15. Measurements of Yarn and Fabric

Errol Wood

Learning objectives

At the completion of this topic the student will have and understanding of:

- Explain how the constructional parameters, evenness and tensile properties of yarn are measured and interpreted
- Describe the features of a software system for predicting the properties and spinning performance of worsted yarn
- Outline the principles by which the tensile, dimensional stability, serviceability, drape and other mechanical properties of fabrics are determined
- Describe and compare the two instrument systems for objectively measuring the handle and related properties of fabrics

Key terms and concepts

Yarn twist and count, evenness, periodicity, yarn strength and elongation, bulk, bundle strength, prediction software, fabric burst strength, dimensional stability, pilling, snagging, abrasion resistance, drape, crease recovery, shear, Kawabata Evaluation System, SiroFAST system

Introduction to the topic

Fibre assemblies relevant to wool include slivers, tops, yarn and fabrics. The kinds of measurements relevant to these structures can be grouped as follows:

- Constituent properties – e.g. fibre diameter, fibre length
- Construction – e.g. linear density, twist
- Mechanical tests – e.g. strength, flexibility, bulk
- Contamination tests – e.g. residual grease, vegetable matter faults, neps, moisture content.

In this topic tests for wool fibre assemblies are considered, for yarns and fabrics.
The principle references for this topic are the texts by Saville (1999) and Booth (1976).

15.1 Yarn tests

Yarn Constructional Parameters

1. Linear density (or count)

The *count* measures the mass of a given length of yarn, and is related to (1) the thickness of the yarn and (2) the number of fibres in the cross-section. It is the most basic yarn property and is expressed either

(a) in tex, a direct system (grams per kilometre), or

(b) metric, an indirect system (metres per kilogram).

To convert between the two count systems, the rules are as follows:

Metric count = 1000 / tex

Count in tex = 1000 / metric

To determine the count of a yarn requires both the length and mass of a representative sample to be measured. For mass, any balance of sufficient accuracy may be used. To eliminate variations in mass due to moisture content, it is best to conduct the measurement in a conditioned environment, i.e., 20^{o}C and 65% relative humidity.

Yarns are also vulnerable to stretching, which can make length measurement unreliable. Therefore, procedures for length measurement need to standardise the tension that is applied to a length of yarn. For long lengths of yarn sampled from bobbins or cones, the yarn is wound on to a wrap reel of suitable girth (usually 1 m) with the correct amount of friction (Figure 15.1). However, the amount of friction introduced cannot be easily measured so the tension has to be set by first making test hanks and then checking their girths on a skein gauge.

Figure 15.1 Wrap reel for yarn length measurement. Source: James H Heal & Co Ltd. (1994).

As an example, if a 500 metre length of yarn is found to have a mass of 40 grams, its linear density is:

(a) in tex: Count = 40g / 0.5 km = 80 tex

(b) in metric: Count = 1000 / 80 = 12.5 Nm.

A **resultant count** is the count of a twisted (or folded or plied) yarn. The resultant, labelled R, for a two-ply yarn formed from this 80 tex yarn would be expressed as R160/2 tex.

In fact, twisting two such singles yarns together would produce a count which is slightly higher than the nominal value, i.e., closer to R165/2 tex.

2. Twist

Twist is used to bind staple fibres together closely into a yarn, and thus giving tensile strength to the yarn. The twist may be specified for singles and plied yarns, and is measured in turns per metre.

Since twist is inserted into a yarn by rotation, the logical method of measuring twist is to reverse the process and count how many turns are required to untwist the yarns until they, or their constituent fibres, become straight. This is called the **straightened fibre method**. However, because of difficulties associated with determining visually when the fibres are straight this method is generally only suitable for folded and continuous filament yarns. The apparatus for this method of measuring twist is shown in Figure 15.2.

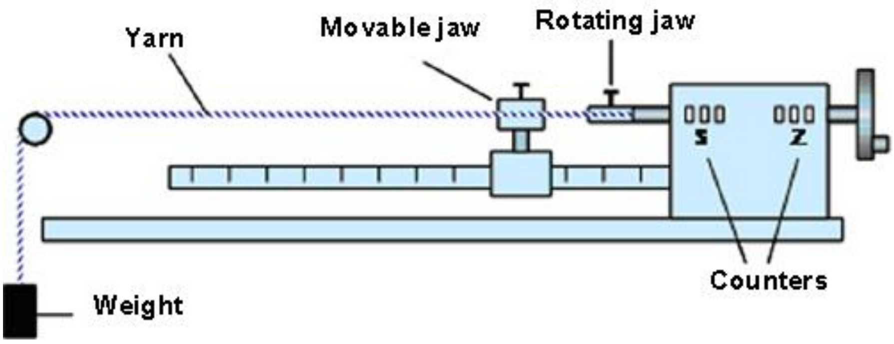

Figure 15.2 Apparatus for twist measurement by straightened fibre method.

When yarn is untwisted it becomes longer until it reaches a maximum length. It then takes up the same amount of twist in the opposite direction and returns to its original length. This is the principle of the **twist contraction method**, which is generally used for singles yarns because it overcomes the difficulty of visually determining the point of zero twist. The apparatus for this test is shown in Figure 15.3.

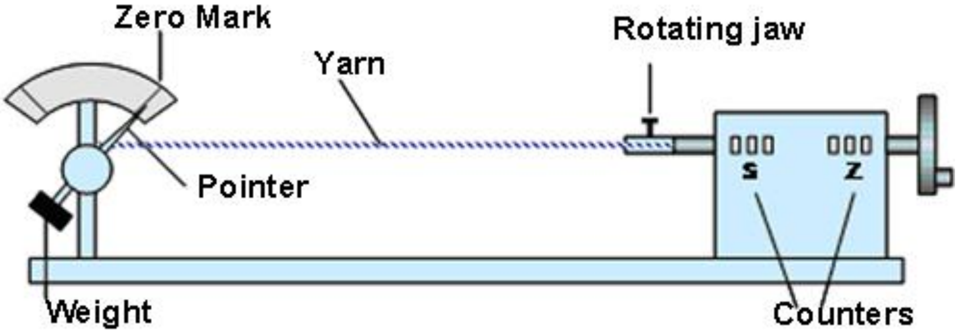

Figure 15.3 Apparatus for twist measurement by twist contraction method.

The method is as follows:

1. One end of the yarn is fixed in the rotating jaw (at right)
2. The other end is clamped to a small drum from which a pointer extends to a quadrant-shaped scale (at left)
3. As twist is taken out by the rotating jaw the yarn extends and the pointer travels to the left across the scale
4. Once all twist has been removed, the yarn begins to contract and the pointer moves back towards its zero position
5. The twist content of the specimen is the total number of turns, as recorded by the counter, divided by two. If the test length of yarn is 250 mm, the number of turns per metre is the number of rotations, multiplied by two.

Evenness

The evenness of yarns (also rovings and slivers) is frequently measured using a Uster Evenness Tester (http://www.uster.com/), or one of several other instruments that operate on the same *capacitance* principle, illustrated in Figure 15.4. The reading, Wood a.pdf, explains simply the physics of capacitance measurement of wool. The relevant international test method is IWTO-18: Method for the determination of evenness of textile strands using capacitance testing equipment. Furter (1982) has reviewed methods for the testing of evenness in yarn production.

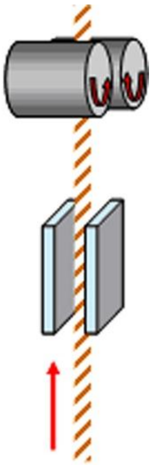

Figure 15.4 Principle of capacitance evenness measurement.

The yarn is rapidly passed between two electrically-charged parallel plates which form a *condenser* (or *capacitor*). Because wool is a *dielectric* material, the fibres interact with the electric field between the plates and thus affect the capacitance of the capacitor.

By continuously measuring changes in the capacitance, which arise from the variations in the mass of fibre between the charged plates, the variations in yarn count can be recorded and analysed.

The Uster instrument reports:

- the mass irregularity, in terms of U% and CV%
- the frequency of thick places, thin places and neps
- the frequency of 'seldom occurring' yarn faults
- the yarn count variation.

Mass irregularity

The U% value is the mean deviation expressed as a percentage of the mean.

The CV% is the square root of the mean square deviation expressed as a percentage of the mean. This parameter, which is more often quoted, gives more emphasis to the larger deviations and so it is a better indicator of the visual effect of the irregularity.

Imperfections

These are 'frequently occurring' faults (thick and thin places and neps), which are counted per km of yarn.

Yarn faults

'Rare' faults (thick and thin) are counted and classified into size and length categories, and expressed per 100 km of yarn.

Uster spectrograms

A useful aid for analysing yarn periodicity is the Uster Spectrogram, produced by the Uster Evenness Tester. A spectrogram depicts the periodic irregularities in a yarn in the form of a graph where the Y-axis (i.e., vertical direction) represents the proportions of irregularity associated with the wavelength represented by the X-axis (horizontal direction). To enable a wide range of wavelengths to be shown, the X-axis is compressed into a logarithmic scale.

A typical spectrogram for a normal yarn is shown in Figure 15.5(a), and that of a yarn containing a prominent periodic fault is in Figure 15.5(b). In general, when the exposed 'chimney' height P>1/3H, where H is the total 'chimney' height, the yarn is sufficiently flawed to be regarded as serious.

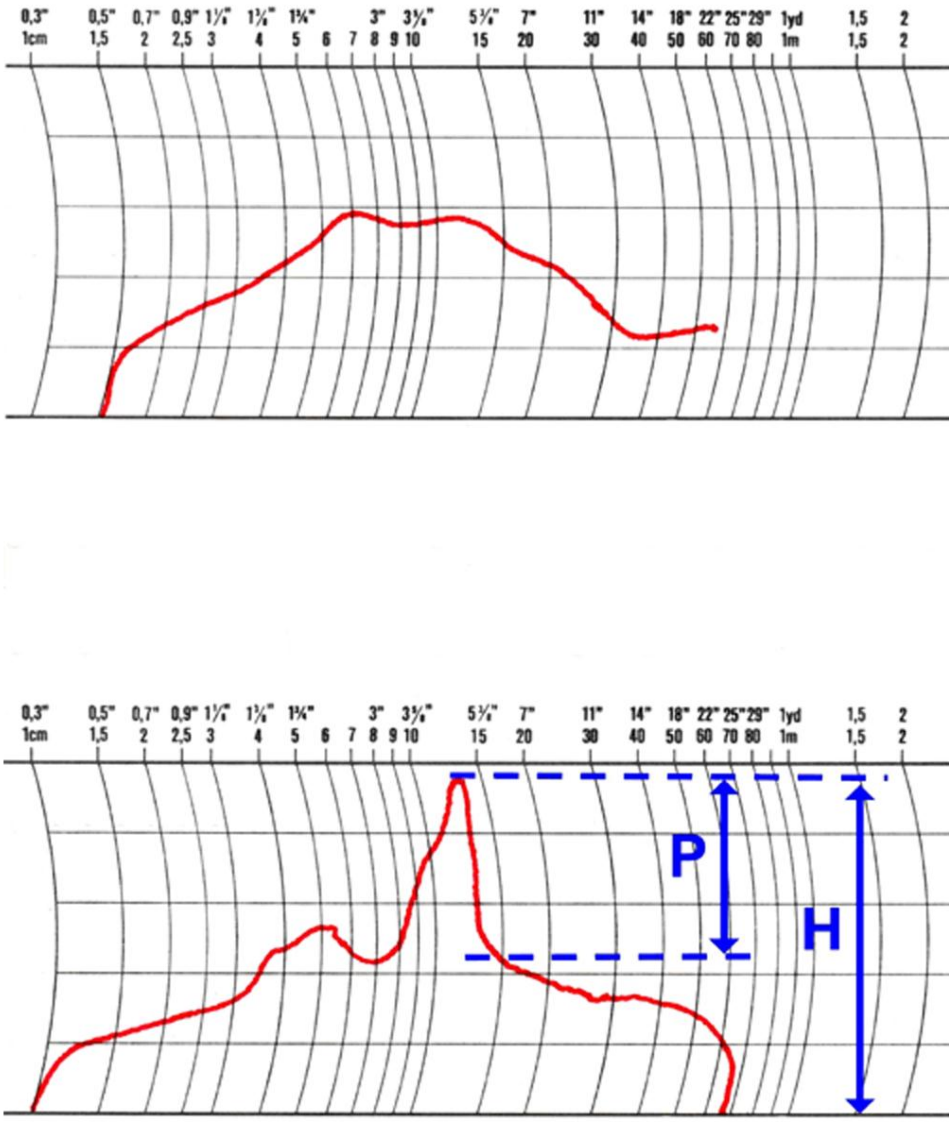

Figure 15.5 (a) Uster spectrograms for an even yarn, and (b) a yarn with a periodicity at 13cm.

The 'chimney' in Figure 15.5(b) indicates that a periodicity with a wavelength of close to 13cm is present in the yarn. This feature strongly suggests that there is a source of a short-term count variation somewhere in the spinning processes, and the wavelength highlighted by the chimney may provide a clue as to the source of this regular variation.

Tensile properties of yarns (strength and elongation)

Yarn strength (or breaking load) is defined as the maximum force that a yarn under tension can sustain before it breaks. This depends on fibre strength and its resistance to fibre slippage; i.e. more specifically:

1. the fibre characteristics (length, strength, crimp, etc)
2. the yarn construction parameters (count, twist)
3. the evenness of the yarn, especially the occurrence of thin places.

The SI unit for yarn strength is the Newton (N) (which is approximately equivalent to the force of gravity on a 100 gram mass).

Extension (or elongation) is a measure of how far a yarn will stretch before it breaks. It is often expressed as a percentage of the original (i.e. unstretched) length.
Yarn strength and extension are related, and in spun yarns are largely determined by (a) the number of fibres in the cross-section of the yarn, (b) the mean length of the fibres and (c) the amount of twist that holds the fibres together in the yarn. As the level of twist increases so will the extension and strength, up to a point where the strength of the yarn will actually start to decrease. The reason for this is explained in the reading Wood b.pdf.

To measure yarn strength, lengths of yarn (often a *gauge length* of 500mm is used) are broken by stretching on a tensile tester (Figure 15.6), and the maximum load and the maximum breaking extension are recorded (Figure 15.7). The maximum load may be measured in centi-Newtons (cN) or gram force (gf). Maximum breaking extension is measured as % elongation at break.

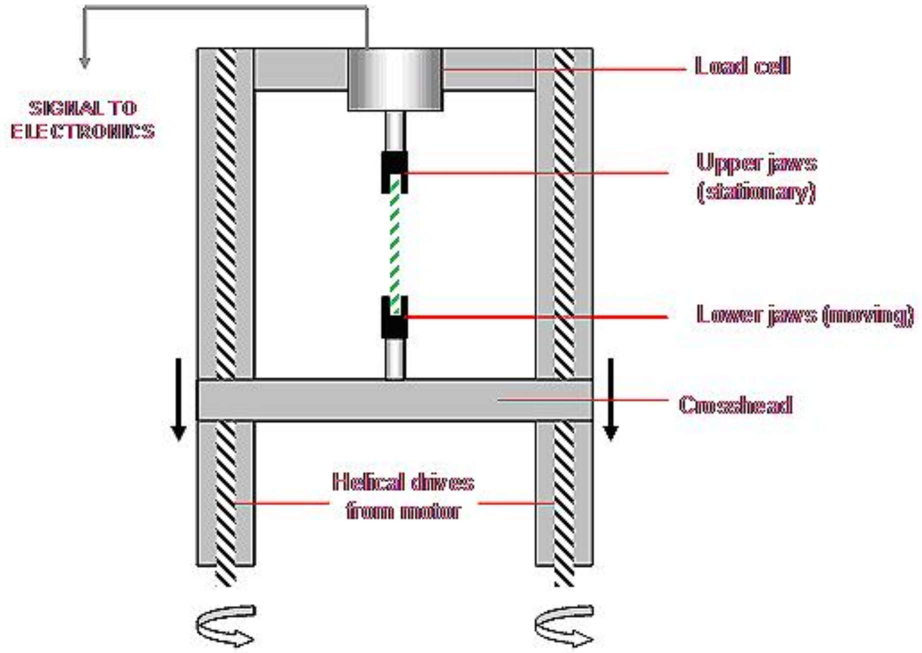

Figure 15.6 A yarn tensile tester.

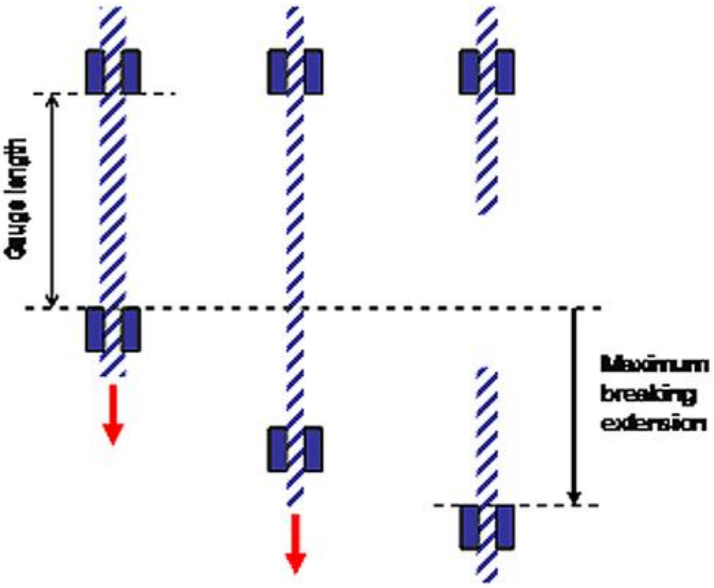

Figure 15.7 Principle of yarn tensile testing: (1) 500 mm length of yarn inserted in jaws of tester, which then move apart; (2) yarn approaching breaking point; (3) yarn at instant of breaking with maximum breaking extension shown.

In general, the strength of a yarn is mostly dependent on its count (i.e. the number of fibres in its cross-section). To properly compare the strength of yarns of different counts, the *tenacity* is normally used. This is the maximum load divided by the yarn count, with units cN/tex or gram per tex (g/tex).

Tensile testers may be operated over a range of speeds and in either of two modes: (a) constant rate of loading or (b) constant rate of extension. Machines that can be adjusted to break the yarn in 20±3 seconds are generally preferred.

For general guidance the requirements for fine weaving yarns are:

Tenacity:	Minimum - 2.5 g/tex;	Target - 4.0 g/tex
Extension at break:	Minimum - 10%	

Yarn bulk (or Specific Volume)

Yarn bulk is determined by the fibre properties (especially the amount of crimp/fibre curvature), and the yarn twist and count. The bulk of a yarn is also influenced by previous treatments such relaxation by steaming, chemical setting, packaging method and the regain.

A simple apparatus, a channel bulkometer, has been developed by WRONZ to measure the bulk of yarns in cm^3 per gram, particular for carpet and knitting yarns. The yarn bulk test measures the volume occupied by a quantity of yarn of known mass when it is subjected to the standard pressure of a 500 gram mass. Figure 15.8 shows this device.

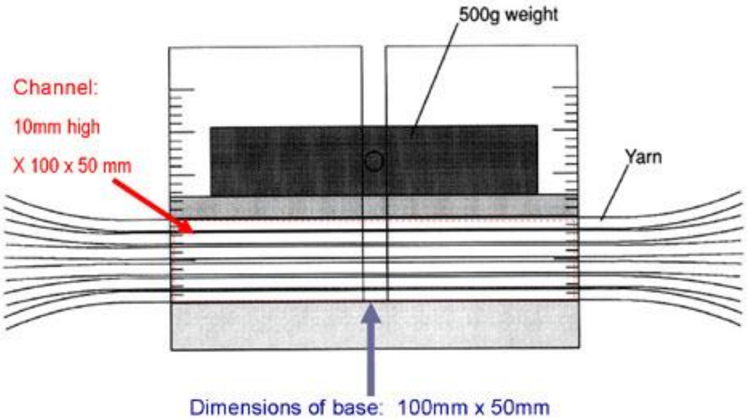

Figure 15.8 The yarn channel bulkometer.

A hank of relaxed yarn (i.e. steamed for 1 minute at 100 ^oC), containing a suitable number of turns, is placed in the channel. A 500g load is applied to the top of the hank by a pressure plate. After 30 seconds has elapsed, the height of the yarn in the channel (h) is read at the four corners of the pressure plate, and the average height H calculated from these four observations.

With the yarn still in the channel under load, it is cut through with electric clippers until only the portion of the hank lying in the channel remains. The mass M of this yarn is determined, and yarn bulk calculated by the formula:

Yarn bulk = A x H / M

where A is the area of the base of the channel (5cm wide x 10cm long= $50cm^2$).

The above is an outline of the preferred 'destructive' version of the yarn bulk test. To carry the non-destructive version of the test requires the length of yarn in the hank, number of turns of yarn and the mass of the hank to be determined in order the calculate M.

Example:
A hank of semiworsted yarn is measured for bulk in the yarn bulkometer using the destructive version. The heights recorded for the four corners of the pressure plate are 1.1, 1.2, 1.2, 1.1 cm.

The mass of yarn left in the channel after the remainder of the hank has been shorn off is 6.3g.

The bulk of the yarn is calculated as follows:

Volume of yarn = average height x area of base of channel
= 1.15 x 50 cm^3 = 57.5 cm^3

Bulk = Volume of yarn /mass of yarn
= 57.5 / 6.3
= 9.1 cm^3/g

As an indication of the usual range of yarn bulk, Table 15.1 gives the values expected for a R600/2 tex carpet yarns (woollen and semiworsted) of conventional twist after steam relaxation. Higher twist yarns will, of course, give lower bulk values than these.

Table 15.1 Typical yarn bulk values.

	Yarn bulk cm^3/g	
	Woollen yarn	**Semi-worsted yarn**
Lean	less than 8	less than 7
Average	8 – 11	7 – 10
Bulky	more than 11	more than 10

Yarn Prediction Software

Sirolan-Yarnspec is a mathematical model developed by CSIRO that predicts what a first-class worsted mill should achieve using a particular top for a given yarn, under specified spinning conditions. In other words, it attempts to quantify best spinning practice. Yarnspec incorporates the results of comprehensive spinning trial results by CSIRO and has been validated in trials with many international mills.

To perform its predictions Yarnspec requires five properties and limited processing information to be specified:

- Top properties: mean fibre diameter, diameter distribution, Hauteur, fibre length distribution, fibe bundle tenacity, crimp
- Yarn specification: count, twist
- Processing information: top-dyed or not, shrinkproofed or not, recombed or not, backwashed or not, spinning speed, draft, ring size, traveller weight.

Yarnspec predicts the following yarn properties and spinning performance parameters:

- Yarn unevenness CV%
- Index of irregularity
- Thin places per kilometre (-50%)
- Thick places per kilometre (+50%)
- Neps per kilometre (+200%)
- Yarn tenacity
- Elongation at break
- Breaking force
- End-breaks per 1000 spindle hours.

Yarnspec enables a spinning mill:

- to produce yarns to the necessary quality by selecting a suitable wool top and optimising the processing parameters
- to minimise materials cost by selecting the most suitable wool top at the lowest possible price
- to benchmark itself against the world's best practice
- to diagnose cases of under performance and identify possible causes.

15.2 Fabric Testing

The tests for fabrics are covered by a plethora of standards, many of which vary in methodology from country to country. Therefore the principles of fabric testing rather than the details of specific tests will be covered here. A summary of fabric tests is included as an Appendix.

Strength and Elongation

The level of strength required for a fabric depends on its end use. While some uses demand high strength, especially industrial products, fabrics intended for apparel or household use need only adequate strength in order to withstand handling during manufacture and use.

In general, a higher-strength product can only be obtained by making a heavier, stiffer fabric or using synthetic fibres. Both of these will produce changes in the properties of the material which may not be desirable for a particular end use.

The breaking strength (or tensile strength) is the maximum force recorded in extending a strip of fabric to achieve complete rupture. This force will depend on the cross-sectional area of the specimen, therefore in comparing different fabrics allowances must be made for this. In the strip strength test (BS 2576) strips of fabric 50 mm wide are stretched to their breaking point.

Tearing is possibly the most common type of strength failure of fabrics in use. A small puncture can be converted into a long rip by a quite small effort. The **tearing strength** is usually measured as the force required to propagate an existing tear rather than the force required to initiate a tear. To prepare a test specimen a cut is made in a standard shape piece of fabric and the force required to extend the cut is measured on a tensile tester.

In **burst strength** testing the fabric is stressed in all directions simultaneously so that the direction with the lowest extension at break will fail first. An elastic diaphragm is used to apply the load to the fabric, with the pressure of the fluid behind the diaphragm being used as a measure of stress in the fabric (Figure 15.9).

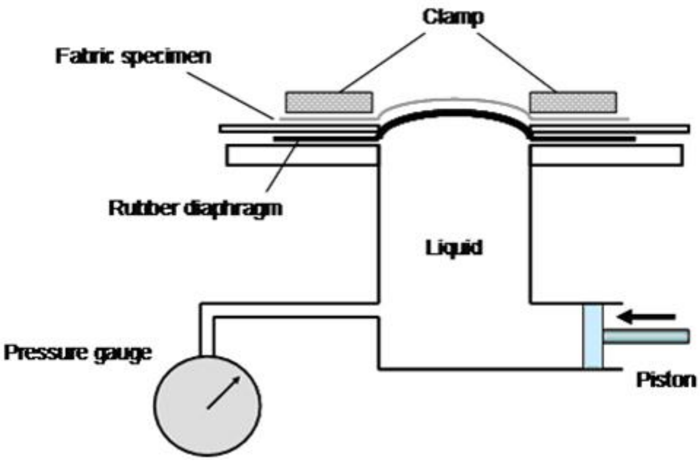

Figure 15.9 Burst strength tester.
The diaphragm is expanded by fluid pressure until the specimen is ruptured. Bursting strength is calibrated by determining the difference between the total pressure required to rupture and the pressure required to inflate the diaphragm.

Certain types of clothing, especially sports wear are required to be a close fit to the body. The fabric for such garments must be able to stretch and recover the original dimensions so that garment remains close fitting. **Elongation** tests that compare the degree of recovery involve measuring the original, unstretched length and the length after the fabric has been allowed to recover for a given period of time.

Serviceability

A garment is considerable serviceable when it is fit for its particular end use. After it is used for a period of time it ceases to be serviceable when it can no longer fill its intended purpose in the way it did when it was new. The effects wear or exposure to conditions that degrade a fabric can be quantified by physical tests. Serviceability has a number of aspects.

Abrasion Resistance

A key performance feature of a fabric is its abrasion resistance. This mostly depends on:

(a) fibre type and properties

(b) yarn twist

(c) fabric structure.

The crimp of the yarns in a fabric affect whether a warp thread or a weft thread is abraded the most. Fabrics with the crimp evenly distributed between warp and weft give the best wear because the damage is spread evenly between them.

The Martindale abrasion tester (Figure 15.10) is designed to give a controlled amount of abrasion between fabric surfaces at comparatively low pressures and in continuously changing directions.

The fabric under test, which is held in the upper holder, is abraded in a complex motion against a standard fabric which is clearly visible. The resistance to abrasion is estimated by visual appearance (i.e. the number of cycles to cause the first thread in the fabric to break) or by the loss in mass of the specimen.

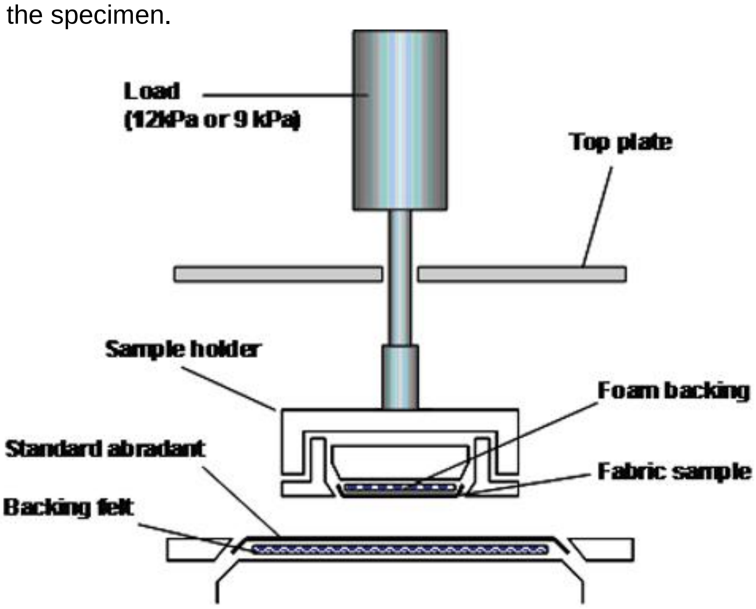

Figure 15.10 Martindale abrasion tester.

The relevant international draft test method is IWTO Draft TM-40: Determination of the abrasion resistance of wool and blended wool fabrics using a Martindale Machine.

Dimensional Stability

The dimensional stability of a fabric is a measure of the extent to which it keeps its original dimensions following manufacture. While an increase in the dimensions is possible, the change is more likely to be an increase, or shrinkage.

Four types of dimensional change are generally recognised – hygral expansion, relaxation shrinkage, swelling shrinkage and felting shrinkage. The effects of these types of shrinkage are measured using standard size samples of fabric, typically 500 mm x 500 mm. The samples are marked out with three sets of marks in each direction, at least 350 mm apart and at least 50 mm from the edge. The samples are then conditioned in a standard atmosphere, measured and subjected to the required treatment. The procedure for conditioning and measurement is repeated to obtain the final dimensions.

Snagging Propensity

Loops of fibre pulled from a fabric are called snags, which detract from the appearance of the fabric. The mace snagging test is a comparative test for the snagging propensity of knitted fabrics. It involves bouncing a spiked metal ball against a sleeve of a test fabric as it rotates on a cylinder. When the test is complete the surface appearance of the specimen is compared with a set of photographic standards and given a rating from 5 (no snagging) to 1 (severe snagging).

Pilling Propensity

Pilling involves the formation by a rubbing action of tiny balls of entangled fibre (pills) which cling to the surface of a fabric and give it an unsightly appearance. The occurrence of pilling is often accompanied by surface fuzzing of a fabric.

Various testing machines are used to assess the pilling propensity of fabrics, including the ICI pilling box (BS EN ISO 12945-01, 2001), random tumble pilling test (ASTM D3512-02, 2002), and the Martindale abrasion tester (where the fabric under test is mounted in both the holder and baseplate so that it is rubbed against itself).

Figure 15.11 shows a pilling box. The test specimens are wrapped and taped onto polyurethane tubes, which are placed in a corked lined box. The pilling box typically undergoes 18,000 rotations, which takes about 5 hours. To assess the specimens they are viewed with oblique light to highlight the surface features and given a rating between 1 (dense fuzzing and/or pilling covering fabric surface) to 5 (no visible change in fabric surface).

Figure 15.11 Pilling box opened to show fabric specimens on tubes.

Drape and other Mechanical Properties of Fabrics

Drape is the term used to describe the way a fabric hangs under its own weight. It has an important bearing on how good a garment will look in use. The required draping characteristics depend on end use. Knitted fabrics are relatively floppy and garments made from them tend to follow the body contours. On the other hand, woven fabrics are relatively stiff so they are used in tailored clothing where the fabric hangs away from the body and disguises its contours. The measurement of the drape of a fabric aims to assess its ability to hide the body contours and its ability to hang in graceful curves. (See Topic 16).

Crease Recovery

Creasing of a fabric during wear is an undesirable change in appearance. The susceptibility of a fabric to creasing depends on the type of fibre used in its construction and a treatment such as resin application to improve crease resistance. Wool, polyester and silk have inherently good crease resistance while cellulosic materials such as cotton, viscose rayon and linen have poor crease resistance.

The test for crease recovery involves folding a specimen of fabric of standard dimensions and placing it under a load for a given period of time to form a crease. The specimen is then allowed to recover for a further length of time and the angle of the crease that remains is measured. The extent of recovery from creasing is a function of (a) the time the crease is maintained, and (b) the time allowed for recovery.

Shear

A shearing force tends to deform a rectangular piece of fabric into a non-square (i.e. parallelogram) shape.

The behaviour of a fabric when it is subjected to a shearing force is one of the factors that determine how the fabric will perform when subjected to a wide variety of complex deformations during use. The ability of a fabric to deform by shearing differentiates it from other thin materials such as paper or films. It is the shearing property that enables a fabric to undergo more complex deformations that simple two-dimensional bending, and thus it can mound to the contours of the body or drape gracefully in clothing applications.

Fabric Thickness and Weight

The thickness of a fabric provides important information on its warmth, heaviness or stiffness in use. However, thickness measurements are not often used because they are very sensitive to the pressure used in the measurement. Instead, the weight of a fabric (in grams per metre) is widely used commercially as an indicator of thickness. The relevant IWTO test method is IWTO Draft TM-22: Method for the determination of weight per unit area of woven cloth.

Objective Evaluation of Fabric Handle

Two instrument systems are available for objectively measuring the mechanical properties of a fabric that relate to its handle.

Kawabata Evaluation System (Kawabata 1980)
The Kawabata Evaluation System measures the mechanical properties of textile fabrics and predicts the aesthetic qualities perceived by human touch. The Kawabata system involves five highly sensitive instruments that measure fabric:

- bending
- shearing
- tensile
- compressive stiffness
- smoothness and frictional properties of a fabric surface (Figure 15.12). This evaluation can include measurement of the transient heat transfer properties associated with the sensation of coolness generated when fabrics contact the skin during wear.

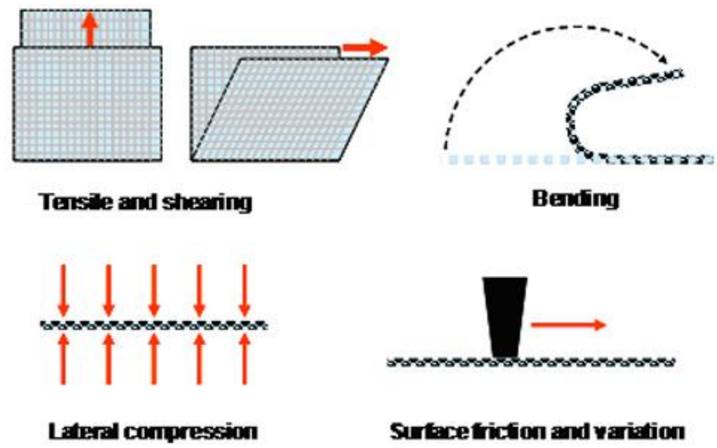

Figure 15.12 Fabric tests carried out by KES instruments.

From each test a series of measurements are obtained, such as linearity of load extension curve, tensile energy and tensile resilience from the tensile test. The measurements from the tests are converted into primary hand values using a set of transformation equations. These equations have been developed through numerous trials, with expert panels comparing their assessments of fabric handle with the instrument results.

The total hand values (THVs) are then calculated from these primary hand values using a further translation equation.

SiroFAST
A development of CSIRO, SiroFAST™ (http://www.sirofast.com/) is an alternative, simpler, system of fabric measurement for assessing the appearance, handle and performance properties of fabrics. A simple series of tests can predict how a fabric will perform when made-up into a garment, hence providing invaluable information for fabric manufacturers, suppliers, finishers and garment manufacturers. The tests are simple and the equipment is easy to use; results can be obtained quickly and are provided in a graphical form which facilitates rapid interpretation and application.

SiroFAST™ measures how a fabric will perform in terms of (1) compression, (2) extension, (3) bending and (4) stability. The three instruments:

- FAST-1: Compression meter
- FAST-2: Bending meter
- FAST-3: Extension meter

are complemented by FAST-4 which is not an instrument but a test method for fabric dimensional stability.

Each test produces what is known as a ‘Fabric Fingerprint’ (essentially a plotted chart as shown in Figure 15.13) and the results can be used for fabric specifications, developing new fabrics, comparing fabric finishing routes, assessing the stability of finished fabrics and predicting tailoring performance and final garment appearance.

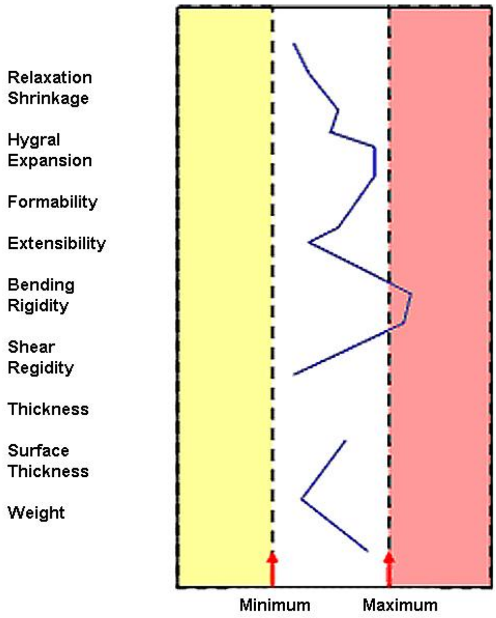

Figure 15.13 'Fabric Fingerprint' produced by SiroFAST system.

Abnormal fabric fingerprints highlight potential problem areas and the early identification of problem fabrics allows remedial action to be taken before the cost of rejects becomes an issue. Furthermore, it enables the best finishing route to be selected, to produce the optimal tailoring performance for the garment.

APPENDIX Summary of the main fabric tests.

Test	What is involved?	How are the results reported?	Significance of the test
Burst strength	The fabric is clamped over a rubber diaphragm. The diaphragm is pumped up to bulge until it bursts the fabric	The pressure required to burst the fabric, in kilopascals	Important in determining if fabric will withstand localised pressures imposed during use
Abrasion	Flat rubbing using a Martindale tester – samples of fabric are rubbed against a standard base fabric	Number of machine cycles (rubs) until fabric wears through	Very important for upholstery fabrics, important for suits and trousers, less so for dresses
Pilling	Fabric samples tumbled for a fixed duration in a Pilling Box under the action of a rubber cylinder	Results report on 1-5 scale: 5 = no pills to 1 = heavy pill formation	Pilling produces an unsightly appearance, also uncomfortable in use. Important for trousers, skirts and coats
Construction	Determination of weave pattern by dissection or microscope	Type of weave Measure number of ends and picks per cm, also area density of fabric in gram/cm^2	Construction important in determining properties of finished fabric
Tensile strength	Measure force required to break strip of fabric by direct pulling on a tensile tester	Maximum force in Newtons required to break fabric (both warp and weft direction)	A direct measure of the strength of a fabric
Tear strength	Cut made in fabric and two ends pulled by a tensile tester to cause fabric to tear along line of cut	Various test methods are used which apply the force in different ways (slow or rapid)	Slow and rapid applications of the tearing force measure different properties
Seam slippage	Two pieces of fabric are seamed under standard conditions. Two ends either side of the seam are clamped and a standard force applied to produce slippage	The gap in the seam is measured (in mm) under tension and after relaxing	It highlights possible problems with less firmly woven fabrics. Seam slippage of up to 1mm is acceptable for light to medium weight apparel fabrics, but for suits no gap is acceptable
Relaxation	The marked area of a fabric specimen is measured before and	The percentage by which the fabric has	All fabrics show some RS when first washed or drycleaned. If this

slippage	after soaking and drying	shrunk in weft and warp directions	exceeds 2% there may be a problem, but depends on type of article (frock versus sheet)
Washing shrinkage	Marked area on fabric measured before and after washing.	Same as for relaxation shrinkage	Knowing how much a fabric will shrink is important before it is cut out and made into a garment
Colourfastness to daylight	Fabric exposed to ultraviolet lamp or daylight alongside a control set of 8 dyed samples which fade at different rates. The trial piece is compared with the control samples to see which of these fades at the same rate.	Results are reported on 1-8 scale: 1 = rapid fading; 8 = excellent resistance	Important for long-lasting textiles such as drapes, furnishing fabrics, bedspreads and carpets. For satisfactory performance a score of at least 6 is essential
Colourfastness to washing	Samples of special white 'multifibre' fabric are sewn to coloured fabric and given standard washing treatment. Washed fabric compared with unwashed piece for loss of colour using grey scales; white fabric checked for staining	Results reported for loss of colour and staining separately: 1 = very poor (severe loss of colour or heavy staining) 5 = excellent (no loss of colour or no staining)	Important to show that an article will not show dye bleeding in washing because: - change in colour of fabric - migration of dye to other articles in wash
Colourfastness to perspiration	The test assesses (a) colour change and (b) staining other clothing. The test sample is sandwiched between two pieces of multifibre cloth and soaked in two solutions of artificial perspiration (slightly acid and slightly alkaline). Each sandwich is pressed and left damp for 4 hours	Same as colourfastness to washing	Mostly only a small colour change is observed except when traces of dye from a deeply coloured garment stain off onto light coloured linings or undergarments.
Colourfastness to rubbing	A piece of fabric is clamped to the base of a crockmeter and rubbed with a piece of white fabric for a fixed number of times. The fabric is tested both wet and dry	Wet and dry samples are reported separately, by comparison with grey scales for (a) loss of colour, (b) extent of staining onto fabric using 1 – 5 scales as above	Excessive application of dye or rinsing off can lead to loose dye which can be removed by rubbing. Poor rubfastness of upholstery fabric can ruin light coloured clothes.
Water repellancy	In a WIRA Shower Tester a shower of droplets falls onto a sloping sample of fabric. The amount of water which passes through is collected and measured.	The amount of water passing through the fabric in a given time, also the water absorbed by the fabric	Many fabrics used for rainwear are water repellent, shower resistant or rain resistant. These usually rely on their ability to shed rain off their surface, but will leak with persistent heavy rain
Air permeability	Measure rate of air flow through a standard area of fabric at a constant pressure	AP is the volume of air (ml) passing through 100 mm^2 specimen of fabric in one second, with a pressure drop of 10mm of water	Important for industrial filters, tents, sails, raincoats, shirts and air bags.
Water absorption	Immerse fabric in water for set time, remove excess and weigh	Weighing before and after immersion enables percent absorption to be calculated	Some textile uses such as towels, cleaning cloths and hygiene products require the material to absorb water
Pilling	Tumble fabric specimen in a pill box or similar device for a set period	Subjectively assess worn specimen and grade on 1 – 5 scale: 5 = no pilling 1 = very severe pilling	Formation of pills on surface of fabric makes them look unsightly
Thermal resistance	A togmeter is used to measure the temperature drops across the two layers of a sandwich of a test fabric and a standard fabric, by heating from one side	The thermal resistance of the specimen is calculated from the temperatures and the thermal resistance of the standard	The insulation value of fabric, e.g. for warmth in apparel, is measured by its thermal resistance R

Crease recovery	A specimen is folded and compressed for a set period and allowed to recover. Angle of residual bend in fabric measured on crease recovery tester	Measure crease recovery angle; convert to Recovery (%)	Creasing of fabric in use is undesirable in many applications
Drape	The size of the shadow cast by a circular, draped fabric in a Cusick Drape Tester	The drape coefficient measures the area of the shadow, as a percentage of the undraped fabric	For certain garments, woven fabrics are required to hang gracefully without puckering or appearing limp.
Handle	Fabrics are tested on the KES instruments for tensile and shearing behaviour, bending, lateral compression and surface characteristics	Various parameters are derived from the instrument results which enable total hand value (THV) to be calculated	Designed to replace panels of experts in the subjective assessment of fabric handle
Tailorability	Fabrics are tested on the SiroFAST instruments for compression, bending, extension and dimensional stability	Instrument results plotted on a control chart to ascertain where problems in tailoring might arise	Information is useful for tailors and worsted finishers
Flammability	A number of laboratory tests are used to measure: ease of ignition, ease of flame spread, heat released, tendency to drip or melt, duration of glow after flame extinguished, smoke or fume generation	The method of reporting test results depends on the particular test method. Different tests are used for curtains, children's nightwear, carpets	Any textile fabric will melt or burn if heated sufficiently. The terms 'flameproof' or 'fire-resistant' are relative terms which can be applied to a fabric to indicate its limited burning properties

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Summary

Fibre assemblies relevant to wool include slivers, tops, yarn and fabrics. Each has a particular level of fibre organisation which enables a bulk property of the assembly to be readily measured. The kinds of measurements relevant to these structures can be grouped as follows:

- Constituent properties – e.g. fibre diameter, fibre length
- Construction – e.g. linear density, twist
- Mechanical tests – e.g. strength, flexibility, bulk (filling capacity)
- Contamination tests – e.g. residual grease, vegetable matter faults, neps, moisture content.

In this topic wool fibre assemblies for yarns, and fabrics. In some cases the rationale for the tests and their methodologies are covered in more detail in other topics. In many cases it is necessary to refer to the relevant IWTO or other international standard for the precise details of a test method.

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Glossary of terms

Abradant	A standard rough-surface cloth used to abrade a specimen in an abrasion resistance tester
Abrasion resistance	The extent to which a textile is able to resist loss of appearance, structure through abrasive wear processes
Bundle	A small number of fibres, assembled in aligned form, usually for tensile testing
Burst strength	The pressure required to rupture a fabric
Capacitance	The property of a capacitor, measuring its ability to store electric charge (ratio of the stored charge / applied voltage)
Capacitor	A pair of parallel metal plates carrying opposite electrical charges so that an electric field can be established in the region between them
Dark fibres (or coloured fibres)	Naturally pigmented, stained or dyed fibres that constitute a visual fault in a sliver, top yarn and ultimately a fabric
Dimensional stability	The ability of a fabric to maintain its original size and shape despite the influences of wear, cleaning or other treatments
Drape	The ability of a fabric to hang in graceful folds, under gravity
Elongation	The amount by which a material is stretched at the point at which it breaks, usually expressed as a percentage of the original length
Evenness	Constant (or nearly constant) linear density along a sliver, top or yarn. A synonym for regularity
Gauge length	The initial distance between the two pairs of jaws in a tensile tester before the stretching of the loaded test specimen begins
Handle	The subjective impression of the characteristics of a fabric formed by manipulating it with the fingers
Linear density (or count)	The mass of sliver, top or yarn, measured on a sample of standard length. The unit is the tex, which is 1 gram per kilometre
Periodicity	A thickness fault in a sliver, top or yarn which is repeated at equally spaced intervals along its length
Pilling	Small accumulations of fibres on the surface of a fabric, formed by a rubbing action
Serviceability	The fitness and suitability of a product for its intended use
Shear	Applying a stress to a fabric in such a manner that tends to change a rectangle into a parallelogram
Snagging	Formation of loops of fibre which are pulled from a fabric when it is in contact with a rough object
Tear strength	Force required to propagate a rip in a fabric
Tensile strength	The force required to stretch a fabric until it breaks
Tensile tester	A device for slowly stretching a yarn, sliver or fabric until it breaks and which is capable of continuously measuring the applied load during the process

Twist	The number of turns per metre (tpm) in a yarn. For singles twist, individual fibres follow a helical path; for folding twist, two or more yarns follow a helical path
Uster spectrogram	A graph produced by the Uster Evenness Tester which indicates periodic faults in a sliver or yarn
Yarn bulk	The volume occupied by a standard mass of yarn when compressed by a light, standard pressure
Yarn elongation (or extension)	The increase in length at the point where a yarn breaks, usually expressed as a percentage of the original (unstretched) length
Yarn strength (or breaking load)	The maximum force a yarn can sustain just before it breaks, measured in kilogram force (kgf) or Newtons (N)