

## Yarn Guide



### Raw materials

Fibres are units of matter having length at least 100 times their diameter or width. Fibres suitable for textile use possess adequate length, fineness, strength, and flexibility for yarn formation and fabric construction, and for withstanding the intended use of the completed fabric. Other properties affecting textile fibre performance include elasticity, crimp (waviness), moisture absorption, reaction to heat and sunlight, reaction to the various chemicals applied during processing and in the dry cleaning or laundering of the completed fabric, and resistance to insects and microorganisms. The wide variation of such properties among textile fibres determines their suitability for various uses.

The first fibres available for textile use were obtained from plant and animal sources. Over a long period of experimentation with the many natural fibres available, cotton, wool, jute, flax, and silk have become recognized as the most satisfactory. The commercial development of man-made fibres began late in the 19th century, experienced much growth during the 1940s, expanded rapidly after World War II, and in the 1970s was still the subject of extensive research and development. This group includes regenerated fibres, such as rayon, made from fibre-forming materials already existing in nature and manipulated into fibrous form, and synthetic fibres, with the fibre-forming substance produced from chemicals derived from such sources as coal and oil, and then made into such fibres as nylon and polyester.

### Types of yarn

Yarns can be described as single, or one-ply; ply, plied, or folded; or as cord, including cable and hawser types.

### Single yarns

Single, or one-ply, yarns are single strands composed of fibres held together by at least a small amount of twist; or of filaments grouped together either with or without twist; or of narrow strips of material; or of single man-made filaments extruded in sufficient thickness for use alone as yarn (monofilaments). Single yarns of the spun type, composed of many short fibres, require twist to hold them together and may be made with either S-twist or Z-twist (see Figure 1 ). Single yarns are used to make the greatest variety of fabrics.

### Ply yarns

Ply, plied, or folded, yarns are composed of two or more single yarns twisted together. Two-ply yarn, for example, is composed of two single strands; three-ply yarn is composed of three single strands. In making ply yarns from spun strands, the individual strands are usually each twisted in one direction and are then combined and twisted in the opposite direction. When both the single strands and the final ply yarns are twisted in the same direction, the fibre is firmer, producing harder texture and reducing flexibility. Ply yarns provide strength for heavy industrial fabrics and are also used for delicate-looking sheer fabrics.

### **Cord yarns**

Cord yarns are produced by twisting ply yarns together, with the final twist usually applied in the opposite direction of the ply twist (see Figure 2 ). Cable cords may follow an SZS form, with S-twisted singles made into Z-twisted plies that are then combined with an S-twist, or may follow a ZSZ form. Hawser cord may follow an SSZ or a ZZS pattern. Cord yarns may be used as rope or twine, may be made into very heavy industrial fabrics, or may be composed of extremely fine fibres that are made up into sheer dress fabrics.

### **Novelty yarns**

Novelty yarns include a wide variety of yarns made with such special effects as slubs, produced by intentionally including small lumps in the yarn structure, and man-made yarns with varying thickness introduced during production. Natural fibres, including some linens, wools to be woven into tweed, and the uneven filaments of some types of silk cloth are allowed to retain their normal irregularities, producing the characteristic uneven surface of the finished fabric. Man-made fibres, which can be modified during production, are especially adaptable for special effects such as crimping and texturizing.

### **Textured yarns**

Texturizing processes were originally applied to man-made fibres to reduce such characteristics as transparency, slipperiness, and the possibility of pilling (formation of small fibre tangles on a fabric surface). Texturizing processes make yarns more opaque, improve appearance and texture, and increase warmth and absorbency. Textured yarns are man-made continuous filaments, modified to impart special texture and appearance (see Figure 3 ). In the production of abraded yarns, the surfaces are roughened or cut at various intervals and given added twist, producing a hairy effect.

Bulking creates air spaces in the yarns, imparting absorbency and improving ventilation. Bulk is frequently introduced by crimping, imparting waviness similar to the natural crimp of wool fibre; by curling, producing curls or loops at various intervals; or by coiling, imparting stretch. Such changes are usually set by heat application, although chemical treatments are sometimes employed. In the early 1970s bulky yarns were most frequently produced by the "false twist" method, a continuous process in which the filament yarn is twisted and set, and then untwisted and heated again to either stabilize or destroy the twist. The "stuffing box" method is often applied to nylon, a process in which the filament yarn is compressed in a heated tube, imparting a zigzag crimp, then slowly withdrawn. In the knit-de-knit process, a synthetic yarn is knitted, heat is applied to set the loops formed by knitting, and the yarn is then unravelled and lightly twisted, thus producing the desired texture in the completed fabric.

Bulk may be introduced chemically by combining filaments of both high and low shrinkage potential in the same yarn, then subjecting the yarn to washing or steaming, causing the high shrinkage filaments to react, producing a bulked yarn without stretch. A yarn may be air bulked by enclosing it in a chamber where it is subjected to a high-pressure jet of air, blowing the individual filaments into random loops that separate, increasing the bulk of the material.

### **Stretch yarns**

Stretch yarns are frequently continuous-filament, man-made yarns that are very tightly twisted, heat-set, then untwisted, producing a spiral crimp giving a springy character. Although bulk is imparted in the process, a very high amount of twist is required to produce yarn that has not only bulk, but also stretch.

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Spandex is the generic term for a highly elastic synthetic fibre composed mainly of segmented polyurethane. Uncovered fibres may be used alone to produce fabrics, but they impart a rubbery feel. For this reason, elastomeric fibre is frequently used as the core of a yarn and is covered with a nonstretch fibre of either natural or man-made origin. Although stretch may be imparted to natural fibres, other properties may be impaired by the process, and the use of an elastic yarn for the core eliminates the need to process the covering fibre.

### **Metallic yarns**

Metallic yarns are usually made from strips of a synthetic film, such as polyester, coated with metallic particles. In another method, aluminum foil strips are sandwiched between layers of film. Metallic yarns may also be made by twisting a strip of metal around a natural or man-made core yarn, producing a metal surface.

For additional information about the production, characteristics, and uses of modern man-made novelty yarns, see man-made fibres.

### **Treatment of raw fibre**

In modern mills, most fibre-processing operations are performed by mechanical means. Such natural fibres as cotton, arriving in bales, and wool, arriving as fleece, are treated at the mill to remove various foreign materials, such as twigs and burrs. Wool must also be treated to remove suint, or wool grease; silk must be treated to remove sericin, a gum from the cocoon, and the very short silk fibres, or waste silk. Raw linen, the fibre of flax, is separated from most impurities before delivery. Man-made fibres, since they are produced by factory operations, rarely contain foreign materials. Blending, frequently employed for natural fibres, involves mixing fibres taken from different lots to obtain uniform length, diameter, density, and moisture content, thus assuring production of a uniform yarn. Blending is also employed when different fibres are combined to produce yarn. Man-made fibres, which can be cut into uniform tow, do not require blending unless they are to be mixed with other fibres.

Cotton, wool, waste silk, and man-made staple are subjected to carding, a process of separating individual fibres and causing many of them to lie parallel, and also removing most of the remaining impurities. Carding produces a thin sheet of uniform thickness that is then condensed to form a thick, continuous, untwisted strand called sliver.

When very fine yarns are desired, carding is followed by combing, a process that removes short fibres, leaving a sliver composed entirely of long fibres, all laid parallel, and both smoother and more lustrous than uncombed types. Slivers may be loosely twisted together, forming roving. Hackling, a process applied to straighten and separate flax, is similar to combing.

### **Conversion to yarn**

Because filaments, such as silk and the man-made fibres, have extreme length, they can be made into yarn without the spinning operation necessary for the shorter staple fibres. When grouped together in a loose, continuous rope without twist, man-made filaments are called tow. Filaments may be loosely twisted together to form yarns of a specified thickness. Staple fibres, such as cotton, only a few inches long, must be tightly twisted together to produce satisfactory length.

Filament yarns are usually thin, smooth, and lustrous; staple yarns are usually thicker, fibrous, and without lustre. Man-made filaments cut to a predetermined short length become staple fibres, usually described by combining the fibre name with the term staple, as in rayon staple.

### Spinning

#### Early spinning methods

Spinning is the process of drawing out and twisting fibres to join them firmly together in a continuous thread or yarn. Spinning is an indispensable preliminary to weaving cloth from those fibres that do not have extreme length. From early times through the Middle Ages spinning was accomplished with the use of two implements, the distaff and the spindle. The distaff was a stick on which the mass of fibres was held. The drawn-out length of fibre was fastened to the weighted spindle, which hung free. The spinner whirled the spindle, causing it to twist the fibre as it was drawn from the distaff. As a length was drawn out the operation was halted, the new yarn wound on the spindle and secured by a notch, and the operation repeated. The spinning wheel, invented in India and introduced to Europe in the Middle Ages, mechanized the process; the spinning of the wheel supplanted the whirl of the weighted spindle, and after each operation the spinner wound the new yarn on the spindle. This was accomplished simply and speedily by holding the yarn outstretched with the left hand and feeding it as the wheel was spun in the reverse direction.

An important advantage conferred by the spinning wheel was the fact that it tended to add more twist at thin places in the forming yarn and to draw out the thicker places, giving a more uniform yarn.

The spinning wheel continued in use into the 19th century, receiving an important improvement in the 16th century in the form of the Saxony wheel, which made possible continuous spinning of coarse wool and cotton yarn. With this improvement in speed, three to five spinning wheels could supply one loom with yarn, but Kay's flying shuttle (described below under Woven fabrics) greatly increased the output of the loom and created a demand for spinning machinery. James Hargreaves' spinning jenny (patented 1770) operated a number of spindles simultaneously, but was suitable only for making yarn used as filling. Sir Richard Arkwright, making use of earlier inventions, produced a better machine, capable of making stronger yarn than Hargreaves' jenny. Still a third machine, Samuel Crompton's "mule" (1779), vastly increased productivity, making it possible for a single operator to work more than 1,000 spindles simultaneously; and it was capable of spinning fine as well as coarse yarn. Several further modifications were introduced in Britain and the United States, but the Crompton mule effectively put yarn spinning on a mass production basis.

#### Modern spinning

In modern spinning, slivers or rovings are fed into machines with rollers that draw out the strands, making them longer and thinner, and spindles that insert the amount of twist necessary to hold the fibres together. Tightness of the twist determines the strength of the yarn, although too much twist may eventually cause weakening and breakage. When the spirals formed by twisted yarns are similar in slope to the central portion of the letter Z, the yarns are described as Z-twist; when the spirals conform in direction to the central portion of the letter S, the yarns are described as S-twist. Crepe yarns, producing a crinkled effect in fabrics, are made with a very high degree of twist, producing a kink. Shadow effects can be produced in finished fabrics by the use of yarns combining opposing twists, producing differing light reflections. The spinning process is completed by winding the yarn on spools or bobbins.

#### Reeling and throwing

Reeling is the process of unwinding raw silk filament from the cocoon directly onto a holder. When several filament strands, either raw silk or man-made, are combined and twisted together, producing yarn of a specified thickness, the process is called throwing.

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### **Yarn packages**

The intended use of a yarn usually determines the packaging method employed. Bobbins are wood, cardboard, or plastic cores on which yarns are wound as they are spun, and have holes in their centres allowing them to fit on spindles or other holding devices. Spools are cylindrical, with end flanges. Cones, having a conical-shaped core, produce a package of conical shape; tubes, with cylindrical-shaped cores, produce cylindrical packages. Cheeses are cylindrical yarn packages wound on a tube, and, unlike most other packages, they have greater diameter than height. Skeins are coils of yarn wound with no supporting core.

Pirns are large barrel-shaped packages used to hold the weft, or filling, yarn supply for the shuttle in weaving; quills are small tapered tubes holding the weft yarns for weaving. Beams are wood or metal cylinders, about five feet long and up to 10 inches in diameter, on which yarns used as warp in weaving are wound.

### **Production of yarn**

Yarn is a strand composed of fibres, filaments (individual fibres of extreme length), or other materials, either natural or man-made, suitable for use in the construction of interlaced fabrics, such as woven or knitted types. The strand may consist of a number of fibres twisted together; a number of filaments grouped together but not twisted; a number of filaments twisted together; a single filament, called a monofilament, either with or without twist; or one or more strips made by dividing a sheet of material, such as paper or metal foil, and either twisted or untwisted. The properties of the yarn employed greatly influence the appearance, texture, and performance of the completed fabric.

### **Factors affecting cost**

The cost of fibres is determined by availability, the kind and amount of processing required, and their versatility. Natural fibres usually require extensive land area for their production, are affected by climatic conditions, and must frequently be transported long distances to the point of manufacture. Because quantity and quality are not easily controlled, prices tend to fluctuate. Research has been directed toward improving various properties during the manufacturing processes.

Man-made fibres can usually be produced near the point of use; their production does not require large land areas; they can be manufactured quickly, in desired quantities, with specific built-in properties; and they require little advance preparation for conversion to yarn. Initial costs are high because of the production equipment employed, but prices tend to be stable and may be reduced as production expands. Research has been directed toward improving the properties of man-made fibres and developing types suitable for specific purposes.

Although the major natural fibres continue to dominate the textile industry, production and consumption of synthetic fibres are growing.

### **Classification of yarn based on use**

#### **Fabric construction yarns**

Almost any textile yarn can be used to produce such interlaced fabrics as woven and knitted types. In weaving, the warp, or lengthwise, yarns are subjected to greater stress and are usually stronger, smoother, and more even and have tighter twist than the weft, or crosswise, yarns. A sizing (stiffening) material such as starch may be applied to warp yarns, increasing their strength to withstand the stresses of fabric construction operations. Weft yarns, subjected to little stress during weaving, may be quite fragile. Warp and weft threads used in the same fabric may be of differing diameter, producing such

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special effects as ribbing or cording in the fabric. Special effects may also be obtained by combining warp and weft yarns of fibre from differing origin, or with different degrees of twist, or by introducing metallic threads into weaves composed of other fibres. Yarns for machine knitting are usually loosely twisted because softness is desired in knit fabrics.

### **Yarns used in handwork**

Yarns used in hand knitting are generally of two or more ply. They include such types as fingering yarns, usually of two or three plies, light to medium in weight and with even diameter, used for various types of apparel; Germantown yarns, soft and thick, usually four-ply and of medium weight, frequently used for sweaters and blankets; Shetland yarns, fine, soft, fluffy, and lightweight, frequently two-ply, used for infants' and children's sweaters and for shawls; worsted knitting yarn, highly twisted and heavy, differing from worsted fabric by being soft instead of crisp, and suitable for sweaters; and zephyr yarns, either all wool, or wool blended with other fibres, very fine and soft, with low twist, and used for lightweight garments.

Embroidery floss, used in hand embroidery, generally has low twist, is of the ply or cord type, and is made of such smooth filaments as silk and rayon. Yarn used for crocheting is frequently a loose cotton cord type; and darning yarns are usually loosely spun.

### **Sewing thread**

Sewing threads are tightly twisted ply yarns made with strands having equally balanced twist, producing a circular cross section. Thread for use in commercial or home sewing machines and for hand sewing should allow easy movement when tension is applied and ease in needle threading; should be smooth, to resist friction during sewing; should have sufficient elasticity to avoid the breaking of stitches or puckering of seams; and should have sufficient strength to hold seams during laundering or dry cleaning and in use.

Threads for special uses may require appropriate treatment. Garments made of water-repellent fabrics, for example, may be sewn with thread that has also been made water-repellent. Thread is usually subjected to special treatment after spinning, and is then wound on spools. Thread size is frequently indicated on the spool end, and systems for indicating degree of fineness vary according to the textile measurement system used locally.

Silk thread has great elasticity and strength combined with fine diameter. It can be permanently stretched in sewing, and is suitable for silks and wools. Buttonhole twist is a strong, lustrous silk about three times the diameter of normal sewing silk, and is used for hand-worked buttonholes, for sewing on buttons, and for various decorative effects.

Cotton thread is compatible with fabric made from yarn of plant origin, such as cotton and linen, and for rayon (made from a plant substance), because it has similar shrinkage characteristics. It is not suitable for most synthetics, which do not shrink, or for fabrics treated to reduce shrinkage. Its low stretch is useful for woven fabrics, but not for knits, which require more stretch.

Nylon thread is strong, with great stretch and recovery, does not shrink, and is suitable for sheers and for very stretchy knits. Polyester thread has similar characteristics, and is appropriate for various synthetic and preshrunk fabrics, and for knits made of synthetic yarns.

### **Measurement systems**

Yarn measurements are expressed as yarn number, count, or size, and describe the relationship of length and weight (or approximate diameter). Because methods of measurement were developed in various areas of the world, there has been a lack of uniformity in such systems.

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### **Indirect systems**

Indirect measuring systems are those employing higher number to describe finer yarns, and are based on length per unit weight. Most countries measure yarns made from staple fibres according to the weight of a length of yarn. If one pound is used as a standard unit, for example, a very fine yarn will have to be much longer than a coarser yarn to weigh a pound, so higher counts indicate finer yarns. The size number is an indication of the length of yarn needed to reach a weight of one pound.

In the United States, the system is based on the number of hanks per pound, with a hank of 840 yards for cotton and spun silk, 300 yards (a lea) for linen, 256 yards for woollen yarns, and 560 yards for worsted yarns. A widely used continental system is based on the number of hanks of 1,000 metres (one kilometre) required to reach a weight of one kilogram.

### **Denier system**

The denier system is a direct-management type, employed internationally to measure the size of silk and man-made filaments and yarns, and derived from an earlier system for measuring silk filaments (based on the weight in drams of 1,000 yards). Denier number indicates the weight in grams of 9,000 metres of filament or filament yarn. For example, if 9,000 metres of a yarn weigh 15 grams, it is a 15-denier yarn; if 9,000 metres of a yarn weigh 100 grams, it is a 100-denier yarn, and much coarser than the 15-denier yarn. Thus a smaller number indicates a finer yarn. This system is not convenient for measurement of staple yarns because their greater weight would require the use of very large numbers.

### **Tex system**

The tex system, originally devised in 1873, is a universal method developed for the measurement of staple fibre yarns and is also applicable to the measurement of filament yarns. It is based on the weight in grams of one kilometre (3,300 feet) of yarn.