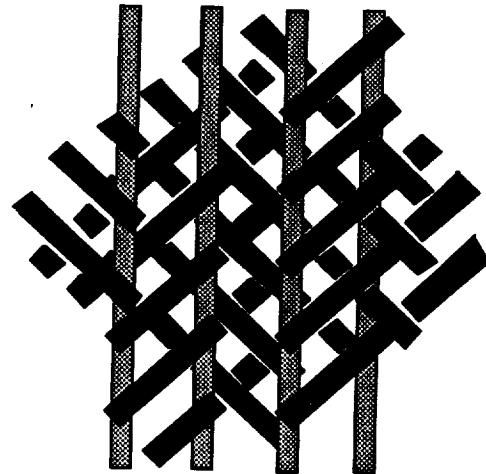
Braid 1. A narrow textile band, often used as trimming or binding, formed by plaiting several strands of yarn. The fabric is formed by interlacing yarns diagonally to the production of the material. 2. In aerospace textiles, a system of three or more yarns which are interlaced in such a way that no two yarns are twisted around each other.

Biaxial Braid Braided structure with two yarn systems one running in one direction and the other in the opposite direction.



Biaxial Regular Braid

Triaxial Braid A braided fabric structure which includes axial yarns running in the longitudinal direction. The axial yarns are entrapped within a braid intersection. The maximum number of axial yarns which may be included in the fabric is one half the number of braiding yarns.



Triaxial Regular Braid

Brushing A finishing process in which rotating brushes raise a nap on knit or woven fabrics.

Bundle A general term for a collection of essentially parallel filaments or fibers.

Burling 1. The process of removing loose threads and knots from fabrics with a type of tweezers called a burling iron. 2. The process of correcting loose tufts and replacing missing tufts following carpet construction.

C

Cabled Yarn A yarn formed by twisting together two or more plied yarns.

Calendar A machine used in finishing to impart a variety of surface effects to fabrics. A calendar essentially consists of two or more heavy rollers, sometimes heated, through which the fabric passes under heavy pressure.

Calendering A mechanical finishing process for fabrics to produce special effects, such as high luster, glazing, moire, and embossed effects. In this operation, the fabric is passed between heated rolls under pressure.

Calendar Rolls 1. The main cylinders on a calendar. 2. Smooth or fluted rolls used on various fiber processing machines such as pickers and cards to compress the lap or sliver as it passes between them.

Can A cylindrical container, about 3 feet high and 10 or 12 inches in diameter, that is used to collect sliver delivered by a card, drawing frame, etc..

Carbon-Carbon A composite material consisting of carbon and graphite fibers in a carbon or graphite matrix.

Carbon fiber Fiber produced by the pyrolysis of organic precursor fibers, such as rayon, polyacrylonitrile (PAN), and pitch, in an inert environment. The term is often used interchangeably with graphite; however, carbon fibers and graphite fiber differ. The basic differences lie in the temperature at which the fibers are made and heat treated, and in the amount of elemental carbon produced. Carbon fibers typically

are carbonized in the region of 1315° C (2400° F) and assay at 93 to 95% carbon while graphite fibers are graphitized at 1900° to 2480° C (3450° to 4500° F) and assay at more than 99% elemental carbon.

Carbonization The process of pyrolysis in an inert atmosphere at temperatures ranging from 800° to 1600° C (1470° to 2910° F) and higher, usually about 1315° C (2400° F). Range is influenced by precursor, individual manufacturer's process, and properties desired.

Card A machine used in the manufacture of staple yarns. Its functions are to separate, align, and deliver the fibers in a sliver form and to remove impurities. The machine consists of a series of rolls, the surfaces of which are covered with many projecting wires or metal teeth. Short staple systems employ flat strips covered with card clothing rather than small rolls.

Carding A process in the manufacturing of spun yarns whereby the staple is opened, cleaned, aligned, and formed into a continuous, untwisted strand called a sliver.

Caterpillar A large slub formed in a combination or plied yarn as a result of one of the ends breaking and sliding or skinning back along the other yarn.

Cavity The space inside a mold in which a resin or molding compound is poured or injected.

Chafed End A warp end that has been abraded during processing. It generally appears as a dull yarn often containing broken filaments.

Circular Knitting Machine A type of knitting machine which forms a knitted fabric in a cylindrical fashion. Most fabrics formed from circular knitting machines are weft knit structures.

Coalesced Filaments Filaments stuck together by design or accident during the extrusion process.

Cockling A crimpness or pucker in the yarn or fabric usually caused by the lack of uniform quality

in the raw material used, improper tension on yarn in weaving, or weaving together yarns of different numbers.

Collimated Roving Roving that has been made using a special process (usually parallel wound), so that the strands are more parallel than in standard roving.

Combed Sliver A continuous band of untwisted fiber, relatively free of short fibers and trash, produced by combing card sliver.

Commingled Yarns In aerospace textiles, two or more continuous multifilament yarns, the filaments of which have been intermixed with each other without adding twist or otherwise disturbing the parallel relationship of the combined filaments. Usually consists of reinforcing yarn, such as graphite or glass, and a thermoplastic matrix yarn.

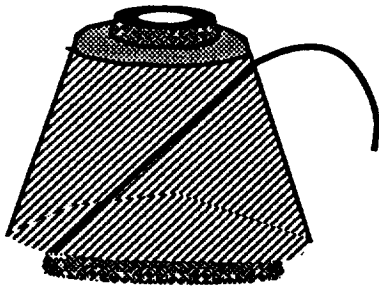


e.g. Carbon ●
e.g. PEEK ○

Commingled Yarns

Compression Molding A mold that is open when the material is introduced and that shapes the material by the pressure of closing by heat.

Cone A conical package of yarn, usually wound on a disposable paper core.



Cone

Conjugate Fiber A two-component fiber with specific ability to crimp on hot or hot/wet treatment because of different shrinkage. (Also see Bilateral Fibers.)

Core Spinning The spinning process for fabricating a core-spun yarn. This consists of feeding a core yarn (which could be an elastomeric filament yarn, a regular filament yarn, a textured yarn, or a previously spun yarn) into the front delivery roll of the spinning frame and of covering the core yarn with a sheath of fibers during the spinning operation.

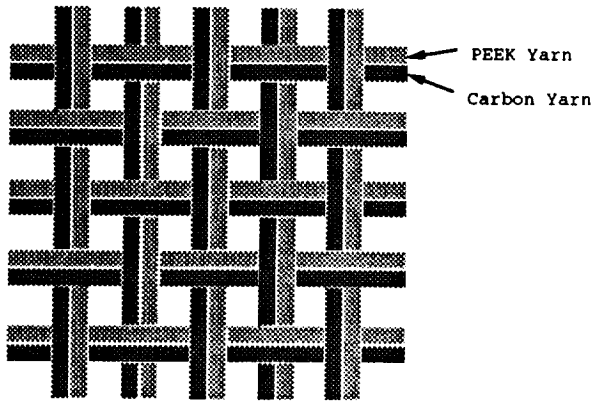
Count 1. A numerical designation of yarn size indicating the relationship of length to weight. (Also see Yarn Number.) 2. The number of warp yarns (ends) and filling yarns (picks) per inch in a woven fabric, or the number of wales and courses per inch in a knit fabric. For example, a fabric count of 68x52 indicates 68 ends per inch in the warp and 52 picks per inch in the filling.

Course The row of loops or stitches running across a knit fabric, corresponding to the filling in woven fabrics.

Cover 1. The degree of evenness of thread spacing. 2. The degree to which underlying structure is concealed by the surface material, as in carpets, the degree to which a pile covers backing. 3. The ability of a dye to conceal defects in a fabric.

Cover Factor The fraction of the surface area that is covered by yarns assuming round yarn shape. An areal ratio of projected fabric surface area to nominal surface area.

Cowoven Fabric In aerospace textiles, a fabric in which a reinforcing fiber and matrix fiber are adjacent to each other as one end in the warp and/or filling direction.



Schematic of Cowoven Fabric

Crash A course fabric with a rough, irregular surface made from thick, uneven yarns.

Creel 1. A framework arranged to hold slivers, rovings, or yarns so that many ends can be withdrawn smoothly and evenly without tangling. 2. A similar device used to aggregate sub-tows in manufactured staple processing, especially polyester.

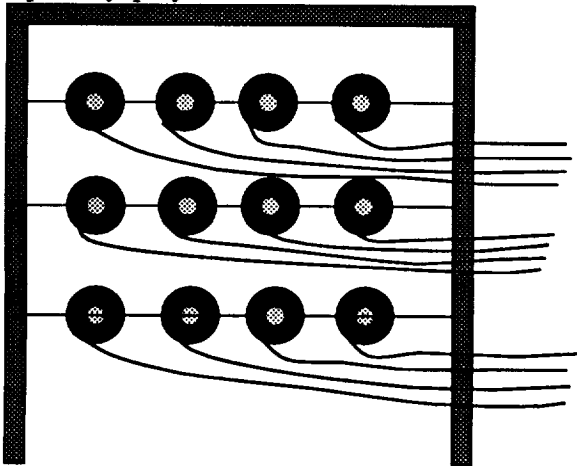


Illustration of a Yarn Creel

Crimp 1. The waviness of a fiber expressed as crimp per unit length, calculated as the ratio of arc length to modular length 2. The difference in distance between two points on an unstretched fiber and the same two points when the fiber is straightened under specified tension. Crimp is expressed as a percentage of the unstretched length. 3. The difference in distance

between two points when the yarn has been removed from the fabric and straightened under specified tension, expressed as a percentage of the distance between the two points as the yarn lies in the fabric.



Illustration of Crimp in a Woven Fabric

D

Denier A weight-per-unit-length measure of any linear material. Formally, it is the number of 0.05 gram weights in a 450-meter length. This is numerically equal to the weight in grams of 9,000 meters of the material. Denier is a direct numbering system in which the lower numbers represent the finer sizes and the higher numbers the coarser sizes. In the U.S., the denier system is used for numbering filament yarns (except glass), manufactured fiber staple (but not spun yarns), and tow. In most countries outside the U.S., the denier system has been replaced by the tex system. The following denier terms are in use:

Denier per Filament(dpf) The denier of an individual continuous filament or an individual staple fiber if it were continuous. In filament yarns, it is the yarn denier divided by the number of filaments.

Yarn Denier The denier of a filament yarn. It is the product of the denier per filament and the number of filaments in the yarn.

Total Denier The denier of a tow before it is crimped. It is the product of the denier per filament and the number of filaments in the tow. The total denier after crimping (called crimped total denier) is higher because of the resultant increase in weight per unit length.

- Dent** On a loom, the space between the wires of a reed. (*c.f. Reed*)
- Dial** In a circular/knitting machine, a circular steel plate with radially arranged slots for needles. A knitting machine equipped with both a dial and a cylinder (q.v.) can produce double-knit fabrics.
- Dimensional Stability** The ability of a textile material to maintain or return to its original geometric configuration.
- Distortion** In a fabric, the displacement of fill fiber from the 90 angle (right angle) relative to the warp fiber. In a laminate, the displacement of the fibers (especially at radii), relative to their idealized location, due to motion during lay-up and cure.
- Doff** 1. To replace empty bobbins with a set of full bobbins. 2. A set of full bobbins produced by one machine (a robing frame, a spinning frame, or a manufactured filament-yarn extrusion machine).
- Doffer** 1. The last or delivery cylinder of the card from which the sheet of fibers is removed by the doffer comb. 2. An operator who removes full bobbins, spools, containers, or other packages from a machine and replaces them with empty ones.
- Double-cloth Construction** Two fabrics are woven in the loom at the same time, one fabric on top of the other, with binder threads holding the two fabrics together. The weave on the two fabrics can be different.
- Double-knit Fabric** A fabric produced on a circular-knitting machine equipped with two sets of latch needles situated at right angles to each other (dial and cylinder).
- Double weave** A fabric woven with two systems of warp or filling threads so combined that only one is visible on either side. Cutting the yarns that hold the two cloths together yields two separate cut-pile fabrics.
- Doubling** 1. A process for combining several strands of sliver, roving, or yarn in yarn manufacturing. 2. The process of twisting together two or more singles or plied yarns, i.e., plying. 3. A British term for twisting. 4. The term doubling is sometimes used in a sense opposite to singling. This is unintentional plying. 5. A yarn, considerably heavier than normal, produced by a broken end becoming attached to and twisting into another end.
- Draft** In weaving, a pattern or plan or drawing-in.
- Drawing** 1. The process of attenuating or increasing the length per unit weight of laps, slivers, slubbings, rovings. 2. The hot or cold stretching of continuous filament yarn or tow to align and arrange the crystalline structure of the molecules to achieve improved tensile properties.
- Drop Stitch** 1. An open design made in knitting by removing some of the needles at set intervals. 2. A defect in knit fabric.

E

End 1. An individual warp yarn. A warp is composed of ends. 2. An individual sliver, slubbing, roving, yarn, thread, or cord. 3. A short length or remnant of fabric.

End Count An exact number of ends supplied on a ball of roving.

Entangling A method of forming a fabric by wrapping and knotting fibers in a web about each other, by mechanical means, or by the use of jets of pressurized water, so as to bond the fibers.

F

Fabric Crimp The angulation induced between a yarn and a woven fabric via the weaving or braiding process.

Fabricating (fabrication) The manufacture of products from molded parts, rods, tubes, sheeting, extrusions, or other form by appropriate operations, such as punching, cutting, drilling, and tapping.

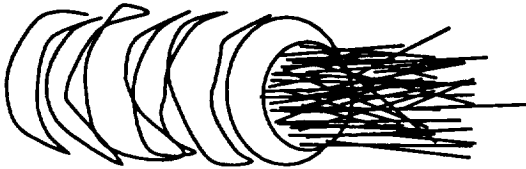
Fabric Crimp Angle The maximum acute angle of a single weaving yarn's direction measured from a plane parallel to the surface of the fabric.

Fabric Fill Face The side of the woven fabric where the greatest number of the yarns are perpendicular to the selvage.

Fabric Warp Face The side of the woven fabric where the greatest number of the yarns are parallel to the fabric.

Face The correct or better-looking side of the fabric.

Fasciated Yarn Yarns consisting of a core of discontinuous fibers with little or no twist and surface fibers wrapped around the core bundle.



Schematic of Fasciated Yarn

Fiber Architecture The spatial arrangement of fibers in the preform. Each architecture has a definite repeating unit.

Fiber Distribution In a web, the orientation (random or parallel) of fibers and the uniformity of their arrangement.

Fiber Placement In general, refers to how the plies are laid into their orientation, i.e., by hand, by a textile process, by tape layer, or by a filament winder. Tolerances and angles are specified. Microprocessor-controlled placement that gives precise control of each axis of motion permits more intricate winding patterns than are

possible with conventional winding and is used to make composites that are more complex than usual filament-wound structures.

Fiber Wash Splaying out of woven or nonwoven fibers from the general reinforcement direction. Fibers are carried along with bleeding resin during cure.

Fibrets Very short ($< 1mm$), fine (diameter < 50 microns) fibrillated fibers that are highly branched and irregular resulting in very high surface area.

Fibrillation Massive amounts of fly produced in a braiding process due to friction and abrasion applied to the yarns. The source of friction is other yarns and the rings and hooks over which the yarns travel. In severe cases, may cause jamming of the braiding machine if not corrected.

Filament The smallest unit of a fibrous material. The basic units formed during drawing and spinning, which are gathered into strands of fiber for use in composites. Filaments usually are of extreme length and very small diameter, usually less than 25 micrometers (1 mil.)

Filling In a woven fabric, the yarn running from selvage to selvage at right angles to the warp. Each crosswise length is called a pick. In the weaving process, the filling yarn is carried by the shuttle or other type of yarn carrier.

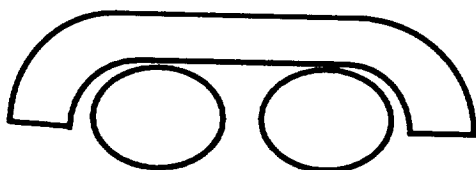
Finishing All the processes through which fabric is passed after bleaching, dyeing, or printing in preparation for the market use. Finishing includes such operations as heat-setting, napping, embossing, pressing, calendering, and the application of chemicals that change the character of the fabric. The term finishing is also sometimes used to refer collectively to all processing operations above, including bleaching, dyeing, printing, etc.

Flat-Knit Fabric 1. A fabric made on a flat-knitting machine, as distinguished from tubular fabrics made on a circular-knitting machine. While tricot and milanese warp-knit fabrics

(non run) are knit in flat form, the trade uses the term flat-knit fabric to refer to weft-knit fabrics made on a flat machine, rather than warp-knit fabrics. 2. A term used in the underwear trade for plain-stitch fabrics made on a circular-knitting machine. These fabrics have a flat surface and are often called flat-knit to differentiate them from rib-knit or Swiss rib fabrics. In this case, the term refers to the texture, not the type of machine on which the fabric was knit.

Flat-Knitting Machine A weft knitting machine with needles arranged in a straight line in a flat plate called the bed. The yarn travels alternately back and forth, and the fabric may be shaped or varied in width, as desired, during the knitting process. Lengthwise edges are selvages. Flat-knitting machines may be divided into two types: latch-needle machines for sweaters, scarves, and similar articles and fine spring-needle machines for full fashioned hosiery.

Float 1. The portion of a warp or filling yarn that extends over two or adjacent filling picks or warp ends in weaving for the purpose of forming certain designs. 2. In a knit fabric, a portion of yarn that extends for some length without being knitted in. 3. a fabric defect consisting of an end lying or floating on the cloth surface instead of being woven in properly. Floats are usually caused by slubs, knot-tails, knots, or fly waste, or sometimes by ends being drawn in heddle eyes incorrectly or being twisted around heddle wires.



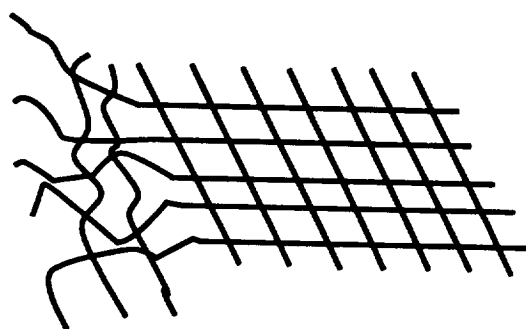
Schematic Illustration of a Single Float

Flocking A method of cloth ornamentation in which adhesives printed or coated on a fabric, and finely chopped are applied all over by means of dusting, air-blasting, or electrostatic attraction. In flock printing, the fibers adhere only

to the printed areas and are removed from the unprinted areas by mechanical action.

Fly The short waste fibers that are released into the air in textile processing operations such as picking, carding, spinning and weaving.

Fraying The slipping or raveling of yarns from unfinished edges of cloth.



Schematic of Frayed Edge on a Woven Fabric

G

Gabardine A firm durable, warp-faced cloth, showing a decided twill line of 45 or 63 degrees right-hand twill.

Graphite The crystalline allotropic form of carbon.

Graphite Fiber A fiber made from a precursor by an oxidation, carbonization, and graphitization process. See also Carbon Fiber.

Greige Fabric An unfinished fabric just off the loom or knitting machine.

Grinning 1. A flaw in fabric, especially a ribbed fabric, that occurs when warp threads show through the covering filling threads or when the threads have slipped leaving open spaces on either side. 2. A condition that occurs when the carpet backing shows through the pile. 3.

A printing term referring to either poor cover where the background shade shows through the print, or to the "two-tone" appearance of a shade printed with incompatible dyes.

Gripper Loom Shuttleless looms. These looms employ a projectile with a jaw that grips the end of the filling yarn during the insertion of the pick.

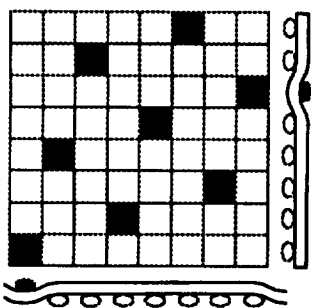
H

Hand The tactile qualities of a fabric, e.g., softness, firmness, elasticity, fineness, resilience, and other qualities perceived by touch.

Hank 1. A skein of yarn. 2. A standard length of slubbing, roving, or yarn. The length is specified by the yarn numbering system in use; e.g., cotton hanks have a length of 840 yards. 3. A term applied to slubbing or roving that indicates the yarn number (count); e.g., a 1.5 hank roving.

Harness A frame holding the heddles in position in the loom during weaving.

Harness Satin Weaving pattern producing a satin appearance. "Eight-harness" means the warp tow crosses over seven fill tows and under the eighth (repeatedly).



Schematic Illustration of 8 Harness Satin Weave

Heddle A cord, round steel wire, or thin flat steel strip with a loop or eye near the center through which one or more warp threads pass on the

loom so that the thread movement may be controlled in weaving. The heddles are held at both ends by the harness frame. They control the weave pattern and shed as the harnesses are raised and lowered during weaving.

Helical Winding In filament wound items, a winding in which a filament band advances along a helical path, not necessarily at a constant angle except in the case of a cylinder.

High Bulk Yarn Qualitative term to describe a textured yarn. A bulked yarn develops more bulk than stretch in the finished fabric.

Highloft General term for a fiber structure containing more air than fiber. Specifically, a lofty, low-density nonwoven structure that is used for applications such as fiberfill, insulation, health care, personal protection, and cleaning materials.

Hispidulous Yarn A yarn which has a "hairy" surface. Generally intended for yarn-yarn interlocking when fabricating composite preforms.

Hot-Head Press A pressing machine capable of generating high temperatures and pressures. Used for pressing and processing permanent-press fabrics.

Hybrid Composite Advanced composite with a combination of different high-strength continuous filaments in the matrix. Also, composite in which continuous and staple fibers are used in the same matrix.

Hybrid Fabric Fabric for composite manufacture in which two or more different yarns are used in the fabric construction. This provides design flexibility to meet performance requirements and controls cost by permitting some lower priced fibers to be used.

Hybrid Yarn In aerospace textiles, a yarn having more than one component.

I

Imbibition A measure of the liquid or water holding capacity of a textile material.

Impregnated Fabric A fabric in which the interstices between the yarns are completely filled, as compared to size or coated materials where the interstices are not completely filled. Not included in the definition is a woven fabric constructed from impregnated yarns, rather than one impregnated after weaving.

Interlock Knit To produce an interlock knit, long and short needles are arranged alternately in both the dial and cylinder; the needles in the dial and cylinder are also positioned in direct alignment. When the long and short needles knit in alternate feeds in both housings, a fabric with a type of cross 1 x 1 rib effect is produced.

Intermingling 1. Use of air jets to create turbulence to entangle the filaments of continuous yarns, without forming loops, after extrusion. Provides dimensional stability and cohesion for further processing but is not of itself a texturing process. It is compatible with high-speed spinning and high-speed take-up. When compared with twisting processes, it also permits increased take-up package size. 2. Combining two or more yarns via an intermingling jet. Can be used to get special effect yarns, i.e., mixing dye variants to get heather effects upon subsequent dyeing.

J

Jacquard A system of weaving that utilizes a highly versatile pattern mechanism to permit the production of large, intricate designs. The weave pattern is achieved by a series of punched cards. Each card perforation controls the action of one warp thread for the passage of one pick. The machine may carry a large number of cards, depending on the design, because there is a separate card for each pick in the pattern.

Jersey 1. A circular-knit or flat-knit fabric made with a plain stitch in which the loops intermesh in only one direction. As a result, the appearance of the face and the back of a jersey fabric is wholly different. **2.** A tricot fabric made with a simple stitch, characterized by excellent drape and wrinkle recovery properties.

Jet Loom A shuttleless loom that employs a jet of water or air to carry the filling yarn through the shed.

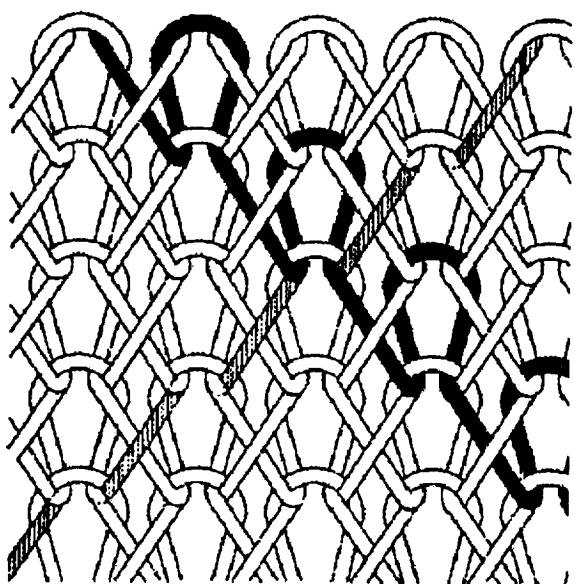
K

Kevlar Trade name for an organic polymer composed of aromatic polyamides having a para-type orientation (parallel chain extending bonds from each aromatic nucleus). Developed at DuPont. Kevlar is known for its high specific strength and toughness.

Knitting A method of constructing fabric by interlocking series of loops of one or more yarns. The two major classes of knitting are warp knitting and weft knitting, as follows:

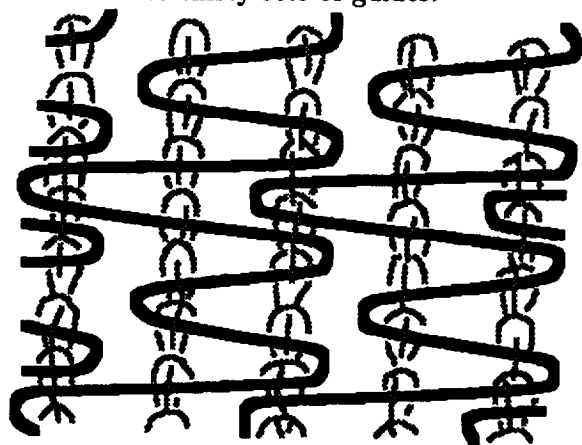
Warp Knitting A type of knitting in which the yarns generally run lengthwise in the fabric. The yarns are prepared as warps on beams with one or more yarns for each needle. Examples of this type of knitting are tricot, milanese, and raschel knitting.

Milanese Knitting A type of run resistant warp knitting with a diagonal rib effect using several sets of yarns.

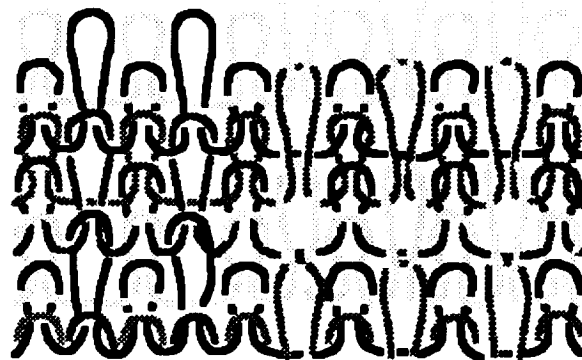


Milanese Knit

Raschel Knitting A versatile type of warp knitting made in plain and jacquard patterns; the latter can be made with intricate eyelet and lacy patterns and is often used for underwear fabrics. Raschel fabrics are coarser than other warp-knit fabrics, but a wide range of fabrics can be made. Raschel knitting machines have one or two sets of latch needles and up to thirty sets of guides.



Raschel Knit



Jacquard Knit

Tricot Knitting A run-resistant type of warp knitting in which either single or double sets of yarn are used.

Weft Knitting A common type of knitting, in which one continuous thread runs cross-wise in the fabric making all of the loops in one course. Weft knitting types are circular and flat knitting.

Circular Knitting The fabric is produced on the knitting machine in the form of a tube, the threads running continuously around the fabric.

Flat Knitting The fabric is produced on the knitting machine in flat form, the threads alternating back and forth across the fabric. The fabric can be given shape in the knitting process by increasing or decreasing loops.

L

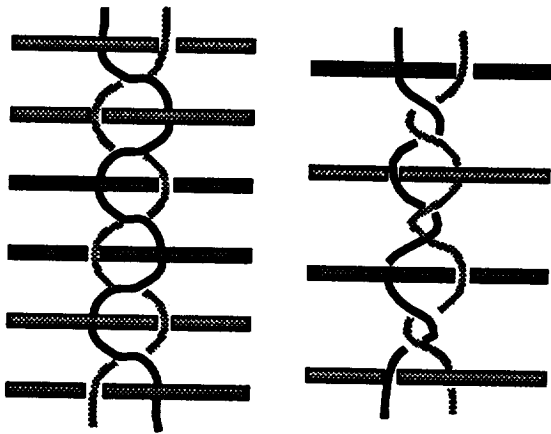
Lace Stitch In this knitting stitch structure, loops are transferred from the needles to create a fabric with an open or a raised effect.

Laid-In Fabric A knit fabric in which an effect yarn is tucked in, not knitted into, the fabric structure. The laid-in yarns are held in position by the knitted yarns.

Lap A continuous, considerably compressed sheet of fibers that is rolled under pressure into a cylindrical package, usually weighing between 40 and 50 pounds. The lap is used to supply the card.

Lase An acronym for load at specified elongation; the load required to produce a given elongation of a yarn or cord.

Leno Weave A weave in which the warp yarns are arranged in pairs with one twisted around the other between picks of filling yarn as in marquisette. This type of weave gives firmness and strength to an open-weave fabric and prevents slippage and displacement of warp and filling yarns.



Leno Weaves
(Left: Half-cross Leno, Right: Full-cross Leno)

Linear Density The mass per unit length of a fiber or yarn, typically expressed as grams per centimeter, pounds per foot, or equivalent units. It is a proportion obtained by dividing the mass of a fiber or yarn by its length.

Loom A machine for weaving fabric by interlacing a series of vertical, or parallel threads (the warp) with a series of horizontal, parallel threads (the filling). The warp yarns from a beam pass through the heddles and reed, and the filling is shot through the "shed" of warp threads by means of a shuttle or other device and is settled in place by the reed and lay. The woven fabric is then wound on a cloth beam. The primary distinction between different types of looms is the manner of filling insertion. The principal elements of any type of loom are the shedding, picking, and beating-up devices. In shedding, a path is formed for the filling by raising some

warp threads while others are left down. Picking consists essentially of projecting the filling yarn from one side of the loom to the other. Beating-up forces the pick, that has just been left in the shed, up to the fell of the fabric. This is accomplished by the reed, which is brought forward with some force by the lay.

Long Staple A long fiber. In reference to cotton, long staple indicates a finer length of not less than 1-1/8 inches. In reference to wool, the term indicates fiber 3 to 4 inches long suitable for combing.

Longitudinal Yarns which run in the 0° direction of the fabric (warp direction). Can refer to yarns in a 3-D weave, 3-D braid, triaxial braid, or multi-axial warp knit.

M

Macro-Lattice A repeating structure in very small microfibrils of alternating crystalline and amorphous regions. Yarn properties are thought to be governed by morphology at the macro-lattice scale.

Machine Twist A hard-twist sewing thread, usually of 3-ply construction spun with a S-twist and plied with a Z-twist, especially made for use with sewing machines.

Mandrel The core around which the filaments or yarns are placed to form a specified shape in composite manufacture. The mandrel constitutes the internal shape of the composite.

Matrix Fiber 1. A manufactured fiber that is essentially a physical combination or mixture of two or more chemically distinct constituents or components combined at or prior the time of extrusion (i.e., produced in fiber form), with components, if separately extruded, would each fall within different definitions of textile fibers. Matrix fibril fibers have the fibril constituent randomly arranged across the cross section of the matrix. When the fibril component is in

high concentration it may actually form a fibrillar network in the matrix. 2. In aerospace textiles, a thermoplastic fiber used with reinforcing fiber to form a composite after consolidation with heat and pressure. 3. In nonwovens manufacture, fibers that are blended with low-melt fibers to form a thermally bonded fabric.

Metap Weave-Knit Process A technique combining weaving and knitting in one operation with two independent yarn systems wound on warp beams. In the fabrics produced, woven strips are linked together with wales of stitches. Generally, the fabrics have 75-85% woven and 25-15% knitted structure.

Microdenier Refers to fibers having less than 1 denier per filament or 0.1 tex per filament.

Milanese Knitting A type of run-resistant warp knitting with a diagonal rib effect using several sets of yarns.

Mold The cavity or matrix into or on which the plastic composition is placed and from which it takes form.

Molded Edge An edge that is not physically altered after molding for use in final form, and particularly one that does not have fiber ends along its length.

Molded Net Description of a molded part that requires no additional processing to meet dimensional requirements.

Mold Shrinkage The rapid thermal shrinkage that a molded part experiences upon removal from a mold and cooled at room temperature.

Mold Surface The side of a laminate that faced the mold (tool) during cure in an autoclave or hydroclave.

Monofilament A single fiber or filament of indefinite length, strong enough to function as a yarn in commercial textile operations.

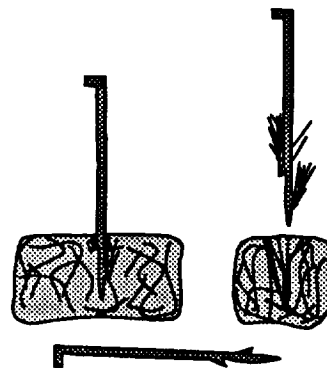
Multifilament Yarn A large number (500 to 2000) of fine, continuous filaments (often 5

to 100 individual filaments) usually with some twist in the yarn to facilitate handling.

N

Napping A finishing process that raises the surface fibers of a fabric by means of passage over rapidly revolving cylinders covered with metal points or teasel burrs. Outing, flannel, and wool broadcloth derive their downy appearance from this process.

Needle Loom A machine for bonding a nonwoven web by mechanically orienting the fibers through the web. The process is called needling, or needlepunching. Barbed needles set into a board punch fiber into the batt and withdraw, leaving the fibers entangled. The needles are spaced in a nonaligned arrangement. By varying the stroke per minute, the advance rate of the batt, the degree of penetration of the needles, and the weight of the batt, a wide range of fabric densities can be made. For additional strength, the fiber web can be needled to a woven, knit, or bonded fabric. Bonding agents may also be used.



Schematic of Single Needle and Needle Penetrating Batt

Nondestructive Evaluation (NDE) Broadly considered synonymous with nondestructive inspection (see also NDI).

Nondestructive Inspection (NDI) A process or procedure, such as ultrasonic or radiographic inspection for determining the quality or characteristics of a material, part, or assembly, without permanently altering the subject or its properties.

Nondestructive Testing (NDT) Broadly considered synonymous with nondestructive inspection (NDI).

Nonwoven Fabric An assembly of textile fibers held together by mechanical interlocking in a random web or mat, by fusing of the fibers (in the case of thermoplastic fibers), or by bonding with a cementing medium such as starch, glue, casein, rubber, latex, or one of the cellulose derivatives or synthetic resins. Initially, the fibers may be oriented in one direction or may be deposited in a random manner. This web or sheet of fibers is bonded together by one of the methods described above. Normally, crimped fibers that range in length from 0.75 to 4.5 inches are used.

O

Optimum Twist In spun yarns, a term to describe the amount of twist that gives the maximum breaking strength or the maximum bulk at strength levels acceptable for weaving or knitting.

Organzine Yarn Two or more threads twisted in the singles and the plied in the reverse direction. The number of turns per inch in the singles and in the ply is usually in the range of 10 to 20 turns. Organzine yarn is generally used in the warp.

P

Packages A large selection of forms for winding yarn is available to meet the requirements of existing machinery and a variety of package builds is used to ensure suitable unwinding in later

stages of manufacturing. Since a package with flanges cannot be unwound easily and quickly by pulling the yarn off overend, most packages are flangeless with self-supporting edges. Some can be unwound at speeds up to 1500 yd/min.

Pick A single filling thread carried by one trip of the weft-insertion device across the loom. The picks interlace with the warp ends to form a woven fabric.

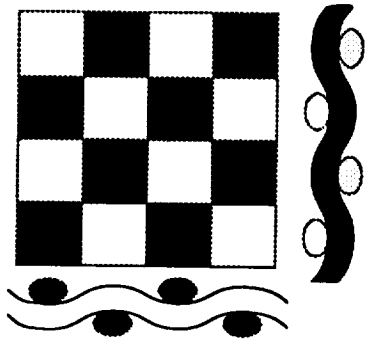
Pick Count 1. The number of filling yarns per inch or per centimeter of fabric.

Picker 1. A machine that opens staple fiber and forms a lap for the carding process used in the production of spun yarns. 2. That part of the picking mechanism of the loom that actually strikes the shuttle.

Pile 1. A fabric effect formed by introducing tufts, loops, or other erect yarns on all or part of the fabric surface. Types are warp, filling, and knotted pile, or loops produced by weaving an extra set of yarns over wires that are then drawn out of the fabric. Plain wires leave uncut loops; wires with a razor-like blade produce a cut-pile surface. Pile fabric can also be made by producing a double-cloth structure woven face to face, with an extra set of yarn interlacing with each cloth alternately. The two fabrics are cut apart by a traversing knife, producing two fabrics with a cut-pile face. Pile should not be confused with nap. Corduroys are another type of pile fabric, where long floats are on the surface are slit, causing the pile to stand erect.

Pile Weave A weave in which an additional set of yarns, either warp or filling, floats on the surface and is cut to form a pile.

Plain Weave One of the three fundamental weaves: plain, satin, and twill. Each filling yarn passes successfully over and under each warp yarn, alternating each row.



Schematic Illustration of a Plain Weave Construction

Planar Winding A winding in which the filament path lies on a plane that intersects the winding surface.

Plied Yarn Yarn made by collecting two or more single yarns.

Ply In general, fabrics or felts consisting of one or more layers (laminates and so forth). The layers make up a stack. A single layer of prepreg. A single pass in filament winding.

Polar Winding A winding in which the filament path passes tangent to the polar opening at one end of the chamber and tangent to the opposite side of the polar opening at the other end.

Postcure Additional elevated-temperature cure especially without pressure, to improve final properties and/or complete the cure, or decrease the percentage of volatiles in the compound.

Prefit A process of checking the fit of mating detail parts in an assembly prior to adhesive bonding, to ensure proper bond lines.

Preform A preshaped fibrous reinforcement formed by distribution of chopped fibers or cloth by air, water flotation, or vacuum over the surface of a perforated screen to the approximate contour and thickness desired in the finished part. Also, a preshaped fibrous reinforcement of mat or cloth formed to the desired shape on mandrel or mock-up before being placed in a mold press.

Prepreg Ready to mold, reinforcing material, either fiber, fabric, or mat that is fully impregnated with resin and in some cases, partially cured. Prepregs are then used by fabricators in laying-up and molding composites after which curing is completed.

Press Clave A simulated autoclave made by using the platens of a press to seal the ends of an open chamber, providing both the force required to prevent the loss of the pressurizing medium and the heat required to cure the laminate inside.

Projectile Loom A shuttleless loom that uses small, bullet-like projectiles to carry the filling yarn through the shed. Fill is inserted from the same side of the loom for each pick. A tucked selvage is formed.

Pucker Uneven surface caused by differential shrinkage of the yarns in a fabric or differential shrinkage of the fabric and sewing thread.

Purl 1. A knitting stitch that results in horizontal ridges across the fabric. It is made by drawing alternate courses through each side of the fabric.
2. A picot or small loop that edges needlework, lace, or ribbon.

Q

Quilting 1. The formation of a large planar fabric by joining small pieces of fabric together. 2. The formation of a fabric by stitching through two pieces of fabric which are separated by a non-woven web. 3. A bonding technique used for nonwovens in which the fibers are connected (bonded) by stitches sewn or knitted through the web.

R

Rack A warp-knitting measure consisting of 480 courses. Tricot fabric quality is judged by the number of inches per rack.

Rapier Loom Looms in which either a double or single rapier (thin metallic shaft with a yarn gripping device) carries the filament through the shed. In a single rapier machine, the yarn is carried completely across the fabric by the rapier. In the double machine, the yarn is passed from one rapier to the other in the middle of the shed.

Raschel Knitting A versatile type of warp knitting made in plain and jacquard patterns; the latter can be made with intricate eyelet and lacy patterns and is often used for underwear fabrics. Raschel fabrics are coarser than other warp-knit fabrics, but a wide range of fabrics can be made. Raschel knitting machines have one or two sets of latch needles and up to thirty sets of guides.

Reaming Further plying of a two-ply yarn with a singles yarn. Reaming is not the same as plying three singles yarns in one operation.

Resin A solid or pseudo-solid organic polymeric material, usually of high molecular weight, that exhibits a tendency to flow when subjected to stress. Many resins are two part catalyzed polymeric systems, typically thermosetting.

Resin Pocket An apparent accumulation of excess resin in a small, localized section visible on cut edges of molded surfaces, or internal to the structure and nonvisible.

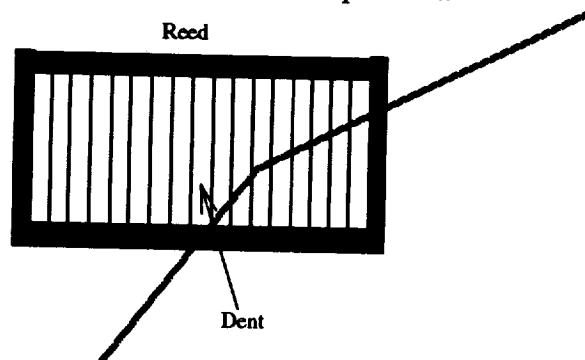
Resin-rich Area Localized area filled with resin and lacking reinforcing material.

Resin-starved Area A localized area which has insufficient resin, usually identified by low gloss, dry spots, or fiber showing on the surface.

Resin Transfer Molding (RTM) A process whereby catalyzed resin is transferred or injected into an enclosed mold in which fibrous reinforcement has been placed.

Reed A comb like device on a loom that separates the warp yarns and also beats each succeeding filling thread against the already woven. The reed usually consists of a top and bottom rib of wood into which metal strips or wires are set.

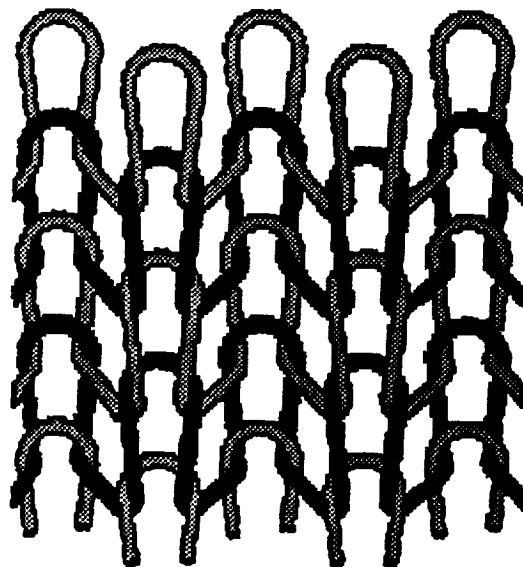
The space between two adjacent wires is called a dent (or split) and the warp is drawn through the dents. The fineness of the reed is calculated by the number of dents per inch.



Schematic of Reed for Weaving Loom

Repeat The distance covered by a single unit of a pattern that is duplicated over and over, measured by the length of the fabric.

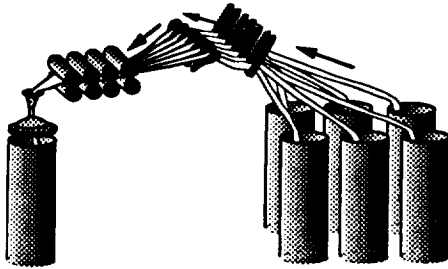
Rib Knit A double-knit fabric in which the wales or vertical rows of stitches intermesh alternately on the face and the back. In other words, odd wales intermesh on one side of the cloth and even wales on the other. Rib-knit fabrics of this type have good elasticity, especially in the width.



Rib Knit

Rick Rack Flat braid in zig-zag formation. It is produced by applying different tensions to individual threads during manufacture.

Roving In spun yarn production, an intermediate state between sliver and yarn. Roving is a condensed sliver that has been drafted, twisted, doubled, and redoubled. The product of the first roving is sometimes called slubbing.



Schematic of Drafting Process and Machinery

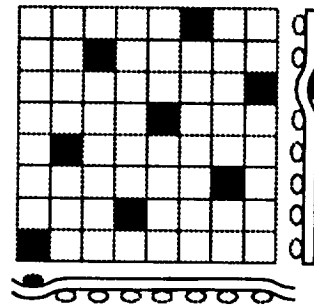
Roving Ball The supply package offered to the winder, consisting of a number of ends or strands wound to a given outside diameter onto a length of cardboard tube. Usually designated by either fiber weight or length in yards.

Roving Cloth A textile fabric, coarse in nature, woven from rovings.

S

S Twist Direction of yarn twist which gives an "S" like appearance to the yarn. Negative, or left-hand twist.

Satin Weave One of the basic weaves (plain, satin, and twill). The face of the fabric consists almost completely of warp or filling floats produced in the repeat of the weave. The points of intersection are distributed as evenly and widely separated as possible. Satin weave fabric has a characteristic smooth, lustrous surface and has a considerably greater number of yarns in the set of threads, either warp or filling, that forms the face than in the other set.



Schematic Illustration of 8 Harness Satin Weave

Scrim A lightweight, open-weave, course fabric; the best qualities are made in two-ply yarns. Cotton scrim usually comes, in white, cream, or ecru and is used for window curtains and as backing for carpets. Fabric with open construction used as base fabric in the production of coated or laminated fabric.

Selvage The narrow edge of woven fabric that runs parallel to the warp. It is made with stronger yarns in a tighter construction than the body of the fabric to prevent raveling. A fast selvage encloses all or part of the picks, and a selvage is not fast when the filling threads are cut at the fabric edge after every pick.

Serge Any smooth-faced cloth made with a two-up and two-down twill weave.

Served Yarn In aerospace textiles, a reinforcing yarn such as graphite or glass around which two different yarns are wound, i.e., one in the Z-direction and one in the S-direction, etc., for protection or compaction of the yarn bundle.

Set Yarn False-twist yarns stabilized to produce bulk.

Shaft A term used with reference to satins indicating the number of harnesses employed to produce the weave.

Shearing A dry finishing operation in which projecting fibers are mechanically cut or trimmed from the face of the fabric. Woolen and worsted

fabrics are almost always sheared. Shearing is also widely employed on other fabrics, especially on napped and pile fabrics where the amount varies according to the desired height of the nap or pile. For flat-finished fabrics such as gabardine, a very close shearing is given.

Sheath-Core Fibers Bicomponent fibers of either two polymer types, or two variants of the same polymer. One polymer forms a core and the other surrounds it as a sheath.

Shed A path through and perpendicular to the warp in the loom. It is formed by raising some warp threads by means of their harness while others are left down. The shuttle passes through the shed to insert the filling.

Shedding The operation of forming a shed in weaving.

Shuttle A boat shaped device, usually made of wood with a metal tip, that carries filling yarns through the shed in the weaving process. It is the most common weft-insertion device. The shuttle holds a quill, or pin, on which the filling yarn is wound. It is equipped with an eyelet at one end to control rate. The filling yarn is furnished during the weaving operation.

Shuttleless Loom A loom in which some other device other than a shuttle is used for weft insertion.

Single-Knit Fabric Also called a plain knit, a fabric constructed with one needle bed and one set of needles.

Singles Yarn The simplest strand of textile material suitable for operations such as weaving and knitting. A singles yarn may be formed from fibers with more or less twist; from filaments with or without twist; from narrow strips of material such as paper, cellophane, or metal foil; or from monofilaments. When twist is present, it is all in the same direction.

Sizing A generic term for compounds that are applied to warp yarn to bind the fiber together

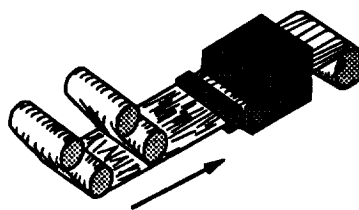
and stiffen the yarn to provide abrasion resistance during weaving. Starch, gelatin, oil, wax, and manufactured polymers such as poly-vinyl alcohol, polystyrene, polyacrylic acid and polyacetates are employed.

Sizing Content The percent of the total strand weight made up by the sizing; usually determined by burning off or dissolving the organic sizing.

Skein A continuous strand of yarn or cord in the form of a collapsed coil. It may be of any specified length and is usually obtained by winding a definite number of turns on a reel under prescribed conditions. The circumference of the reel on which the yarn is wound is usually 45 to 60 inches.

Skewness The distance measured parallel to and along a selvage between the point at which a filling yarn meets this selvage and perpendicular to the selvage from a point at which the filling yarn meets the other selvage. Skewness may be expressed directly in inches or as a percentage of the width of the fabric at the point of measurement.

Slasher A machine used to apply size to the warp ends, while transferring the warp yarns from section beams to the loop beam.



Schematic of Slashing Process

Slashing A process of sizing warp yarns on a slasher.

Sleeving A braided, knit, or woven product or fabric in tubular or cylindrical form that is less than 4 inches in width (i.e., 8 inches in diameter)

Sley The number of warp yarns per inch in a woven cloth on or off the loom.

Sliver A continuous strand of loosely assembled fibers without twist. Sliver is delivered by the card, the comber, or the drawing frame. The production of sliver is the first step in the textile operation that brings staple fiber into a form that can be drawn (reduced in bulk) and eventually twisted into a spun yarn.

Spectra Highly oriented polyethylene fibers produced by Allied.

Spinneret A metal disc, containing numerous minute axial holes, used in manufactured fiber extrusion. The spinning solution or melted polymer is forced through the holes to form the fiber filaments.

Spinning The process or processes used in the production of singles yarns or of fabrics generated directly from polymer.

Yarn from Staple Fiber The formation of a yarn by a combination of drawing or drafting and twisting prepared strands of fibers, such as rovings.

Filament Yarn In the spinning of manufactured filaments, fiber forming substances in the plastic or molten state, or in a solution, are forced through fine orifices in a metallic plate called a spinneret, or jet, at a controlled rate. The solidified filaments are drawn-off by rotating rolls, or godets and wound onto bobbins or pirns. There are several methods of spinning manufactured filaments:

Dry Spinning A process in which a solution of the fiber-forming substance is extruded in a continuous stream into a heated chamber to remove the solvent, leaving the solid filament, as in the manufacture of acetate.

Gel Spinning A spinning process in which the primary mechanism of solidification is the gelling of the polymer solution by cooling to form a gel filament consisting of precipitated polymer and solvent. Solvent removal

is accomplished following solidification by washing in a liquid bath. The resultant fibers can be drawn to give a product with the highest tensile strength and modulus.

Melt Spinning A process in which the fiber-forming substance is melted and extruded into air or other gas, or into a suitable liquid, where it is cooled and solidified, as in the manufacture of polyester and nylon.

Phase-Separation Spinning

A fiber extrusion process of polymer and solvent at high temperature into a cooling zone. During the cooling process, a phase separation occurs, usually accompanied by crystallization of the solvent. Solvent can be removed before or after drawing.

Reaction Spinning Process in which an initial prepolymer is formed and then extruded into a reagent bath where polymerization and filament formation occur simultaneously. Spandex fibers can be made by this process.

Spiral Yarns Specialty yarns made by winding heavier, slacky, twisted yarn around a finer yarn with a hard twist to give a *slub*-like appearance.

Splicing The joining of two ends of yarn or cordage by interweaving the strands.

Spool A flanged wooden or metal cylinder upon which yarn, thread, or wire is wound. The spool has an axial hole for a pin or spindle used in winding.

Spun-Bound Product Nonwoven fabrics formed by filaments that have been extruded, drawn, then laid on a continuous belt. Bonding is accomplished by several methods such as by hotroll calendaring or by passing the web through a saturated-steam chamber at an elevated pressure.

Spunlaced Fabric A nonwoven fabric produced by entangling fibers in a repeating pattern to form

a strong fabric free of binders.

Spun Yarn A yarn consisting of staple fibers usually bound together by twist or a melt spun fiber before it is drawn.

Staple Natural fibers or cut lengths from filaments. Manufactured staple fibers are cut to a definite length, from 8 inches down to about 1-1/2 inches, so that they can be processed on cotton, woolen, or worsted yarn spinning systems.

Starved Area An area in a plastic part that has an insufficient amount of resin to wet out the reinforcement completely. This condition may be due to improper wetting, impregnation, or resin flow; excessive molding pressure; or improper bleeder cloth thickness.

Starved Joint An adhesive that has been deprived of the proper film thickness of adhesive due to insufficient adhesive spreading or to the application of excessive pressure during the lamination process.

Sticker A distortion in the weave characterized by tight and slack places in the same warp yarns. The principle causes are rolled ends on the beam, warp ends restricted by broken filament slubs, and knots catching at lease rods, drop-wires, heddles or reeds.

Stitching The process of passing a fiber or thread through the thickness of fabric layers to secure them. In composite manufacture, stitching is used to make preforms or to improve damage tolerance of complex-shaped parts.

Stops Metal pieces inserted between die halves. Used to control the thickness of a press-molded part.

Stretch Breaking In conversion of tow-to-top, fibers are hot stretched and broken rather than cut to prevent some of the damage done by cutting.

Stuffer Box A mechanism for crimping in which a fiber bundle (e.g., tow or filament yarn) is jammed against itself, causing it to crimp. By

the suitable application of heat (usually wet steam) and pressure to the stuffed tow, a high and permanent crimp can be forced into the bundle.

Stuffers Extra yarns running the warp direction through a woven fabric to increase the fabrics strength and weight.

T

Take-Up (Twist) The change in length of a filament, yarn, or cord caused by twisting, expressed as a percentage of the original (untwisted) length.

Take-Up (Yarn in Fabric) The difference in distance between two points in a yarn as it lies in a fabric and the same two points after the yarn has been removed from the fabric and straightened under specified tension, expressed as a percentage of the straightened length.

Tenacity The tensile stress when expressed as force per unit linear density of the unstrained specimen.

Tenter Frame A machine that dries fabric to a specified width under tension. The machine consists essentially of a pair of endless chains on horizontal tracks. The fabric is held firmly at the edges by pins or clips on the two chains that diverge as they advance through the heated chamber, adjusting the fabric to the desired width.

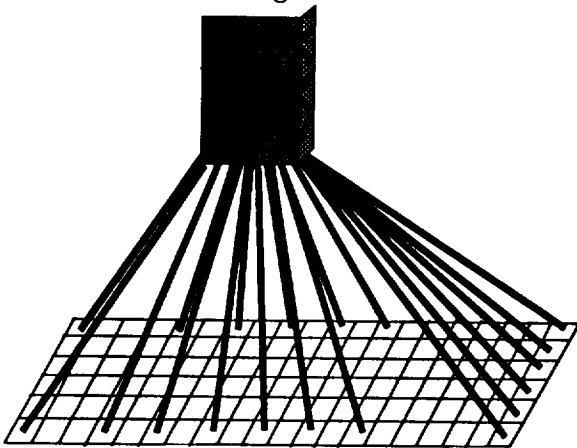
Tex A unit for expressing linear density, equal to the weight in grams of 1 kilometer of yarn, filament, fiber, or other textile strand.

Textured Yarn Yarns that develop stretch and bulk on subsequent processing.

Texturing The process of crimping, imparting random loops or otherwise modifying continuous filament yarn to increase cover, resilience, abrasion resistance, warmth, insulation and moisture absorption or to provide a different surface texture.

Thread Count The number of yarns (threads) per inch in either the lengthwise (warp) or crosswise (weft or fill) direction of woven fabrics.

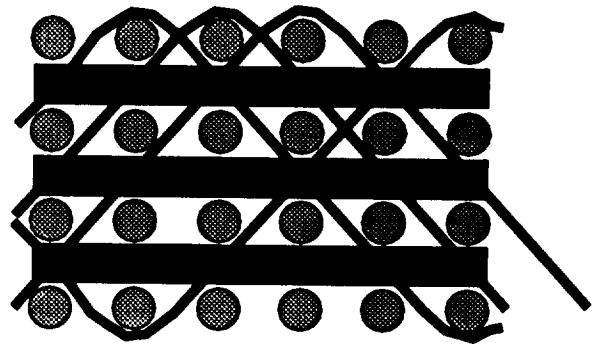
Three-Dimensional Braiding A fabric structure formed by the intertwining of yarns in a single basic direction. 3-D Braids can be formed in rectangular or cylindrical shapes, generally following the overall shape of the supporting loom. Longitudinal yarns can be introduced into the structure easily. Transverse yarns (either Y or Z) can be entered into the structure with additional operational processes. "2-step Braiding" is a special type of 3-D braiding, as are biaxial and triaxial braiding.



Schematic of Three Dimensional Braiding Structure

Three-Dimensional Weaving A fabric formation process used to produce three-dimensional textiles. The yarns are simultaneously woven in three directions (length, width, and thickness) rather than in the conventional two. The fabric is formed of three basic components, longitudinal (axial), filling, and "weavers." The types of structures that can be produced fall into four broad classes:

- contoured fabrics,
- expandable fabrics,
- interwoven fabrics, and
- contoured interwoven fabrics.



Schematic of Three Dimensional Weave Structure

Through Thickness Braiding A trade name for 3-D braiding by Atlantic Research Co.

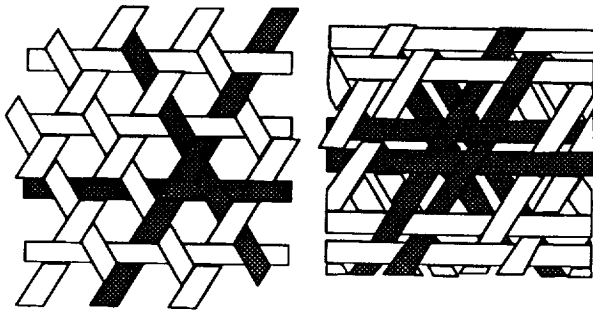
Tooling Resin Resins that have applications as tooling aids, coreboxes, prototypes, hammer forms, stretch forms, foundry patterns, and so forth. Epoxy and silicon are common examples.

Tool Side A side of the part that is cured against the tool (mold or mandrel).

Tow A large strand of continuous manufactured fiber filaments without definite twist, collected in a loose, rope-like form, usually held together by crimp. Tow is the form most manufactured fiber reaches before being cut into staple.

Tracker A fiber, tow, or yarn added to a prepeg for verifying fiber alignment, and in the case of woven materials, for distinguishing warp fibers from fill fibers.

Triaxial Weave A type of woven fabric which is formed through the placement of three distinct yarn orientations. There are two types of triaxial weaves, those with 1 warp and two wefts, and a new generation of machines which uses 2 warps and one weft.



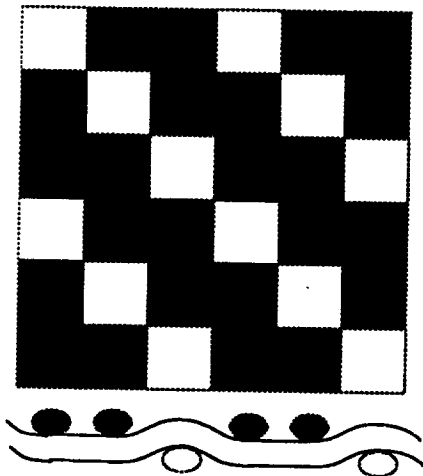
Left: Triaxial Plain Weave, Right: Triaxial Bi-Plain

Tricot A generic term for the most common type of warp-knit fabric. It has fine wales on the face and coursewise ribs on the back. It can be made in a plain jersey construction or in many other designs.

Tyranno A Si_3N_4 based fiber produced by Nippon. A multi-filament yarn with fiber diameters in the range of 10-20 μm .

Twaron An aramid fiber produced in Europe.

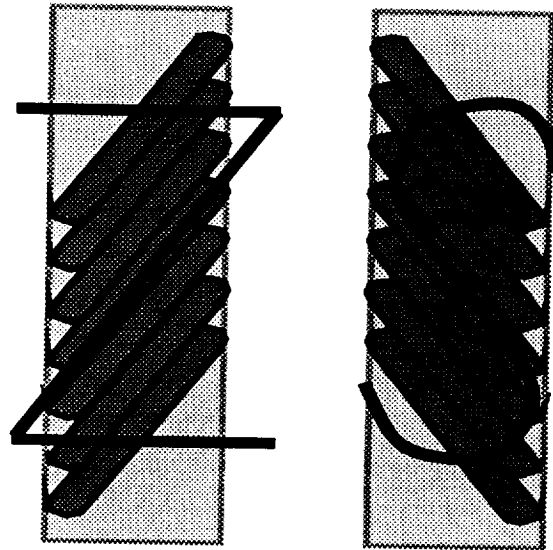
Twill Weave A fundamental weave characterized by diagonal lines produced by a series of floats staggered in the warp-wise direction. The floats are normally formed by filling (filling-faced twill). A warp face twill is a weave in which the warp yarns produce the diagonal effect.



Schematic Illustration of a 3/1 Twill Weave

Twist The number of turns about its axis per unit of length of a yarn or other textile strand. Twist is expressed as turns per inch (*tpi*) or turns per cm (*tpc*).

Twist (Direction) The direction of twist in yarns and other textile strands, as indicated by the capital letters S and Z, in reference to whether the twist direction conforms to the middle-section slope of the particular letter.



Definitions of S and Z Twist

Twist Multiplier The ratio of turns per inch to the square root of the yarn count.

U

Uni-Weave A type of plain weave fabric wherein the warp direction consists of load bearing carbon yarns, and the fill direction contains a small amount of glass fiber. Generally the amount of glass fiber is less than 10%.

Unit Cell The smallest repeating volume of a material which fully characterizes the structure. The unit cell may depend upon the property under examination (*e.g.* geometrical unit cells may be different than mechanical response unit cells).

V

Variability Variability refers to a distribution of measured properties within a given process. Variability can be measured in terms of geometrical, physical or mechanical response. Typically variability is used to describe some apparently random aspect of the manufacturing process.

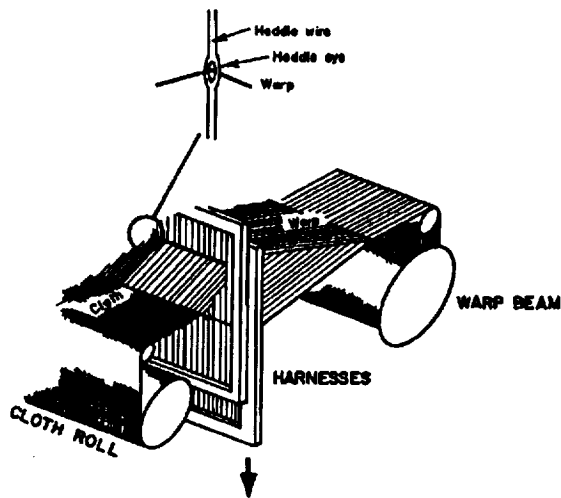
W

Wale 1. In knit fabrics, a column of loops lying lengthwise in the fabric. The number of wales per inch is a measure of the fineness of the fabric. 2. In woven fabrics, one of the series of ribs, cords, etc., running either warp-wise or filling-wise.

Warp A yarn running lengthwise in a fabric. A group of yarns in long lengths and approximately parallel.

Warp Knit Fabric A fabric that is formed with the knitting yarns running lengthwise (warp-wise).

Weave The particular manner in which a fabric is formed by interlacing yarns.



Schematic of Weaving Operation

Weavers The yarns which run in the warp-thickness plane of a three dimensional fabric. These are the yarns which hold the longitudinal and filling yarns together.

Weft The transverse threads or fibers in a woven fabric. Those fibers running perpendicular to the warp. Also called fill or filling yarn.

Weft Insertion Any one of the various methods, shuttle, rapier, water jet, etc., for making a pick during a weave.

Welt 1. A finished edge on knit goods, especially hosiery. 2. A small cord covered with fabric and sewn along a seam or border to add strength.

Wet-Laid Nonwoven Fabric made by the wet-forming process. The short fibers typically have more random orientation in the web and the web has more isotropic properties than carded webs.

Wind Angle The angular measure in degrees between the direction parallel to the filaments and an established reference.

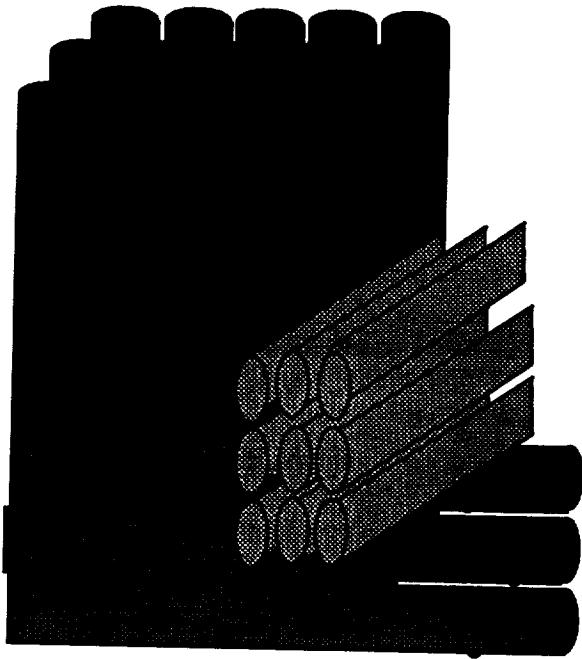
Woven Fabric A material (usually a planar structure) constructed by interlacing yarns, fibers, or filaments, to form such fabric patterns as plain, harness satin, or leno weaves.

Woven Roving A heavy glass fiber fabric made by weaving roving or yarn bundles.

Wrinkle A surface imperfection in laminated plastics that has the appearance of a crease or fold in one or more outer sheets of the paper, fabric or other base which has been pressed in.

X

XYZ A fabric-like structure formed by the orthogonal placement of fibers/yarns in three directions.



Schematic Illustration of XYZ Type Fabric Structure

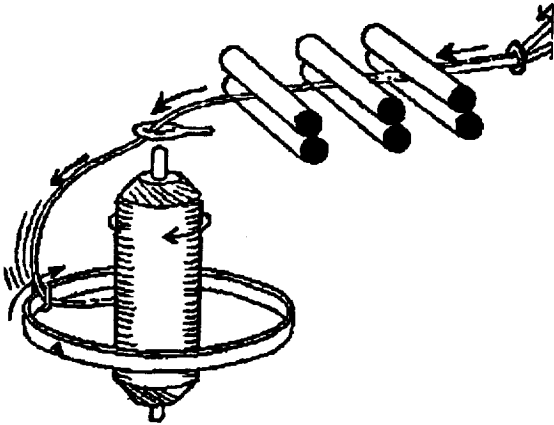
Direct yarn number (equal to linear density) in the mass per unit length of yarn. (2) Indirect yarn number (equal to the reciprocal of linear density) is the length per unit mass of yarn.

Z

Z Twist Direction of yarn twist which gives a "Z" like appearance to the yarn. Positive twist, or right-hand twist.

Y

Yarn An assembling of twisted filaments, fibers, or other strands, to form a continuous length that is suitable for use in weaving or interweaving into textile materials.



Schematic Illustration of Ring Spinning Process for Manufacturing Yarns

Yarn Number A relative measure of the fineness of yarns. Two classes of systems are in use: (1)

APPENDIX A. LIST OF PARTICIPANTS

Albany International Research Co.

Dr. David Brookstein
777 West Street
P.O. Box 9114
Monsfield, MA 02048-9114

Atlantic Research Corporation

Mr. Eddie C. Crow, Jr., Mr. Jerry Patterson,
Mr. Jeff Hooper, Mr. Dick Brown
5390 Cherokee Ave.
Alexandria, VA 22312

Bentley Harris MFC

Ms. Janice Maiden and Tammi Ebersole
241 Welsh Pool Road
Lionville, PA 19353

Boeing Comercial Airplanes

Dr. William Avery
MS 6H-CF
P.O. Box 3707
Seattle, WA 98124-2207

Boeing Helicopter Co.

Mr. Mark J. Fedro
M/S P38-13
P.O. Box 16858
Philadelphia, PA 19142

College of William and Mary

Dr. David Kranbuehl
Department of Chemistry
Williamsburg, VA 23187-8795

Cooper Composites

Mr. Todd D. Drummond
1840 South Michigan Ave.
Chicago, IL 60616

McDonnell Douglas Aerospace-West

Mr. Max Klotzsche, Mr. Alan Markus
Mail Code 1-22
3855 Lakewood Blvd.
Long Beach, CA 90846

Fabric Development, Inc.

Mr. Piyush A. Shah, Ms. Mary P. Shafer
1217 Mill Street
Quakertown, PA 18951

Fiber Innovations, Inc.

Mr. Garrett Sharpless
588 Pleasant St.
Norwood, MA 02062

Grumman Aircraft Systems Division

Mr. Jim Suarez, Mr. Richard Collins, Mr.
Sam Dastin
Mail Stop B44-035
Bethpage, NY 11714

Hexcel Corporation - Trevarno

Mr. William Swanson
11555 Dublin Blvd.
P.O. Box 2312
Dublin, CA 94568-0705

ICI Composites Structures

Mr. Tom Schmitt
2055 East Technology Circle
Tempe, AZ 85284

ICI Fiberite

Mr. Steve Clarke, Mr. Alberto Morales
6309 Interstate Highway 30
Greenville, TX 75401

Textile Products Inc.

Mr. Rick Fingerhut
2512 woodland Drive
Anaheim, CA 92801-2636

Lockheed Aeronautical Systems Company

Mr. Tom Bayha, Mr. Bonner Staff, Mr. Ron
Barrie
Dept. 73C1, Zone 0150
Marietta, GA 30063

NASA Langley

MS 226: Mr. Marvin Dow, Mr. Benson
Dexter, Mr. Jerry Deaton, Mr. Roberto
Cano, Mr. Greg Hasko, Mr. Larry
Dickinson, Ms. Sue Kullerd

MS 188E: Dr. C. C. Poe, Jr., Dr. John
Masters

MS 231: Dr. Joe Heyman, Dr. Pat Johnston,
Mr. William Prosser, Mr. Ed Generazio,
Mr. William Winfree

MS 226: Ms. Maylene Hugh

MS 241: Dr. Randall Davis, Dr. John Davis

North Carolina State University

Dr. Warren Jasper
College of Textiles
NCSU Box 8301
Raleigh, NC 27695-8301

Pathe Computer Controls, Inc.

Mr. Richard Codos
17 Camptown Road
Irvington, NJ 07111

Puritan Industries, Inc.

Mr. Andrew Papanek
122 Powdermill Road
P.O. Box 172
Collinsville, CT 06022

Techniweave

Mr. Keith Burgess
109 Chestnut Hill Road
P.O. Box 6314
Rochester, NH 03867

Textile Technologies Inc.

2800 Turnpike Drive
Suite 1
Hatboro, PA 19040

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE September 1993	3. REPORT TYPE AND DATES COVERED Contractor Report		
4. TITLE AND SUBTITLE Illustrated Glossary of Textile Terms for Composites			5. FUNDING NUMBERS L-185430 510-02-11-08	
6. AUTHOR(S) Christopher M. Pastore				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) North Carolina State University Department of Textile Engineering, Chemistry and Science Raleigh, NC 27695-8301			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) National Aeronautics and Space Administration Langley Research Center Hampton, VA 23681-0001			10. SPONSORING / MONITORING AGENCY REPORT NUMBER NASA CR-191539	
11. SUPPLEMENTARY NOTES Langley Technical Monitor: H. Benson Dexter				
12a. DISTRIBUTION / AVAILABILITY STATEMENT Unclassified-Unlimited Subject Category 24			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) A glossary has been developed to define textile terminology applicable to the manufacture of composites. Terms describing fabric structure have been illustrated for clarity. Descriptive terms for defects from both textile and composites industry have been included.				
14. SUBJECT TERMS Textile terminology; composites; manufacture of textile composites			15. NUMBER OF PAGES 31	
			16. PRICE CODE A03	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT	