Engineering the performance of knitwear

Mr Laurie Staynes

CSIRO Textile And Fibre Technology

Innovation: Engineering the performance of wool knitwear for softness and appearance retention

Introduction

The successful production of soft handling high performing quality wool knitwear with good appearance retention properties relies on a number of important factors:

- judicious raw material selection
- selection of suitable processing sequence and conditions
- strict application of quality and process control measures.

If the handle or appearance of the garment is not satisfactory at point of sale it is unlikely that the consumer will purchase the product in the first place. Where a purchase is made and during subsequent wear/maintenance the product performs badly, it is unlikely that the consumer will make the same purchase again. In addition, the consumer is likely to associate that particular brand and possibly also the fibre as unsatisfactory, thereby reducing any opportunity for a second sale. Before moving on to discuss the measures available to improve the quality of wool knitwear or, more importantly, how the consumer views its quality, it is important to define clearly what 'quality' is in wool knitwear:

- handle and comfort (at point of sale and during wear)
- appearance (at point of sale and after wear and laundering)
- performance (during wear and after laundering).

Selecting raw material for optimised softness and wear performance

Although there are many vertical processors who produce their own tops from greasy wool blends for their own spinning plants, the majority of worsted spinners do not have top-making facilities. The selection of raw material for these spinners becomes a matter of obtaining wool tops that meet a given set of top specifications. Examples of these specifications are discussed below.

Average fibre diameter and wool quality

Traditionally and in some countries still today, wool quality has been described by a 'grade'; for example, 64s, 70s, 80s. Wool was graded by an experienced wool classer; the grade would be an estimate of the finest worsted count to which the wool could be spun on a traditional roller-drafting worsted drawing and spinning system. A given set of wool qualities tended to be internal to a particular company or group of companies; however, with the development of fibre measurement techniques, a number of semi-official scales of quality relating to fibre diameter emerged between 1930 and 1950, all differing to a greater or lesser extent. As a consequence of the resulting confusion, the International Wool Textile Organisation (IWTO) passed a resolution discouraging the publication of those scales and urging their withdrawal. Thus, no international wool quality scale has ever existed and with the increasing use of instrumental measurement and specification (fibre diameter, length, yield, and so on) the need for such a scale has declined.

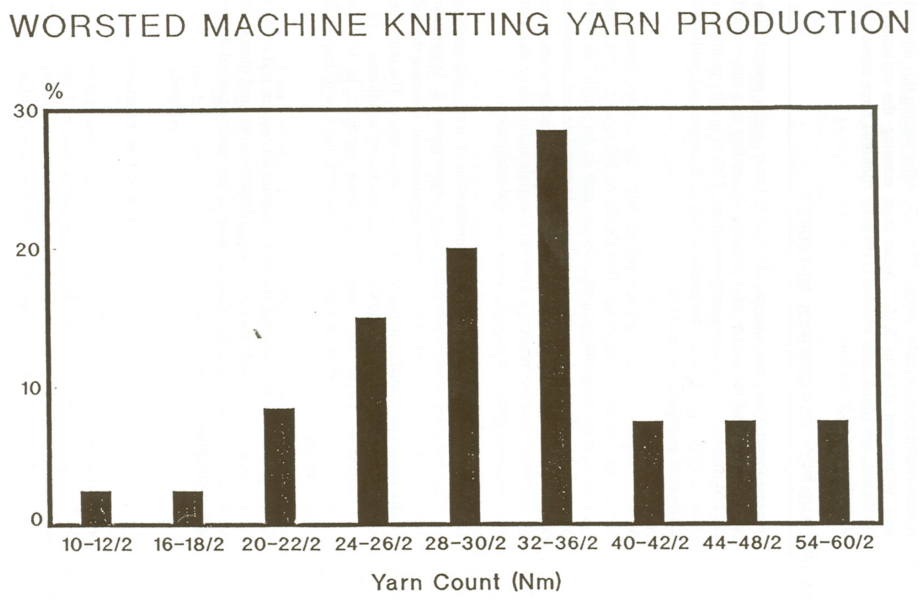
It is for this reason that spinners describe wool quality primarily by its average fibre diameter, supplemented by other characteristics, such as length and colour.

Unlike worsted wool weaving yarns, where the majority are spun near count limits (that is, 40 fibres per single cross-section), machine knitting yarns, particularly those aimed at the knitwear market, are spun to meet a given set of product requirements such as hand feel, next-to-skin softness and appearance. The formula to calculate the approximate yarn count from a given micron of wool does not therefore generally apply to machine knitting yarns:

$$\text{Yarn count (tex)} = 0.0436 \times \text{fibre micron}^2.$$

Providing one is aware that this approximate relationship describes the ‘finest’ yarn count able to be produced from a given fibre micron, the misuse of this formula in the specification of hosiery yarns should not occur.

Before looking at examples of the average fibre diameter employed in the production of different machine knitting yarn counts, it is useful to look at the common count range into which this micron falls. From the figure below it may be seen that world wide more than 60% of machine knitting yarn production is concentrated in the count range of 2/24 Nm to 2/36 Nm.



The table below shows the average fibre diameter of the tops commonly used for producing different count ranges between 2/24s Nm and 2/36s Nm.

Common top diameters for different two-fold flatbed machine knitting yarn counts

Yarn count (Nm)	Top diameter (Micron)
2/20	<25
2/28	<22.5
2/36	<21.5
2/48	<19.5
2/60	<18.5

It is quite obvious that especially for the medium to coarse yarn counts, very often the yarns are not limit spun.

Although folded yarns are sometimes used in some heavier weight single jersey fabrics (<24 npi), the majority of circular single and double knit jersey fabrics are produced from singles yarns, the most popular yarn counts being 1/40 Nm and 1/50 Nm (≥24 npi). By far the greatest proportion of jersey fabric yarns are produced from topf <19.5 micron with counts finer than 1/60 Nm spun with finer wools (<18.5) in order to avoid fabric skin comfort issues.

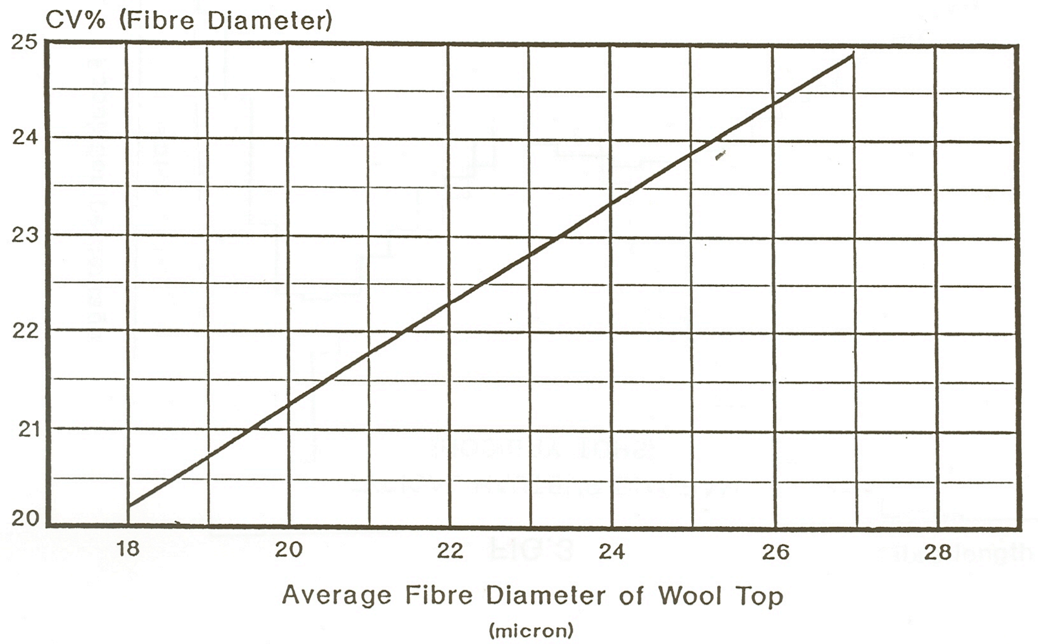
Fibre diameter distribution in the top

The fibre diameter distribution in the top can affect the number of imperfections in the yarn. For the same average diameter, a top that has a higher Coefficient of Variation (CV %) in fibre diameter may result in a more irregular yarn and produce more thin places. This is because the variation in the fibre diameter is an extra source of variability that will contribute to the total variability in the linear density of the yarn.

The actual effect of fibre diameter distribution in the top on yarn irregularity is not, however, insignificant in practical terms; for example, a yarn with 40 fibres in the cross-section requires a variation of 6 to 8% (absolute) in the CV of the fibre diameter distribution to effect a change of 1% (absolute) in the yarn CV. According to the experience of Uster, the difference in yarn evenness becomes visually detectable when the CV of the two yarns differs by 2%.

There is a guide for the expected CV% of a fibre diameter for average top diameter in the figure below:

RELATIONSHIP BETWEEN WOOL MICRON AND CV%



Of greater importance is probably the actual form of fibre diameter distribution. In the case of fine machine knitting yarns used for underwear and next-to-skin wear, the probability of any constituent fibre evoking unpleasant prickle sensations when protruding from the fabric surface must be reduced to an absolute minimum.

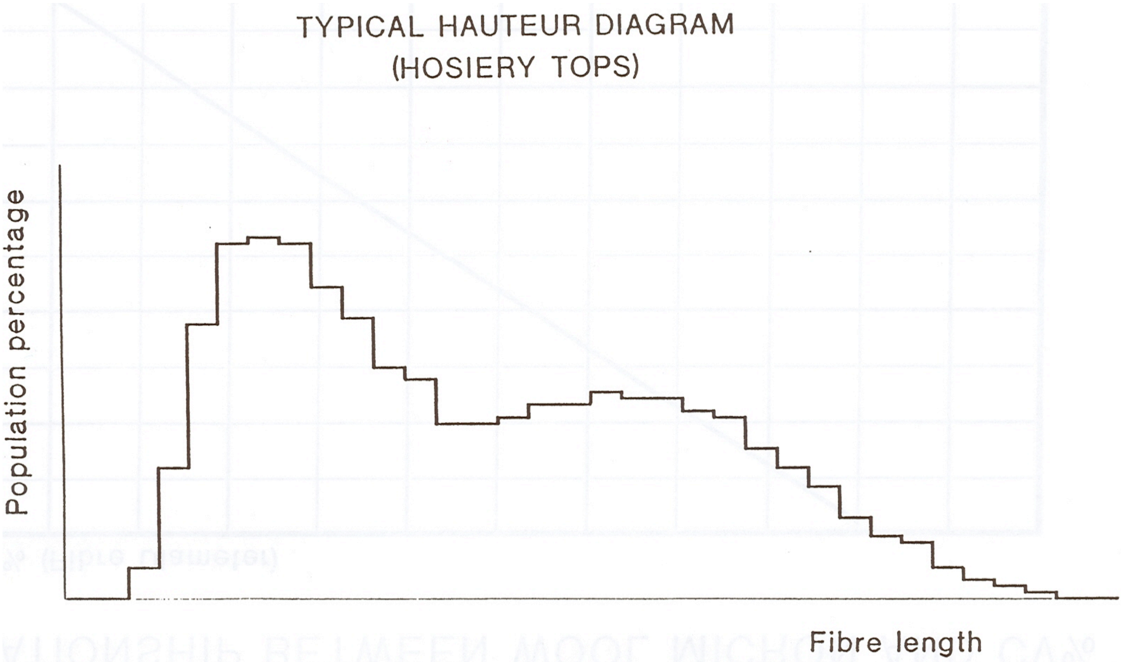
Fibre length features and distributions

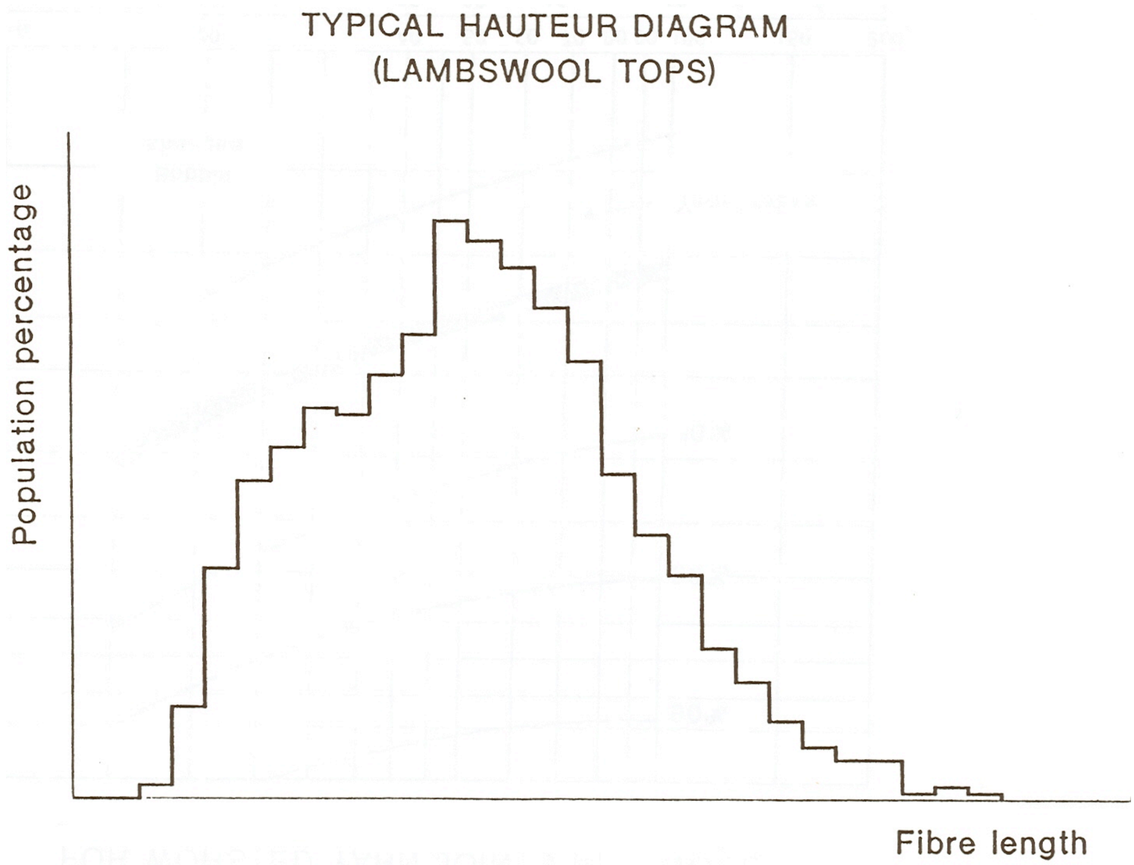
Wool tops used to produce yarns for machine knitting tend to be shorter in length to those used in the production of warp weaving yarns. Compared to weaving tops, hosiery tops are some 5 to 10 mm shorter in hauteur. The reasons for this are two-fold. Firstly, for a given number of fibres per cross-sectional area, a shorter top will provide a higher number of fibre ends per unit length in the yarn, resulting in a more bulky and softer yarn. Second, there is not the same call for the abrasion resistance and yarn strength required of weaving yarns.

Average hosiery top lengths

Fibre micron	Hauteur (mm)
<25	60–65 maximum
26–27	65 average
28	80 maximum

Well defined crimp definition is a sought after attribute in hosiery yarn tops as this translates to bulky yarns or lighter weight fabrics while providing good fabric cover. Typically, the hauteur diagram of hosiery tops is left-skewed due to the relatively high amount of short fibres present when compared with a warp top of similar mean fibre length. It should be kept in mind, however, that although increased short fibre content may provide the yarn with additional bulk and loftiness, this may be at the expense of increased hairiness in rewinding and inferior fabric properties such as increased propensity to facing-up and pilling and reduced burst strength.





Faults and contaminants

Neps, slubs, vegetable matter and coloured fibre form the basis of faults and contaminants in wool top.

For neps, only those with a core diameter of 0.5–2.5 mm are counted. For fine wools, 16 neps per 100 grams of sliver is considered the maximum acceptable. Neps with core diameters greater than 2.5–3 mm are given the term 'slubs', which for all practical purposes should be nonexistent in a well-combed top.

Acceptable levels for vegetable matter are based on size. For contaminants >10 mm, 1.5–3 pieces per 50 gram is generally considered acceptable. For 3 mm to 10 mm, vegetable matter contamination of 5–10 pieces per 50 grams is the accepted limit. When vegetable matter contamination level is significantly higher than that stated above and final product quality is critical, re-combing may become necessary. It should be noted, however, that re-combing is not very effective in reducing vegetable matter in the shive/grass category.

Of all of the contaminants found in wool top sliver, coloured fibre probably occupies a unique position as its level can be absolutely critical for certain end uses such as underwear, bleached whites, pastel and light shades. While an upper limit of 10 'dark' fibres per 100 grams of top sliver may be considered acceptable for woven fabric, a more stringent threshold may be required for knits, which unlike wovens are extremely difficult to mend.

Re-combing

Where top dyeing takes place, re-combing becomes inevitable. Tops that are shrink-resist treated, whether top dyed or not, should be re-combed to remove any fibre entanglements in the sliver. Where counts finer than 36 Nm are to be spun re-combing should also take place. Re-combing can reduce short fibre content, reducing the potential for facing-up and pilling and possibly reducing the risk of loop distortion as the resulting yarn is likely to be more even.

Engineering hosiery yarn for optimum softness and appearance retention

Spinning, winding and twisting

The recommended spinning draft ratio using good quality drafting arms with double apron fibre control systems is 18–22. In most applications this drafting range is also appropriate for spinning machine knitting yarns.

Good creeling arrangements and the use of front zone condensers are always recommended, regardless of roving type. When front zone condensers are used, both their condition and positioning require care and regular attention. Good operator training in these aspects is also vital.

Machine knitting yarns are usually spun using a metric twist factor of 70–80. To calculate the actual turns per metre in the yarn, the following formula is used:

Yarn Twist (tpm) = Metric Twist Factor x √Resultant Count (Nm).

After spinning, the yarn is cleared, possibly assembly wound and then twisted, the recommended folding twist to singles twist ratio being around 60%.

To reduce the risk of loop distortion, particularly in single jersey fabrics, yarns should not be steamed at all. By avoiding steaming, the risk of having uneven piece/garment dyeing is also reduced. The risk of spirality in single jersey fabrics does not exist in two-ply yarns so long as the folding twist balances out the singles twist. In the case of finer gauge single jersey fabrics, which demand the use of single ply yarns, a compromise in twist levels must be struck between acceptable levels of spirality on the one hand and adequate burst strength and fabric appearance change (facing-up and pilling) on the other.

Yarns for double jersey knitting have much higher twist than other knitting yarns. The metric twist factor for these yarns tends to fall in the range of 90–105. As these yarns are mostly used in singles form, steaming is usually unavoidable, especially in view of their higher twist levels. Spirality of fabrics knitted from single-ply yarns is not an issue in balanced double-knit fabric constructions.

In carrying out yarn steaming it is imperative to ensure that setting conditions are uniform both between and within yarn packages and other detrimental properties, such as alkaline pH are minimised. A typical yarn steaming procedure for singles knitting yarn is as shown in the table below.

Sequence	Operation	Time (minutes)	Vacuum pressure Hg/bar
1	Vacuum		25”/0.12
2	Steam	3	15”/0.48
3	Vacuum	3–5	25”/0.12
4	Steam	10	15”/0.48
5	Vacuum	5–10	25”/0.12

To ensure the correct functioning of the autoclave, regular calibration of the internal operation condition and control dial reading should be carried out. Routine use of temperature recording self-adhesive strips on steaming packages will also provide information on the performance of the autoclave.

After steaming, the yarn must be allowed to condition for at least 12–24 hours so that it may reach equilibrium with ambient conditions prior to winding. Excessive moisture in the yarn may cause stretch of the fibres/yarn during winding and reduction in wax pickup. For capacitance type clearers, yarns with uneven moisture distribution may also be subjected to false cuts.

For two-fold yarns, twisting may take place on two-for-one twisters, two-stage up-twisters or conventional ring twisters. Good and consistent quality twisting relies on consistent yarn tensioning and good piecening-in practices.

If assembly winding precedes twisting, particular attention must be given to the uniform tensioning of the two ends during this process to prevent hairy or corkscrew yarns.

To avoid yarn contamination, machine cleanliness during spinning, twisting and winding is of paramount importance. Unless travelling cleaners with short turnaround times are installed, fibre debris and fly/dust should be removed by wiping and not blown during machine operation. Only at lot changes should machines be blown clean and care must be taken to avoid cross-contamination of other yarns/machines.

Yarn clearing and jointing

The selection of a particular level of clearing for a given type of yarn has always been based on experience and available technology; for example, the advent of splicing. When knotting was the standard jointing technique it was always necessary to consider whether the fault was a greater or lesser evil than the knot, which itself 'disturbed' the surface of the yarn. Today, with splicing as the norm, winding productivity and the threshold fault sizes that are considered to be disturbing in fabric form have become the main considerations for the determination of an acceptable clearing level. Many spinners do, however, retain some knotting heads for the jointing of fine to extra-fine yarns (for example, finer than 64Nm).

For machine knitting yarns, additional consideration must be given to the fact that knitting efficiency can be affected by yarn fault incidence and type. For medium to coarse counts, knitting faults are mostly the result of thick places in the yarn such as slubs and knots. For finer yarns, breaks caused by thin places are the major problem – knitting efficiency and fabric quality is rarely affected by knots.

Comparing knitting yarn with weaving yarn, spinners tend to clear out more short 'fly-type' faults from knitting yarns as such faults may cause jamming of the yarn between the knitting machine needle and wall of the trick, resulting in the formation of holes in the fabric. Translating this to the Uster Classimat fault grading system, this could imply that all the A3, B3, some C2 and all D2 fault should be cleared out. As the majority of knitting yarns are not spun near count limits, a tighter clearing level does not necessarily imply a higher clearer cutting rate than a weaving yarn of equivalent count.

Many spinners also adopt a two-fold clearing procedure during rewinding of two-fold yarns. This is a recommended procedure, particularly for medium to coarse count yarns for single jersey knitting. Clearers designed specifically for this purpose have been developed and are usually based on optical principles.

Quality controllers are strongly recommended to inspect regularly the faults that have been extracted, whether singles or two-fold. Careful fault analysis will often determine the fault origins as well as identify clearer performance.

Yarn waxing

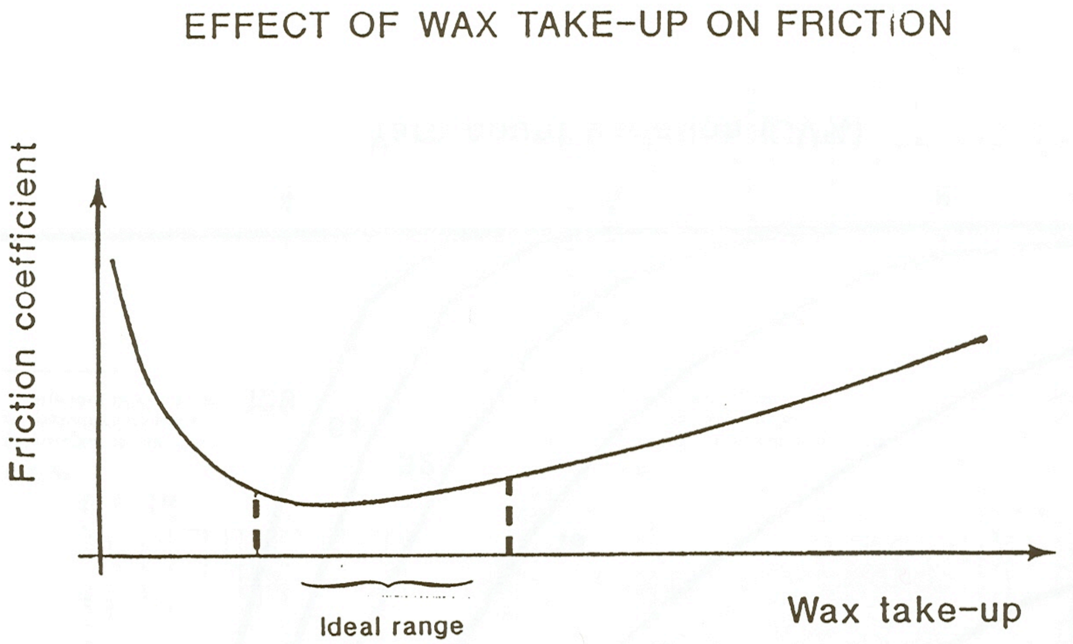
All worsted spun machine knitting yarns need to be waxed before use so that yarn-to-metal friction can be reduced during knitting.

While most knitting yarns are waxed at the point of manufacture, in some instances where the yarns may have been stored over a long period or stored under hot conditions where the wax can melt and penetrate into the yarn reducing its effectiveness, it may be necessary to re-wax prior to knitting.

In terms of type, good knitting yarn wax should conform at least to the following specifications:

Structure	-	Coarse crystalline
Oil content	-	0.5% mineral oil residue
		<5% fully-refined white paraffin oil
Melting point	-	50–60°C
Hardness	-	Based on DIN 5179 and ASTM D1321-65
		1.2–1.3 mm penetration for raw stock wax
		1.9–2.0 mm penetration for finished roll wax (2.4–2.5 mm for soft twist and bleached yarns and low winding tension).

In terms of amount, the average wax take-up rate should be around two grams of wax per kilogram of yarn. The uniformity of wax take-up can be affected by the mounting method of the wax roll and winding tension. Generally speaking, a 'side pressing' wax-roll mounting system gives better uniformity of wax application than gravity mounting. Winding tension should be chosen within such a range that the effect of any variation on the yarn-to-metal friction is minimal.



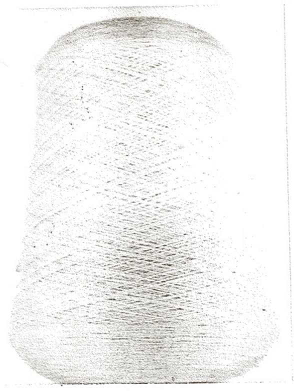
The expected decrease in yarn-to-metal friction following waxing of undyed or dyed wool yarn should be around 50%. Experience has shown that in most cases the over-application of wax and corresponding increase in coefficient of friction does not lead to complaints during knitting.

Knitting yarn packages

Because of the unwinding conditions on the knitting machine, a knitting yarn package needs to have a greater taper to prevent the unwinding yarn fouling the edge of the package. Traditional knitting packages have a taper of 9°15' but, due to the improved package formation and better package change-over properties, steeper angled 5°57' packages have become more popular.

Wool knitting yarn packages should be soft wound to a package density of less than 400 g/l and preferably weigh no more than 1 kg.

Correctly formed package



Distorted shape package

Yarn conditioning and packaging

Wool yarns are normally sold on the basis of dry weight plus an additional allowance for moisture. The standard allowances stipulated by IWTO for dry combed worsted yarn is 18.25% and, although yarns may not contain this amount of moisture, an adjustment is made to the invoice in order to base charges on the nett weight at correct moisture content. Knitting yarns are usually delivered with between 14% and 18% regain. The higher range of regain should only apply when the transportation distance is short, weather condition does not fluctuate significantly and the storage condition is under control. It is commonly accepted that moisture in the yarn assists knitting as it increases yarn extensibility and reduces the likelihood of loop distortion. Moisture is usually applied by the spinner by mechanical means. The main task here is to ensure that the distribution of moisture is even throughout the package. Moisture content in yarn is particularly critical for knitters who do not use yarns soon after receipt from the spinner or who have storage conditions that are not ideal, where yarns may dry out. To retain moisture and prevent physical and insect damage to the yarn individual cones should be packed in polythene bags. Perforated bags are sometimes used to prevent a build-up of condensation.

If the yarn storage conditions are likely to be hot and humid and the yarns stored for a long period of time, high moisture content in the yarn should be avoided to prevent mildew formation on the yarn. The message for the spinner is to liaise with their customers to ensure that yarns are conditioned and packaged according to requirements.

Yarn quality

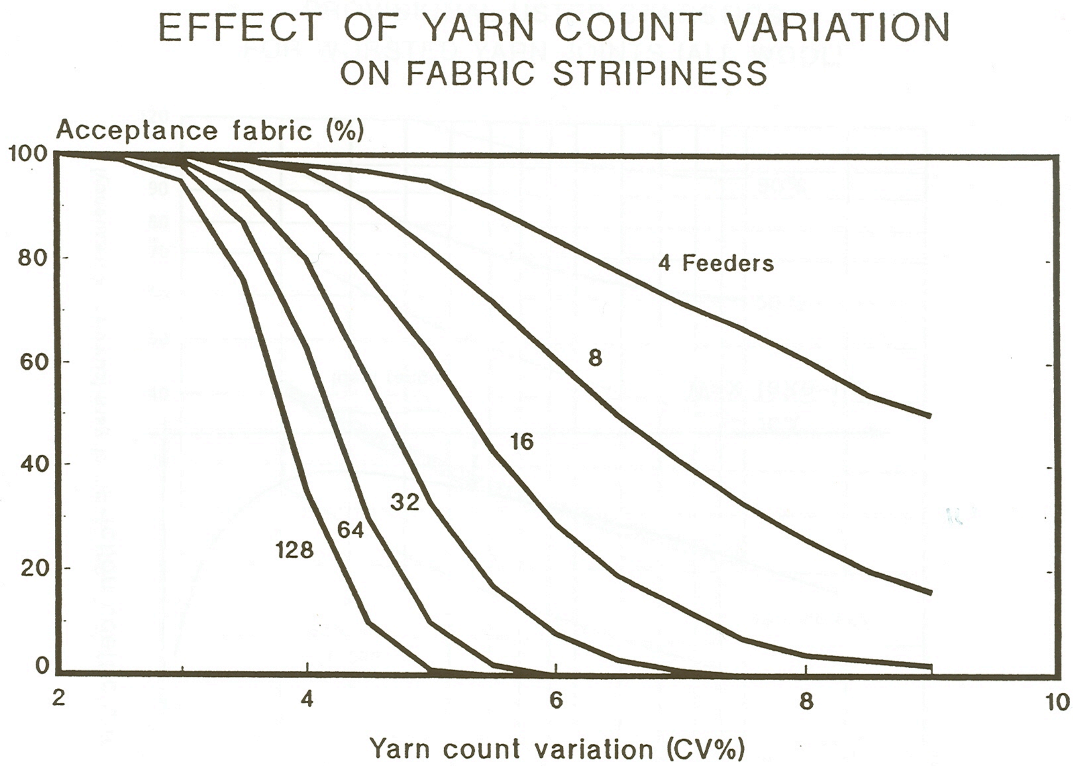
Fibre diameter and to some extent fibre length vary considerably between different knitting yarns depending on the desired product characteristics, making strict adherence to a given set of yarn specifications difficult. Within these confines it is still possible to set guidelines on minimum acceptable yarn quality requirements for industrial knitting yarns.

Yarn count and count variation

IWTO stipulate that the average count of worsted yarn delivered should fall within the tolerances specified below, the tolerance being calculated as a percentage of the count contracted for:

<15 Nm:	+/-0.5 Nm
15 Nm – 29.99 Nm:	+/-0.75Nm
30 Nm – 69.99 Nm:	+/-2.5%
>70 Nm:	+/-3%.

Unfortunately these specifications offer little information on the allowable yarn count variations related to the variation in average yarn count between one package and another. The family of curves shown in the graph below represent the relationship between the amount of acceptable fabric and yarn count variation for a different number of feeders on the knitting machine. The judgement criteria are based on a critical level of stripe visibility of +/-10% yarn count deviation, which is critical with most knitted fabrics. The curves suggest that with high yarn count variation, it may be impossible to knit an acceptable fabric using a large diameter multi-feeder circular knitting machine.



Experience shows that the number of end breaks in processing also increases with higher yarn count variation. A count variation CV of over 3% is considered as detrimental to the general appearance of the final fabric. Uster statistics show that the average figure for worsted yarns is around 1.7%.

Yarn strength and extension

The tenacity of a two-fold worsted machine knitting yarn usually lies between 5 and 7 g/tex, the lower end generally representing top-dyed yarns. Singles yarn for fine-gauge double jersey should, however, measure at least 5 g/tex for satisfactory knitting.

The minimum average breaking extension for knitting yarn should be 10%. Folded yarn and coarser count singles yarn is usually substantially more extensible that this. The average breaking extension of medium to fine count singles yarn tends to be around 9%. It is important, therefore, that the latter be well waxed before use and positive yarn feeding at knitting used where possible.

Evenness and imperfections

Single yarn irregularity and imperfection should be kept below the 75% line of the Uster statistics. In conjunction with this requirement, the spectrogram should always be consulted as the Uster CV% measurement will mean little if periodic faults exist.

Yarn-to-metal friction

As mentioned earlier, the coefficient of friction of a well waxed worsted wool yarn should measure around half that of the unwaxed yarn. For a typical worsted yarn the coefficient of friction prior to waxing is around 0.27 to 0.30. Following waxing, this figure should drop to between 0.14 and 0.15. It is also important to ensure that the coefficient of friction is constant, as irregular surface frictional properties can have a detrimental effect on knitting and fabric quality.

Engineering knitting fabric for optimised softness and appearance retention

Minimising faults

The effect of raw material contamination (such as coloured fibre and vegetable matter) and fibre/yarn processing defects (such as slubs, neps, thick and thin, joints, oil and dirt) have already been covered; however, there is still a need to minimise the addition of new faults during the knitting process.

The major cause of faults during knitting is poor housekeeping and operator practices. By far the biggest problem is the deposition of loose fibre or ‘fly’ in the fabric. This problem extends from contamination of the fabric by a small number of coloured fibres to holes resulting from the accumulation of large quantities of loose fibre.

Loose fibre can accumulate on:

- yarn packages as a result of rewinding of yarn
- yarn packages, yarn creel and knitting machine frame as a result of normal unwinding of yarn from the package
- machine parts as a result of surface friction against the yarn as it runs through guides and feeders
- machine needle beds (verge bits and tricks) as a result of friction between the yarn and knitting elements.

Contaminants may be of self-colour or contrasting colour, the same fibre or different fibre and their source may be from the same or some other machine. Faults in the form of colour fly or slubs are likely to be visible in the greige fabric. Contamination from self-coloured fibres of a different type may not become visible until after dyeing. The elimination of fly-borne contaminants depends on good housekeeping practices. Machines running staple fibre yarns (which are prone to the creation of fly) should be isolated from their neighbours (different rooms/use of transparent curtaining between machines). Fly should be removed from yarn packages and creel/machine parts on a regular basis through vacuum cleaning (at the end of each piece). On the commencement of each new piece yarn guides should be checked for accumulation of loose fibre and slubs that may have arisen as a result of disturbing fly during cleaning.

Controlling knitting density

To ensure consistent fabric quality it is important to control knitting density. Knit density is the single most important fabric property for controlling pilling, loop distortion, fabric dimensional stability and fabric handle (softness).

While the task of achieving many of the above properties may be made easier through correct fibre selection and fibre processing conditions and the range of acceptable fabric structure broadened through the use of a well specified quality yarn, this can be lost if fabric density is not optimised and controlled.

Specifying, measuring and controlling fabric density is based on measuring and controlling the loop length in the fabric. If the loop length in a fabric is too long, the fabric becomes slack and is inclined to suffer from:

- bagging
- snagging
- low bursting strength
- loop distortion and cockling
- pilling and facing-up
- poor dimensional stability to wear and laundering
- generally poor wash and wear performance.

If, on the other hand, the loop length is too short, the fabric becomes stiff and suffers from:

- low elasticity
- harsh handle
- heavy weight
- generally poor aesthetic properties.

Measuring fabric density

There are several methods of measuring fabric density, some carried out prior to or during the knitting process, others based on analysis of already knitted fabric. To some extent the method used will depend on the situation, type of knitting machine and fabric being produced. Modern computer-controlled flat-bed and circular knitting machines can be programmed to knit a predetermined loop length and are capable of measuring and adjusting for variations in loop length in real time during the knitting process. These techniques are commonly used to control garment dimensions in knitted-to-shape products, where relatively small variations in loop length between panels may result in out-of-specification garments.

Course length measuring devices are available for use on circular knitting machines. Loop length may be calculated from course length by dividing the number of needles knitted. For reasons of simplicity, course length measurement on its own is often used for controlling fabric density.

On machines that do not have loop or course length measuring devices attached, measuring the run-in of a set length of yarn can be used to calculate loop length. The procedure in this instance is:

- using a felt tipped pen, mark a pre-determined length of yarn (effectively a course length), say 10 cm
- knit the marked length of yarn
- count the number of needles or loops between the two marks (10 cm)
- calculate the loop length in mm using the formula:

Loop Length = Course Length ÷ Number of Needles.

The loop length should be within ± 2% of specified length. If outside this acceptable tolerance level adjust loop length and repeat test.

Cover Factor or Tightness Factor can also be used to measure stitch density, which is measured as follows:

- take the fabric to be measured and count and mark a given number of loops, for example, 100
- using scissors, cut vertically down the fabric (wale) at the outer edge of each mark (leaving a strip of fabric 100 wales wide)
- unravel and measure in centimetres, using a suitable device (HATRA Course Length Board or Shirley Crimp Tester) 10 consecutive courses
- average the length of the 10 individual measurements
- determine loop length (L) in centimetres by dividing the average length of yarn in centimetres by the number of loops; for example, 100.

Calculate the Cover Factor using the formula:

$$Cover\ Factor\ (CF) = 1 \div (L \times \sqrt{N})$$

where N = Resultant metric (Nm) yarn count or

Tightness Factor using the formula:

$$Tightness\ Factor = \sqrt{T} \div l$$

where l is the average loop length in centimetres and N is the yarn count in tex.

Methods based on the use of loop length (Cover Factor and Tightness Factor) are the only accurate methods for controlling knit density and should be adopted for setting up machines and day-to-day routine quality control. The use of Cover Factor or Tightness Factor provides the additional benefit over course or loop length of allowing constant fabric density to be maintained regardless of changes or variation in yarn count or knitting machine diameter/needle density (machine gauge).

While Cover Factor or Tightness Factor can be used for double knit and complex structure fabrics, they are used mainly for plain single jersey fabric. Cover Factor and Tightness Factor are used in specifying commercial quality fabrics and in the preparation of sample fabrics for pill and wash testing. Examples of typical Cover Factors and Tightness Factors are as follows:

Woollen spun yarn garments (for example, lambswool, shetland) CF 1.1 (TF 13)

Worsted spun knitwear (sweaters and cardigans)	CF1.28 (TF 15)
Fine worsted spun jersey fabric (knitted polo tops)	CF1.37 (TF 16)
Standard wash test (woollen yarn)	CF 1.0 (TF 12)
Standard wash test (worsted yarn)	CF 1.1 (TF 13)
Pill testing	CF 1.2 (TF 14)

Selection of appropriate knit construction

While fabric density plays a major role in knit fabric performance, knit structure also influences fabric and garment performance.

In general, rib knit fabrics out-perform plain jersey fabrics in almost every respect (for example, pilling, facing-up, dimensional stability to laundering, snagging, abrasion resistance). Unfortunately, rib fabrics of matching weight to single jersey require the use of much finer and stronger yarns, finer machine gauges and a more complex knitting routine. Aesthetically, rib fabrics do not offer the softness of hand and high levels of drape offered by similar weight single jersey fabrics. As fabric structures become more complex, be they single jersey or rib, fabric performance reduces. Fabrics that contain floating yarns suffer reduced weft extension and are more prone to felting, fabrics that contain tuck stitches suffer poor dimensional stability during wear and laundering (they tend to grow in the width) and poor pilling performance, and wool fabrics that contain held stitches are inclined to suffer poor length extension and high length relaxation. It is not by accident that most corporate knitwear is based on plain 1 x 1 rib constructions, while ladies' fashion knits are single jersey-based.

Fabric/garment finishing procedures

Minimal finishing is carried out on worsted spun wool knitwear. Most worsted wool knitwear is manufactured from dyed yarns and fabric/garment finishing consists largely of steaming and pressing to reduce relaxation shrinkage and improve garment point-of-sale appearance. Lightweight garments manufactured from knitted piece-goods are likely to be fabric dyed (piece dyed) and care must be exercised to avoid surface facing-up or fuzzing during dyeing. Care must also be taken to avoid the imposition of high length relaxation, particularly in lighter weight fabrics. Over application of softeners or handle modifiers should be avoided as these often result in facing-up and pilling of garments during wear/laundering due to the reduction in inter-fibre friction these products cause.

Final garment appearance

As most worsted spun knitwear receives 'steam only' finish, cleanliness at all stages of manufacturing is critical. Soiling may be result from contact with dirty machinery or handling practices. The application of processing lubricants (oils/waxes) should also be kept as low as possible. Dirt and processing lubricants that remain on the garment through point of sale may increase the rate of soiling and create an oily smell in the garment. Machinery should be kept clean and dirty hands should be washed before tying knots or handling fabrics or garments. The checklist below identifies common faults, causes and remedies.

Fabric handle faults

Fault	Cause	Remedy
Harsh/dry handle	Wool micron too coarse	Select a finer micron wool
	Yarn twist level too high	Reduce twist/use appropriate twist
	Knitting density too high	Check/reduce Cover Factor
	Inappropriate finishing	Introduce/modify finishing procedure
	Insufficient softener application	Check softener application level/select more appropriate softener
Sticky Handle	Excessive lubricant	Reduce application levels/check scouring conditions/introduce fabric/garment scouring
	Ineffective rinsing after wet finishing	Ensure more efficient rinsing (warm) after wet finishing
	Precipitation of insoluble matter result from use of hard water in finishing	Use softened water for finishing
	Inappropriate softener/over application of softener	Change softener/apply less softener
Lack of bulk	Insufficient milling	Increase milling time
	Lack of stable foam during milling	Change/increase detergent used
	Over pressing	Reduce/avoid buck pressure during steaming/pressing

Fabric appearance faults

Fault	Cause	Remedy
Cockling/loop distortion	Too coarse a micron or high percentage of coarse fibres	Use yarn produced from finer wool
	Yarn steaming resulting in increased flexural rigidity of the yarn	Avoid yarn steaming (setting)
	Incorrect twist balance	Ensure correct twist balance
	Large twist variations	Use yarn with twist levels and CV% within the specified range
	Large difference in knit density (fabric width) between rib border and body fabric of garment	Knit the rib border and body fabric to similar tightness
	Setting of yarn during package dyeing	Use yarn from top dyed wool or hank dyed yarn or use anti-setting agents/low temperature dyeing techniques to minimise yarn flattening/set
Spirality	Singles yarn or incorrect twist balance in plied yarns	Move to balanced twist two-ply yarns
	Feeder drop in high feeder density single jersey circular knitting machines	Use machine with lower feeder density
Facing-up	Excessive short fibre content in yarn (more fibre ends)	Increase fibre length, change fibre length distribution profile (reduce left skew)
	Soft twist yarn	Increase spinning twist factor
	Low fabric density	Increase fabric cover factor/tightness factor
	Wet finishing procedure (scouring/piece dyeing) too	Increase liquor ratio, reduce reel speed, reduce jet pressure

	severe Excessive tumble drying Borderline shrink resist treatment level – by product of chlorine Hercosett SR treatment	Reduce drying time Confirm machine washability performance of wool, adopt resin-bridge fabric machine washability treatment (SIROLAN BAP)
Uneven knit structure appearance	Unbalanced yarn twist High or uneven yarn surface friction Poor yarn evenness (high number of thick and thin places) Faulty knitting (unbalanced stitch cam settings)	Use yarn with correct twist balance Use yarn with low and uniform yarn-to-steel friction coefficient Use yarn with fault rate within commercially recommended range Check and balance yarn input speeds/tensions
Presence of contaminants in fabric	Contaminated yarn (coloured fibre/vegetable matter) Dirty fabric (oil and grease from processing, dirt from poor handling practices)	Check yarn quality, check knitting room practices (keep machines separated, only clean machines at ends of pieces, don't clean machines using compressed air) Check housekeeping procedures
Uneven fabric shade	Mixed yarn batches Inconsistent yarn setting conditions (steaming)	Keep different yarn an dye batches separate Check yarn steaming conditions (inside to outside of package and between package)
Vertical lines (faults) in fabric	Stiff, bent, worn or damaged needles or sinkers, worn or damaged needle tricks	Replace knitting elements, fit new cylinder and dial or cylinder and sinker ring
Horizontal lines (faults) in fabric	Poor quality yarn High or uneven yarn-to-	Check yarn evenness Check yarn friction and re-wax if

	metal friction	necessary
	Variation in yarn count within package and from package to package	Check yarn evenness and count within and between packages
	Twist variation in yarn	Check for variation in twist around piecing-ins (knots and splices)
	Shade variation in yarn	Check dye batch, dye levelness
	Uneven yarn input tension	Check and balance yarn input tension
Tuck stitches (faults) in fabric	Knitting too tight (cover factor too high)	Check and re-adjust (reduce) cover factor
	Fabric takedown tension too low	Check and increase fabric takedown tension as required
Holes in fabric	Dropped stitches	Fabric takedown tension too low
		Yarn input tension too low
		Yarn feeder incorrectly set
		High yarn twist liveliness
	Cut yarns	Bursting of thin sections of yarn – check yarn evenness
		Shearing of knots during loop formation – check area of holes for knots/thick places in yarn
		Check knitting element condition

Performance-related faults

Fault	Cause	Remedy
Pilling	High short fibre content Low yarn twist High yarn surface hairiness Low fabric density Fabric surface facing-up during processing Over application of fabric softener Shrink resist treatment method	Change top fibre length profile to reduce percentage of short fibre Increase yarn twist – check twist level is within recommended range Use less hairy yarn, check affect of knitting on yarn surface properties Check and/or increase fabric cover factor Reduce mechanical action on fabric during processing Check softener application level/reduce to recommended application range Consider move from chlorine Hercosett on yarn to SIROLAN BAP on fabric or combination of both
Poor Burst Strength	Weak Yarn Thin places in yarn Chemical/physical damage during top/yarn/ piece dyeing/finishing	Use yarn with greater strength (higher spinning twist, plied) Check yarn evenness/fibres in cross section – use finer micron/more even yarn Check dyeing/finishing conditions, use SIROLAN LTA dyeing techniques to reduce fibre damage
Excessive Relaxation Shrinkage	Incorrect or ineffective finishing procedure	Reduce length/width stretching of fabric during drying. Consider use of fabric compactor
Prickle during wear	Presence of coarse wool fibres	Use finer micron wool/reduced CVD

Questions

1. In what way do tops used in the production of hosiery yarns differ from those used in weaving?

    a. They may contain more vegetable matter.

    b. They are produced from shorter wool.

    c. They are produced from finer wool.

    d. They may contain more coloured fibre.

2. Steaming of singles (single ply) hosiery yarns is often carried out to reduce snarling. Why should steaming of two-fold balanced twist hosiery yarns be avoided?

    a. It may increase yarn to metal friction.

    b. It may alter yarn count.

    c. It may lead to increased loop distortion.

    d. It may detract from fabric softness.

3. Why is it important to wax knitting yarns?

    a. It improves fabric softness.

    b. It reduces yarn to metal friction.

    c. It creates less hairy yarns.

    d. It assists in maintaining yarn moisture regain.

4. Fabric Cover Factor and Tightness Factor are measurements of which fabric characteristic?

    a. Density.

    b. Loop length.

    c. Course length.

    d. Weight.

5. The degree of stripiness in knitted fabric is influenced by deviation in yarn count. The risk of achieving unacceptable stripiness during knitting as a result of yarn count variation increases with which of the following?

    a. Higher machine speeds.

    b. Increased number of yarn feeds.

    c. Increased yarn input tension.

    d. Higher yarn moisture regain.

6. The use of longer wools, increased spinning Twist Factor or knitted Cover Factor may contribute to which of the following?

   a. Improved fabric performance.

   b. Improved fabric handling.

   c. Improved fabric spirality.

   d. Improved loop distortion.