FABRIC DIMENSIONS AND PROPERTIES

FABRIC LENGTH

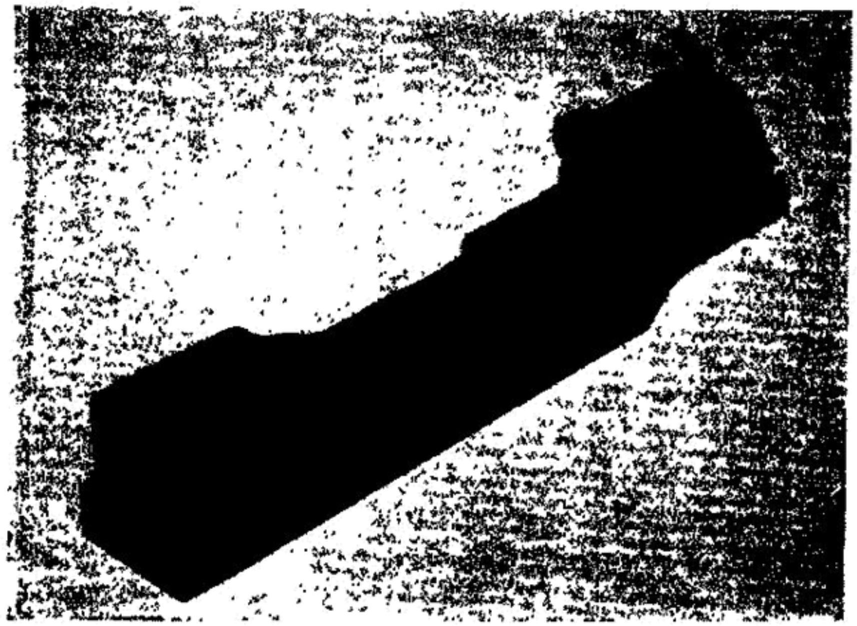
HOW long is a piece of cloth? The answer to this question is influenced by the conditions under which it is measured. During the manufacturing and finishing processes cloth is subjected to various strains. Some of these are recoverable if the fabric is allowed to relax in an open state and is free from restraint. Recovery is often greater when the fabric is immersed in water, a point which will be raised later when shrinkage is discussed.

Measurement of cloth dimensions should be made in a standard testing atmosphere whenever possible, since humidity may affect the results. A table wide enough to accommodate the open cloth width is preferred and with one edge graduated. A trial measurement is made on the cloth before it is allowed to condition. Marks are made on the selvedge at 5 yd intervals throughout the full piece; any fraction of 5 yds at the end is measured to the nearest ½ in. After 24 hr in the testing atmosphere the cloth is measured again. If any change in length is less than 0·25 per cent of the first result, then the second measurement is taken as the correct length. Some fabrics may recover more than 0·25 per cent in the first 24 hr; if this is so, they are left for a further 24 hr and remeasured. This procedure is repeated until the change in length is less than 0·25 per cent and the final measurement taken.

It is not always possible to condition the full piece of cloth. The cloth is therefore measured without conditioning and a correction made by length measurements on a sample. With the cloth in a similar atmosphere to storage conditions, four pairs of marks across the width of the cloth are made, each pair at least 1 yd apart in the warp direction. The distance between each pair is accurately measured, the sample cut out and conditioned for at least 24 hr in a standard atmosphere, and the distances measured again. If the distance shows a change of more than 0·25 per cent, further conditioning time is allowed. The length of the bulk of the cloth is then estimated from the initial length measurement of the full piece and the average change in the distances between the four pairs of marks on the sample.

Length measurement in warehouses and inspection rooms

The checking of fabric length as the cloth moves over an inspection table, plaiting machine, or some other cloth-handling machine has been simplified by the development of accurate measuring devices which are mounted on the machine itself. One example is the 'Trumeter' illustrated in Figure 7.1. Measurement by accurate rollers is carried out, as the speed of the machine and the meter may provide the information in the form of a printed ticket in addition to indicating the length on the counter.



(*By courtesy of Trumeter Ltd*)

Figure 7.1. The 'Trumeter' cloth length measuring machine

FABRIC WIDTH

The width of the fabric, when it is removed from the loom, may not be the same when it finally reaches the customer. The loom state fabric may undergo ordeals by water, beat, pressure, tension, acids, and alkalis. Some processes cause contraction in width (wet treatments) and some may stretch the cloth (stentering). Textile materials possess powers of recovery from imposed strains and when allowed to relax free from tension, contraction may occur.

The choice of cloth width is influenced by a number of factors. Important amongst these is the end-use of the cloth. For example, handkerchief cloth may be woven so that either two gentlemen's or three ladies' handkerchiefs occupy the yarn space in the reed of the loom. Again, bedding for single beds will be woven in narrower looms than those used for weaving for double-bed fabrics. The maker-up of fabrics buys his cloth in widths which allow him to cut out his patterns with a minimum of waste. When the cloth delivered is sub-standard in width, a maker-up may demand a discount from the weaver to off-set the potential increase in waste. It must also be remembered that a proposed change in fabric width affects not only the weaving department. Both the yarn preparation machinery and the finishing plant have to accommodate the change. Progressive manufacturing concerns make a close study of the effects of cloth width on the overall costs of manufacture (see Brunnschweiler, D. *J. Text. Inst.* **50**, P574 (1959)). The development of looms such as the Sulzer enables the manufacturer to weave several widths in one loom simultaneously, using special selvedge devices to split up the cloth into the required widths.

Measurement of fabric width

In the standard method (B.S. Handbook, p. 165) it is recommended that the fabric should be exposed to a standard atmosphere for at least 24 hr before final measurements are taken. Measurements made before and after conditioning will then show whether the change in width, if any, is within the order of accuracy required. On a piece of cloth, ten measurements should be made at points distributed at roughly equal distances throughout the full length of the piece. Where the full length is not used a sample length of not less than 1 yd should be used and its width measured at three places. The mean width and the range in width should be reported.

The accuracy of measurement is indicated in B.S. 1930:1953:

0·1 in. for fabrics 18 in. or more in width.

0·05 in. for fabrics exceeding 4 in. but less than 18 in. in width.

0·02 in. for fabrics 4 in. or less in width.

Points to watch include:

(1) The possibility of wavy selvedges due to weft tension variation or weave effects. Maximum and minimum widths should be recorded and the wavy selvedge reported.

(2) Where the width 'within lists' is required the width between the innermost selvedge threads is measured.

(3) Where only samples are measured the width of the unconditioned bulk is corrected from the measured changes in width of the samples.

Continuous measurement of width

In the methods just described only a small number of width measurements are taken. An apparatus is described by Jiewertz

(*J. Text. Inst.* **45**, T696 (1954)) which has been designed for the continuous measurement of the width of running fabrics. It is based upon a pair of photo-electric cells, one at each selvedge, which scan the edges and detect changes in width. The signals are translated into cloth width and indicated on a meter or recorded on a chart. An accuracy of ± 0·3 cm is claimed.

FABRIC THICKNESS

Engineers use calipers and screw micrometers to measure the thickness of machine parts but the textile technologist handles material which is readily compressed, therefore the instruments he uses differ from those of the engineer. The principle of the measurement of fabric thickness is expressed neatly in B.S. 2544:1954:

> 'Essentially, the determination of the thickness of a compressible material such as a textile fabric consists of the precise measurement of the distance between two plane parallel plates when they are separated by the cloth, a known arbitrary pressure between the plates being applied and maintained. It is convenient to regard one of the plates as the presser foot and the other as the anvil.'

Several points require consideration in the practical application of this principle:

Shape and size of the presser foot. A circular foot is usually used, a common diameter being ⅜ in., but this may differ if desired. The ratio of the foot diameter to the cloth thickness should be not less than 5:1.

Shape and size of the anvil. When a circular anvil is used it should be at least 2 in. greater in diameter than the presser foot. In addition, where the sample is larger than the anvil, it is convenient to surround the anvil with a suitable support, e.g. a smooth plane board.

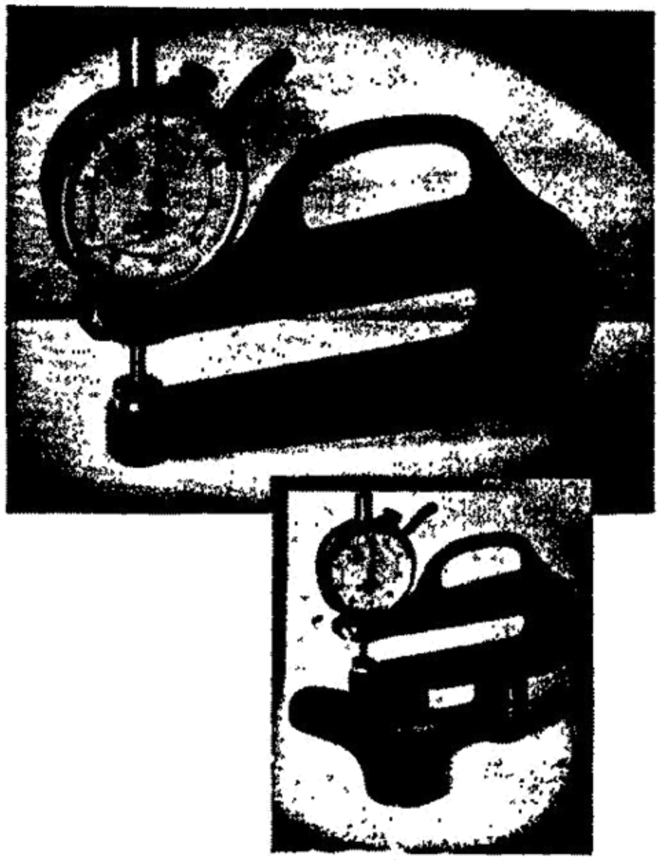
Applied pressure. Preferred pressures are recommended and may be specified, e.g. 0·1 lb/in^2, or 10·0 lb/in^2. Suitable weights may be added to the presser foot to obtain these pressures. In Chapter 10 of the W.I.R.A. handbook *Testing and Control*, two special instruments are described, one for measuring cloth thickness with very small pressures as low as 5 mg/cm^2, and a second which may produce pressures up to 50 lb/in^2.

Velocity of presser foot. The presser foot should be lowered on to the sample slowly at about 2/1,000 in/sec. Precision here is difficult, of course, but common sense will suggest a slow and careful movement.

Time. The thickness is read from the dial of the instrument when the easily visible movement of the pointer has stopped.

Indication of thickness. A clock-type dial gauge is usually built into a thickness tester. It should be rigidly mounted in a suitable frame and, after setting to zero, be capable of measuring to an accuracy of 1 per cent for cloths of 5/1,000 in. or more, and to 0·00005 in. for thinner fabrics.

A thickness tester is illustrated in Figure 7.2.



(By courtesy of James H. Heal & Co. Ltd)

Figure 7.2. Heal's thickness gauge

Test method

The presser foot and anvil should be cleaned by drawing some clean paper between them. After cleaning, the gauge is set to zero and any required weights added to the presser foot column. No special specimen preparation is required except that selvedges and creased areas should be avoided. Where possible, the material is tested in a standard atmosphere after conditioning for 24 hr. At least 10 determinations should be made, either at different places in the piece or on different samples. The mean value is obtained and reported to the nearest 1/10,000 in. or to 1 per cent, whichever is the greater. In the test report, details of the pressure, size of presser foot, and the time should be given.

The Reynolds and Branson thickness tester

The thickness of fabric samples can be measured by this type of instrument under pressures from 5 g/cm² upwards. Figure 7.3(a) shows that the fabric is tested in a vertical plane. The sample is pressed between two circular anvils each having a surface area of 1 cm²; one of them is fitted to a lever mounted on a flat spring which acts as a frictionless bearing. The lever has a recess in which the 5 g pan is suspended. Thus, a pressure of 5 g/cm² is obtained. Other pressures can be readily obtained by adding weights to the pan.

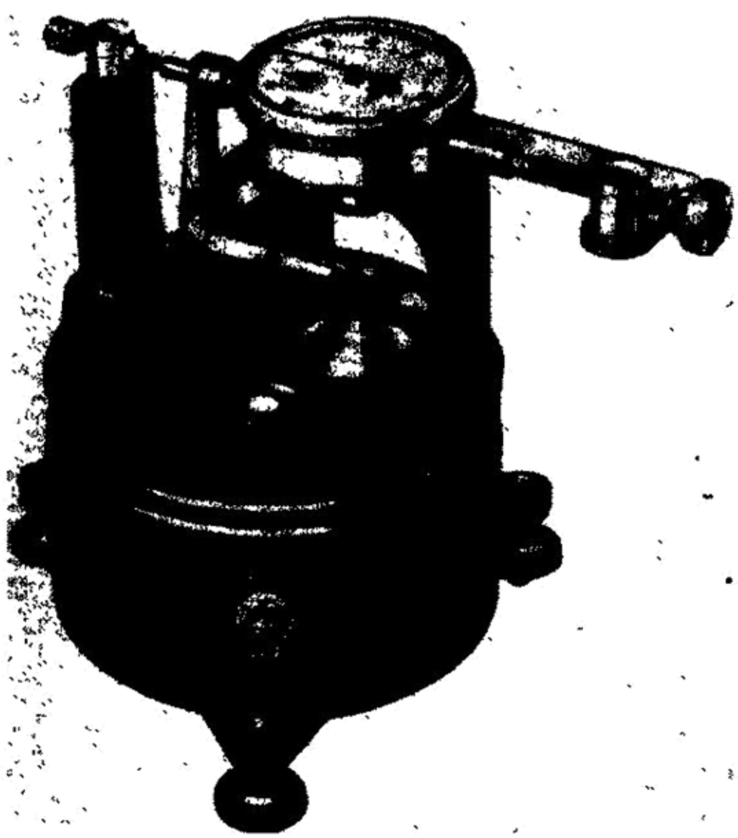


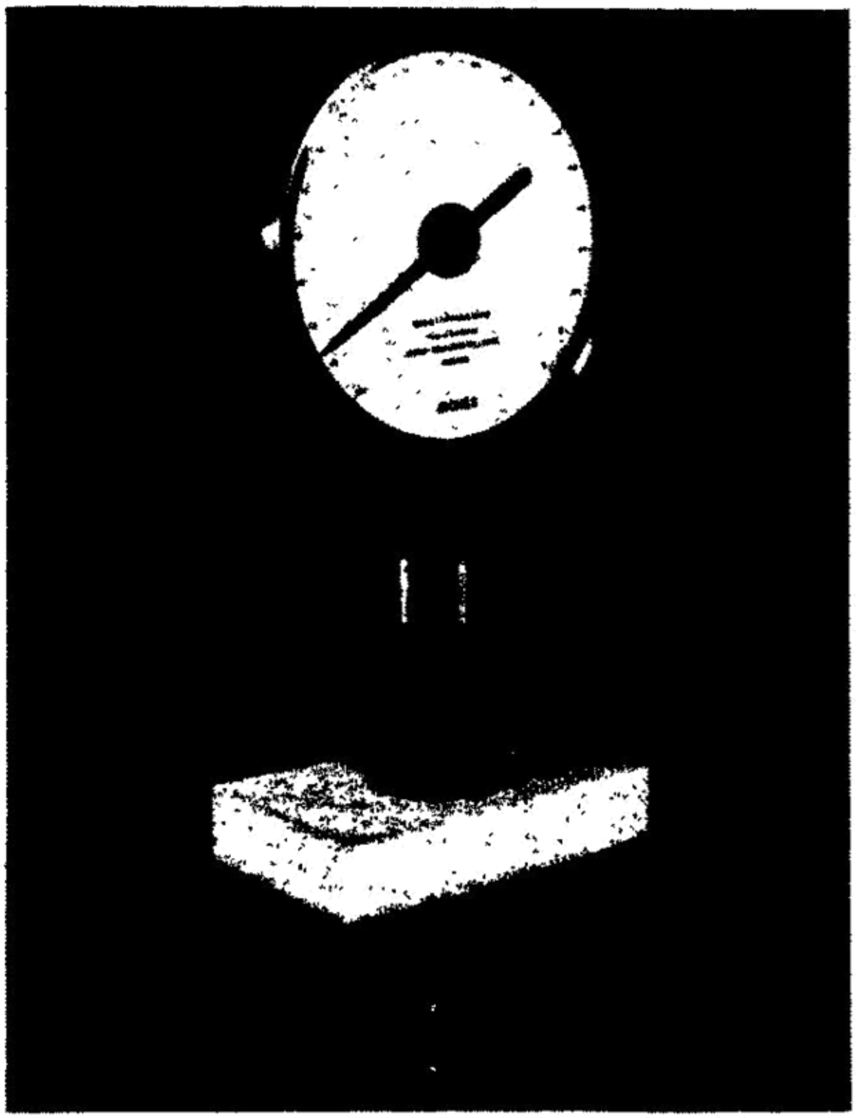
Figure 7.3(a). The Reynolds and Branson cloth thickness tester

The instrument is set level and switched on. At this point an indicator lamp glows dimly. Without the 5 g balance pan on the lever, the contact behind the lever anvil should only just touch the knurled adjusting screw. The pan is replaced and the gauge spindle advanced by means of the large knurled screw until the indicator lamp glows brightly. The pointer is now set to zero by turning the milled dial ring. With a sample of fabric between the anvils the gauge will indicate the thickness at 5 g/cm² pressure, the readings of the gauge being either to 0·001 in. or 0·01 mm.

Testing the thickness of compressible materials

A special instrument for measuring the thickness of felts and other thick materials is described in the B.S. Handbook, p. 177.

Many sheet materials are compressible, for example, carpets, sponge rubber, polyurethane foam and felts. The 'Shirley' thickness gauge, Figure 7.3(b), has been designed to measure, at known pressure, such materials. In the illustration the presser foot has an area of 10 in^2 but the foot is interchangeable with another of 1 in^2. It will be seen that on the shaft of the presser foot there are added weights. These auxiliary weights enable a range of pressures to be used. Further, by loading the presser foot in stages and then unloading it in stages the indicated thickness readings allow study of the compressibility and resilience of the material.



(*By courtesy of the Cotton, Silk and Man-Made Fibres Research Association*)

Figure 7.3(b). The Shirley thickness gauge

The model, with the dial graduated from 0 to 2 in., has a range of pressures from 1/1,000 to 1 lb/in^2 using the large presser foot, and from 1/100 to 10 lb/in^2 using the small foot. Each scale division is 0·005 in. and an estimate to 0·001 in. can be made. An alternative instrument is for metric measurements. In both types the maximum thickness that can be measured can be increased by half as much again, i.e. 3 in. on the inches model, by raising the measuring head.

Use of the results of thickness tests

The information obtained may be used in various ways:

(1) For checking materials against specification.
(2) In the study of other fabric properties such as thermal insulation, resilience, dimensional stability, fabric stiffness, abrasion, etc.
(3) In the study of fabric geometry.

FABRIC WEIGHT PER UNIT AREA AND PER UNIT LENGTH

The weight of a fabric can be described in two ways, either as the 'weight per unit area' or the 'weight per unit length'; the former is self-explanatory but the latter requires a little explanation because the weight of a unit length of fabric will obviously be affected by its width. To a layman, a '16 oz worsted' does not mean very much, but to a person dealing regularly with worsted cloths the description is sufficient to indicate a certain quality of material. For instance, a 20 oz worsted suiting would suggest a close weave material which would make an excellent winter suit, whereas a 16 oz worsted is a lighter material for the warmer weather. In fabric descriptions, the weight per unit length is usually referred to as the 'weight per running yard'. It is necessary, therefore, to know the agreed standard width upon which the weight per running yard is based, e.g. 56 in. for worsted.

Weight per unit area

The method of obtaining this value is implicit in the title; one has merely to weigh a known area and divide the weight by the area. The actual determination is not so straightforward since sampling, marking out, cutting, accuracy of weighing, and moisture content must all be considered. Area measurement and cutting should be to an accuracy of 1 per cent and for an area less than 100 in^2 a cutting die or template is recommended. Weighing should be accurate to 1 part in 500. The effects of moisture content can be accounted for either by conditioning the specimen in the standard atmosphere or by taking the specimen to oven dry weight and adding the official regain.

Some quadrant balances have one scale graduated in ounces per square yard. A template is used to cut the sample and the square of fabric suspended on the hook of the balance. For quick checks this method is useful and for particular purposes may be considered sufficiently accurate.

Weight per unit length

In general, the points to watch are similar to those mentioned above. The minimum length measured should be 18 in.

The B.S. 2471:1954 covers in detail the various procedures for the determination of both fabric weight per unit area and unit length (see B.S. Handbook, p. 167).

Conversion of values

Provided that it is assumed that the effect of selvedge construction is negligible, weight per unit area can be readily converted to weight per unit length, and vice versa.

Let W = weight per square yard,
R = weight per running yard, and
w = fabric width in inches.

then, $W = \dfrac{36R}{w}$ and $R = \dfrac{Ww}{36}$

THREADS PER INCH IN WOVEN FABRIC

In woven fabric the warp yarns are commonly referred to as 'ends' and the number of warp threads per inch width of cloth stated as so many 'ends per inch'. The threads of weft are called 'picks'. A fabric may therefore be described in terms of 'ends and picks'. For example, a cotton poplin may be woven with 144 ends per inch and 76 picks per inch. The warp yarn could be a doubled yarn, say 2/100s, and perhaps the weft, too, may be 2/100s. A short description of this poplin would be 144 × 76, 2/100 × 2/100, and to a person conversant with poplins a good quality would be indicated. The determination of the number of threads per inch may be made in several ways, five of which are given in the Textile Institute Tentative Specification No. 28, 1955. These methods will be found in the B.S. Handbook,* to which the reader should refer for details of procedure. The five methods are listed here and they are followed by a few remarks on points which are sometimes overlooked.

(1) One-inch counting glass—a simple microscope.

*B.S. 2862:1957, *Threads per Inch in Woven Fabric*. B.S. Handbook No. 11, p. 222.

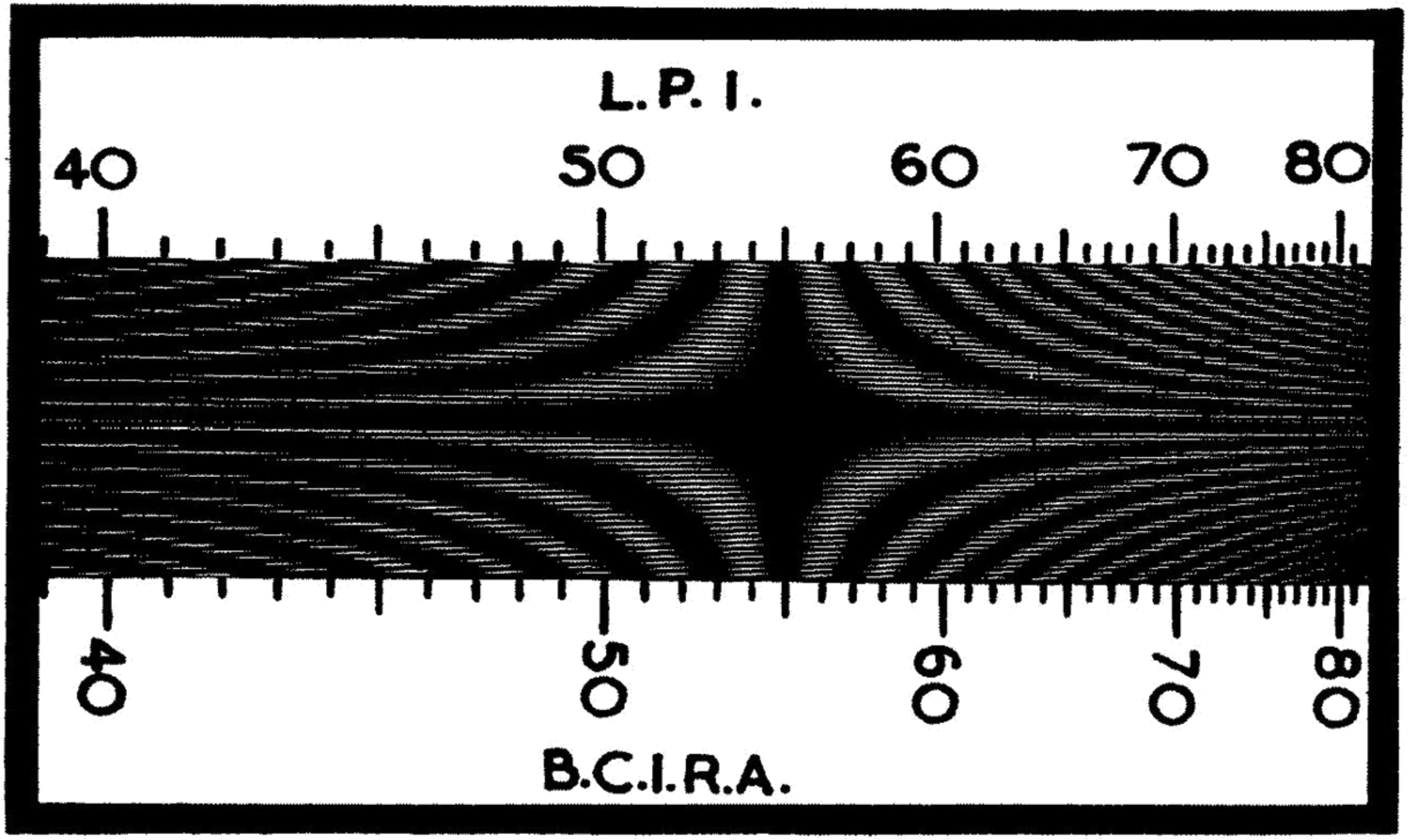


Figure 7.4. The 'Shirley' taper line grating. Threads per inch = 55, indicated by shadow cross. Long side of grating is laid parallel to threads being counted

(2) Traversing thread counter—a travelling microscope fitted with a pointer to aid counting.
(3) Fabric dissection—a known width is unravelled and the threads counted, a useful method where the threads are difficult to distinguish, as in felted threads, or where the structure is complex, e.g. plied fabrics.
(4) Parallel line gratings—a rapid optical method.
(5) Taper line gratings—a development of No. 4 (see Figure 7.4).

The 1 in. counting glass is not recommended when the number of threads per inch is less than 25. In such cases, a 3 in. sample could be unravelled and the threads counted.

A ground glass plate illuminated from below forms a useful surface on which the cloth can be laid when counting threads with a counting glass.

It is sometimes convenient to count the number of repeats of the pattern instead of the individual threads. The threads per inch are then obtained by multiplying the number of threads per repeat by the number of repeats, adding on any fraction of a repeat by counting the remaining threads individually. This method is useful when the number of threads per inch is high.

The regions near the selvedges should be avoided because the spacing of the threads is often a little different than in the body of the cloth.

In the specification it will be noted that specimens should be conditioned for at least 24 hr before testing. This must, of course, be stated in a standard, but in practice the information is often wanted quickly and this refinement is dispensed with.

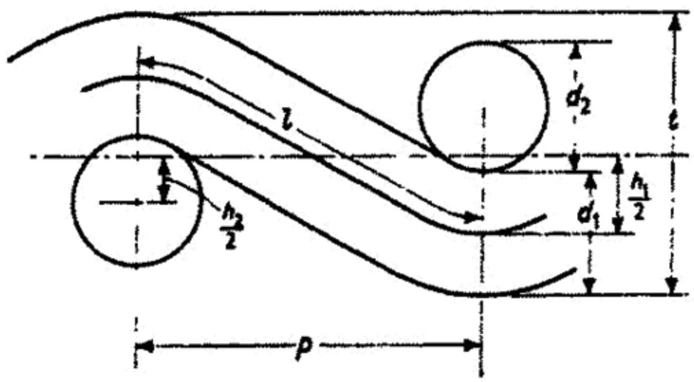
CRIMP OF YARN IN FABRIC

In *The Little Oxford English Dictionary* the first definition of crimp is: noun, 'agent who entraps men for seamen or soldiers'. A second definition is perhaps closer to its textile meaning: verb, 'to press into small folds, corrugate'.

When warp and weft yarns interlace in fabric they follow a wavy or corrugated path. Crimp percentage is a measure of this waviness in yarns. In his paper on cloth geometry, Peirce (*J. Text. Inst.* **28**, T45 (1937)) states that 'crimp, geometrically considered, is the percentage excess of length of the yarn axis over the cloth length'. It is impracticable to measure the length of the yarn axis as it lies in the cloth, therefore a definition is used which bears a close relationship to the methods used in crimp determination.

Crimp (B.S. Handbook, p. 230). 'Percentage crimp is defined as the mean difference between the straightened thread length and the distance between the ends of the thread while in the cloth, expressed as a percentage.'

A term used in the literature of cloth geometry is 'crimp amplitude' and this refers to the extent to which threads are deflected from the central plane of the cloth (see Pollitt, J. *J. Text. Inst.* **40**, P11 (1949)). Figure 7.5 illustrates the geometrical interpretation of crimp and crimp amplitude, using the assumption that the yarns are circular in cross-section and remain so when in the cloth.



$$\textit{Crimp percentage} = \frac{1 - p}{p} \times 100$$

Warp crimp amplitude $= h_1$ } Warp crimp amplitude is the extent to which
Weft crimp amplitude $= h_2$ } threads are deflected from the central plane of the cloth

Figure 7.5. Crimp geometry

Crimp and fabric properties

Warp and weft crimp percentages are two of the eleven structural elements in fabric construction discussed by Peirce. The relationships between the geometry of a cloth structure and its physical behaviour in use are complex and although much pioneer work has been done there are many unresolved problems still to be investigated. The notes which follow are included to give the reader a few examples of the importance of crimp.

Resistance to abrasion. In a paper by Backer and Tanenhaus (*Text. Res. J.* **21**, p. 635 (1951)) it is pointed out that the yarns with high crimp take the brunt of abrasive action. This is because crowns formed as the yarn bends round a transverse thread will protrude from the fabric surface and meet the destructive abrasive agent first. The other set of yarns lying in the centre of the fabric will only play their part in resisting abrasion when the highly crimped threads are nearly worn through.

Shrinkage. The mechanism of the shrinkage of cotton fabrics when washed is explained by Collins (*J. Text. Inst.* **30**, P46 (1939)). When the yarns are wet they swell, and consequently a thread, say a warp thread, has a longer bending path to take round a swollen weft thread. The warp thread must either increase in length or, alternatively, the weft threads must move closer together. An increase in warp length requires the application of tension and therefore when wben tension is absent as, for example, wben the fabric is in a washing machine, equilibrium conditions will be attained by the weft threads moving closer together. Collins states that 'the largest amount of shrinkage is that represented by increase of crimp; yarn shrinkage takes a second place, being generally much less than increase in crimp, while fibre shrinkage is almost negligible'. (See Figure 7.41.)

Since shrinkage is mainly due to yarn swelling and the resulting crimp increase, mechanical means of controlled pre-shrinking have been developed, e.g. the Sanforizing and Rigmel processes (see Marsh, J. T. *Introduction to Textile Finishing*, Chapter 9).

Fabric behaviour during tensile testing. When a test strip of fabric is extended in one direction crimp is removed and the threads straigbten out. Tbis causes the threads at rigbt angles to the loading direction to be crimped further. 'Crimp interchange' is said to take place. The specimen loses its original rectangular shape and 'waisting' occurs, i.e. the middle region of the strip contracts. If the testing machine is autographic the load–extension curve will show relatively bigh extension per unit increase in load in the early stages of the test, most of which will be due to the removal of crimp. Figure 8.48 illustrates this point.

Faults in fabric. Variation in crimp can give rise to faults in fabrics, e.g. reduction in strength, 'bright' picks and diamond barring in rayons, stripes in yarn dyed cloths, and so on. The cause of crimp variation is often loss of control over the tensions employed during yarn preparation and weaving.

Fabric design. Control of crimp percentage is necessary when a fabric is designed to give a desired degree of extensibility. Again, some fabrics require control of crimp in the finishing processes to give the correct crimp balance between warp and weft so that the finished appearance is satisfactory. The tensions applied must therefore be carefully controlled.

Fabric costing. Since crimp is related to length it follows that the amount of yarn required to produce a given length of cloth is affected by the crimp percentages of warp and weft. Knowledge of values is useful in calculating the cost and the yarn requirements.

From the notes above it will be appreciated that the measurement of crimp can be of service in fabric analysis, fabric research and design, process control, and in the economics of fabric production.

The measurement of crimp percentage

From the definition of crimp two values must be known, the cloth length from which the yarn is removed and the straightened length of the thread. In order to straighten the thread, tension must be applied, just sufficient to remove all the kinks without stretching the yarn. In practice, it is seldom possible to remove all the crimp before the yarn itself begins to stretch. The standardised tensions recommended in the B.S. Handbook p. 234, are given in Table 7.1.

One quick non-standard check on crimp can be made when the only instruments to hand are a pair of scissors and a rule. Two cuts are made in the cloth sample and the distance between them noted. Threads are removed and placed over the rule, one end held by a forefinger and the thread smoothed along with the other forefinger, and the straightened length observed. The thread length will be only a few inches and the accuracy of the method is not great.

Table 7.1

Yarn	*Count*	*Tension (g)*
Cotton	Finer than 7 tex	0·75 tex
	Coarser than 7 tex	0·20 tex + 4
Woollen and Worsted	15 to 60 tex	0·20 tex + 4
	60 to 300 tex	0·07 tex + 12
All man-made continuous-filament yarns	All counts	Tex/2

Where a higher degree of accuracy is necessary special crimp testers are used. Five groups of threads are selected for test, two warp way and three weft way groups. The mean crimp percentage is calculated warp way and weft way. Rectangular strips are carefully marked on the cloth and each strip cut into the form of a flap as in Figure 7.6. From each strip ten threads will be removed. Removal of threads is as follows: the central part of the first thread is separated from the flap fringe by means of a dissecting needle, but the two extreme ends are left secured. One end is then removed and placed in the grip of the tester, and the other end is removed and placed in the second grip. In this way the thread is transferred from the cloth to the crimp tester without loss of twist and with a minimum of handling.

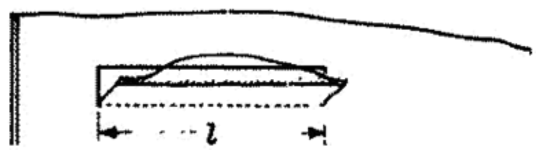
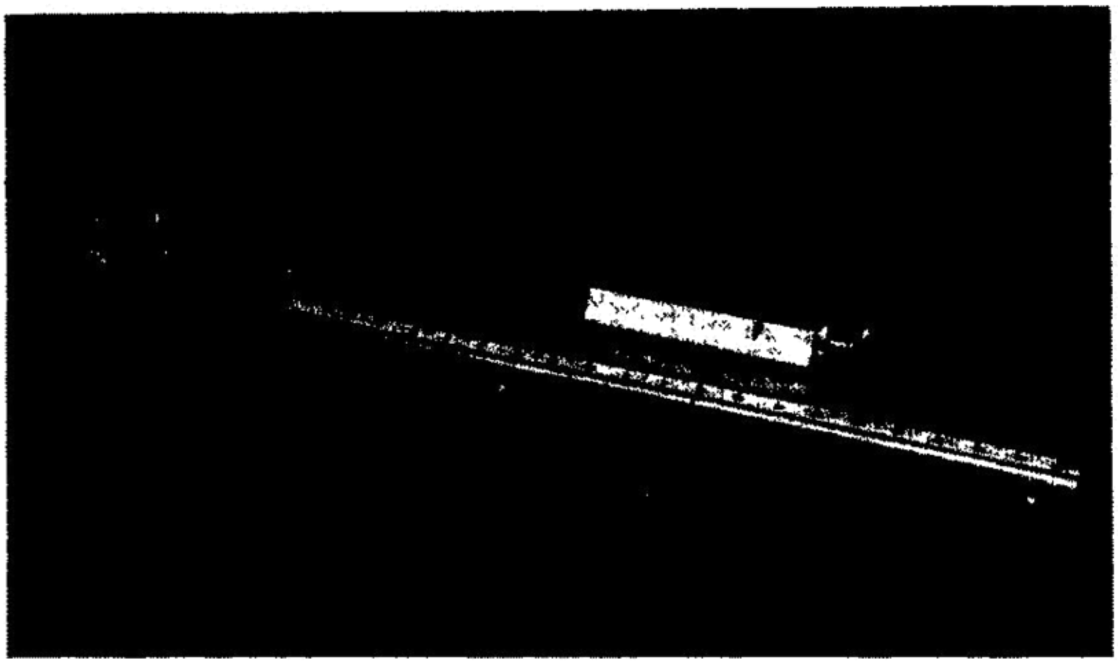


Figure 7.6. Preparation of specimens for crimp testing

Several crimp testers are available, three of which were designed and developed by British research associations, B.C.I.R.A., W.I.R.A., and B.R.R.A. The Shirley and W.I.R.A. models are primarily for spun yarns, whereas the B.R.R.A. model has been designed to meet the demand for greater accuracy when very small differences in crimp in continuous-filament fabrics must be measured, differences which in spun yarns would make negligible difference to the cloth appearance, but with rayons may be the cause of a fabric defect such as warp stripiness.

The W.I.R.A. crimp meter. Test lengths up to 16 in. can be handled in this instrument. In Figure 7.7, G_1 is a grip on the vertical arm of the pivoted beam B. When the beam is horizontal it just touches a contact and the torch bulb T lights up. On the long arm of the beam a sliding weight W can be set by means of a scale marked on the beam to the recommended tension in grams. The other grip G_2 is carried on a plate which is in turn mounted on a screwed rod in the assembly A. When G_2 is at its extreme position to the left a pointer is at 'zero' on the scale S. By turning the handwheel H, G_2 has a maximum movement to the right of 5 in.

To make a test the assembly A is set to a scale K on the base of the tester to a length equal to the strip length, the pointer of grip G_2 being at zero. The weight W is set to the required tension. One end of the thread is then clamped in grip G_1 with its extreme tip in line with a datum line marked in the transparent upper face of the grip. The other end is then clamped in grip G_2 in a similar manner. At this stage the thread will usually sag and the beam will be tilted. The handwbeel H is turned, grip G_2 moves to the right, the thread straightens up, and eventually the beam touches the contact. As soon as the bulb lights, the movement of G_2 is noted. This value is the increase in length due to the crimp removal. The results from the twenty warp way threads and the thirty weft way threads are recorded and the mean warp and weft crimp percentages calculated.



(By courtesy of W.I.R.A.)

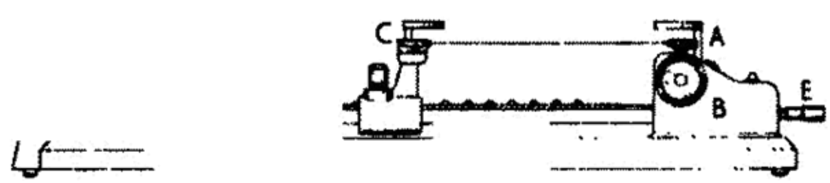
Figure 7.7. The W.I.R.A. crimp tester

The Manra crimp tester. This description of the crimp tester designed by B.R.R.A. is based on the maker's leaflet (Louis Newmark Ltd).

The Manra crimp tester was specially designed to facilitate tbe measurement of very small differences in the crimp of yarns taken from continuous-filament fabrics. By means of this instrument, determination of crimp can be made within an accuracy of less than 0·1 per cent. The instrument is mounted on a rigid casting and is precision-built to eliminate errors due to vibration, backlash, etc. A pivoted grip A, Figure 7.8, is tensioned by a spiral spring, the tension indicates the tension necessary to bring the arm to its zero position. The grip C is mounted on a carriage carried by rail D in such a way that it can be set at any one of a number of fixed distances from grip A. The upper face of each grip is of transparent plastic on which is engraved a fine line so that the ends of the length of yarn under test can be accurately located in the grips. The rail D carrying the grip C can be moved horizontally through a distance of 25 mm by means of the micrometer E which is graduated 0·01 mm.

The micrometer is set to zero and the grip C is set at a convenient position on rail D. Knob B is set to give the approriate tension for the yarn to be tested. A thread is removed from a strip of fabric whose length is the same as the selected distance between the grips, care being taken to avoid loss of twist. The thread is inserted into the the grips so that its ends coincide with the datum lines. The distance between the grips is increased by turning the micrometer until the grip A reaches its zero position, indicated by the extinction of an indicator light. The increase in the length of the thread due to the removal of crimp is indicated directly on the micrometer scale.

(a) *(By courtesy of Newmark Ltd)*



(b)

Figure 7.8. The Manra crimp tester

Other methods. The reader is referred to Garner, *Textile Laboratory Manual*, p. 177, and to Skinkle, *Textile Testing*, p. 80, for descriptions of the determination of crimp by other methods, especially from examination of the load–extension curve of the crimped thread.

In the earlier sections of this chapter fabric dimensions have been discussed individually, more or less in isolation. However, a few moments' reflection will reveal that a fabric is a structure characterised by the interdependence of most of its dimensional values. In any discussion on fabric structure and fabric geometry, Peirce's classical paper, 'The Geometry of Cloth Structure' in *J. Text. Inst.* March 1937, will be referred to. His paper has formed a basis upon which a number of other workers have developed the subject. An excellent summary and comment on cloth geometry is given by Pollitt (*J. Text. Inst.* **40**, P11 (1949)). The notes which follow are largely derived from Peirce and Pollitt's work. It is not intended to deal with cloth structure as a subject in itself but to illustrate how the fabric dimensions are inter-related, more particularly in plain weave cloth.

*Yarn count, diameter, and cloth cover**

The yarn diameter of a cotton yarn count N has been shown to be

$$d = \frac{1}{28\sqrt{N}}$$

where d is the diameter in inches.

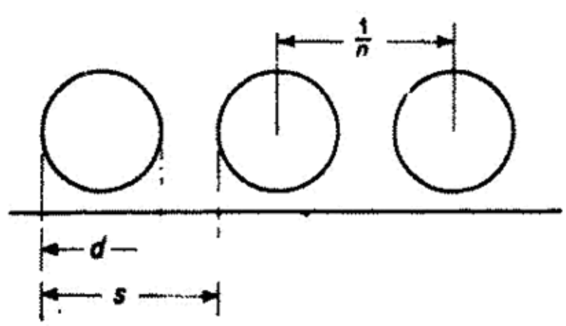


Figure 7.9. Cover factor

Figure 7.9 represents the cross-sections of threads in a fabric. If the number of threads per inch is n, then the distance, s, from one thread to the next will be $1/n$ in. The ratio d/s will therefore represent the fraction of the spacing, s, covered by the projection from a thread. This fraction may be expressed in terms of yarn count and ends per inch.

* See also
Morton, T. H. 'A Direct Reading Cover Photometer.' *J. Text. Inst.* **53**, T22 (1962).

Thus,

$$s \qquad 28\sqrt{N} \times \frac{n}{1} = \qquad 28\sqrt{N}$$

For convenience, this last formula is multiplied by 28 to give a value known as the *cover factor*. Hence,

$$\text{Cover factor } K = \frac{\text{Threads per inch}}{\sqrt{(\text{Counts})}} = \frac{n}{\sqrt{N}}$$

If all the threads just touched, the cover factor would be 28. However, since space between the threads must be left to allow the transverse threads to interlace, a cover factor of 28 is theoretically impossible. This theory assumes, however, that the threads remain circular in cross-section, but as threads can, in practice, be compressed and distorted, cover factors even in excess of 28 can be achieved. Figure 7.10 shows a square plain weave structure, i.e. a structure with warp and weft counts equal and ends and picks per inch equal. In this simple case the fraction d/s is $1/\sqrt{3}$, giving a maximum cover factor of 16·2 for both warp and weft.

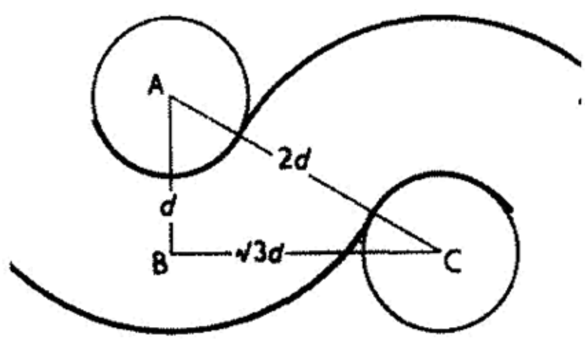


Figure 7.10. Square plain cloth structure

Cover factors are calculated for warp and weft, therefore pairs of values can be quoted in descriptions of fabric in much the same way as pairs of counts or pairs of threads per inch. The chief value of cover factors comes from their continued use to establish familiarity with different values and pairs of values as represented by different types of cloth. Thus, for open muslin 5·4 × 5·4 might be quoted, 8 × 8 for voile, 16 × 16 for canvas, 22 × 10 for a poplin, and so on. For an opaque, soft, and inexpensive cloth 11 × 10 could be chosen, and for a well covered domestic cloth 13 × 12. At higher values the fabric becomes stiffer and drapes less easily.