

Methods of test for textiles (other than those methods already published as British Standards)

Foreword

This Published Document has been prepared under the direction of the Textiles and Clothing Standards Policy Committee.

The 1974 edition of BS Handbook No. 11 “*Methods of test for textiles*” included many methods that for a variety of reasons had not been developed as British Standard tests. Several of these recommended methods have been upgraded to British Standard status (details of these and other methods of test can be found in the BSI Catalogue) but these are not included in this Published Document. The remainder, except for a few methods that are no longer thought to be in use, have been included in this Published Document. These methods therefore do not carry the status of a British Standard, but have been published in this form as a result of requests that these methods be retained in some form.

The methods included in this Published Document have not been revised technically. However, the opportunity has been taken to delete figures showing proprietary test equipment that may now no longer be available and to revise the terminology.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 66, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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1 Scope

This Published Document describes miscellaneous methods of test for textiles.

It does not include any British Standard methods of test for textiles.

Notes on the identification of warp and weft directions are given in Appendix A.

NOTE The titles of the publications referred to in this Published Document are listed on the inside back cover.

2 Methods of test for raw silk

2.1 Winding test

2.1.1 Principle. Raw silk threads are wound for a set period and the number of breaks determined along with the feasibility of skeins for the winding operation.

2.1.2 Apparatus

2.1.2.1 Winding frame, capable of being adjusted to a winding speed of 110, 140 or 165 m/min and equipped to drive the bobbins from both ends and to run smoothly at a uniform angular speed.

2.1.2.2 Swifts, automatic, self-centring, pin-hub swifts, each with a mass of about 530 g.

2.1.2.3 Bobbins, smooth and well balanced so as to give regular tension and uniform angular speed, with the following dimensions:

- | | |
|-------------------------|--------|
| a) diameter of head | 60 mm; |
| b) diameter of barrel | 38 mm; |
| c) length between heads | 85 mm; |
| d) mass | 105 g. |

2.1.3 Sample. The sample for the test shall be 40 skeins out of the 50 skeins in the case of a lot consisting of skeins of approximately 70 g mass each, and 20 skeins out of the 25 skeins in the case of a lot consisting of skeins of approximately 140 g mass each.

2.1.4 Procedure

2.1.4.1 General. During the winding test, maintain the room in which the test is conducted at as near to the standard temperate atmosphere for testing textiles as possible (see BS 1051).

Wind one half of the sample skeins to be used from the outer surface of the skeins, and the other half from the inner surface of the skeins. Take care when putting the sample skeins on the swifts to ensure that each skein is in good condition.

2.1.4.2 Breaks counting. Continue the winding for a certain period (a preliminary winding operation is admitted only for the winding from the inner surface). Count and record the breaks occurring during a specified period. Determine the average winding speed, the breaks counting period and the time of the preliminary winding operation, by the size under test as given in Table 1.

2.1.4.3 Skein-finish inspection. Throughout the winding inspect the skeins for the presence of the following defects:

- a) hard gum spots;
- b) gummed threads;
- c) irregular traverse;
- d) partial lack of traverse;
- e) improper marking of the thread end;
- f) improper skein-lacing;
- g) slackened threads;
- h) pulled threads;
- i) entangled threads;
- j) doubled skeins;
- k) threads drooping from the swift;
- l) fine passages;
- m) involved wastes;
- n) double ends;
- o) others.

Table 1 — Information on breaks counting

Size under test		Average speed	Breaks counting period				Preliminary winding
			70 g skein		140 g skein		Only inner
			Outer	Inner	Outer	Inner	
dtex	denier	m/min	min	min	min	min	min
13 or finer	12 or finer	110	70	60	130	120	10
14 to 20	13 to 18	140	70	60	130	120	10
21 to 36	19 to 33	165	70	60	130	120	10
37 to 77	34 to 69	165	35	30	65	60	5
78 or coarser	70 or coarser	165	25	20	45	40	5

Observe the feasibility of the sample skeins for the winding operation during the whole period of winding from the beginning of putting the skeins on the swifts, and determine any inconveniences affecting the winding efficiency as follows:

- 1) inconvenience in spreading skein over the swift; hard or slight;
- 2) inconvenience in finding the right end to continue the winding; hard or slight;

NOTE "Hard" means that, in order to remove the inconvenience, it is necessary to strip off threads from the skein in a layer. "Slight" means that, in order to remove the inconvenience, a mending is required but no stripping off of threads.

- 3) continued breaking on account of gum spots: in order to remove the inconvenience it is necessary to soften the gum spots to strip off threads;
- 4) continued breaking on account of the defects other than gum spots: in order to remove the inconvenience it is necessary to strip off threads from the skein in a layer;
- 5) removal of double ends: there exist double ends, 3 m in length or longer;
- 6) removal of involved wastes: there exist involved wastes, or double ends less than 3 m in length.

Soften the gum spots which cause a continued breaking of raw silk threads by grasping the skein firmly in both hands about 10 cm apart, or by holding the skein at both ends of its width with the gum spot between the hands; then twist it one half turn while it is stretched taut and gently rub it, or tear off the threads piece by piece by means of the tips of fingers of the right hand while the skein is fixed at one side by the left hand, until the gum spot becomes loose and open. Take care not to damage the thread. Then continue the winding operation of the skein mended in this way.

2.1.5 Expression of results

2.1.5.1 General. The results of the winding test shall be recorded as in **2.1.5.2** or **2.1.5.3**.

2.1.5.2 Breaks counting. The record shall show the number of skeins belonging to each number of breaks by a table of frequency distribution and the total number of breaks occurring in 40 sample skeins in the case of approximately 70 g mass each and in 20 sample skeins in the case of approximately 140 g mass each during the specified period.

2.1.5.3 Skein-finish inspection. The total penalty shall be calculated using the following penalty table on the basis of the inspection, and the result of skein-finish inspection shall be indicated by "good", "fair" or "poor" according to the table.

Inconvenience		Penalty
Inconvenience in spreading skein over the swift:	hard	3.0
	slight	0.5
Inconvenience in finding the right end to continue the winding:	hard	3.0
	slight	0.5
Continued breaking on account of gum spots		2.0
Continued breaking on account of defects other than gum spots		3.0
Removal of double ends		3.0
Removal of involved wastes		0.5

Total penalty	Indication
0	Good
0.5 to 10.0	Fair
Above 10.0	Poor

If the result is indicated as “poor”, the inconvenience suffered shall be mentioned together with the degree and frequency in the test certificate.

The double ends shall, even if the result indication is “fair”, be mentioned in the test certificate when they are 500 m or more in length, or two or more in number, or three or more in ply.

2.2 Size uniformity

2.2.1 Apparatus

2.2.1.1 Sizing reel. The measuring machine for making the sizing skeins has a reel 1.125 m in circumference (400 revolutions equal to 450 m) which revolves at a uniform velocity of 300 r/min and is provided with a dial showing the number of revolutions and an automatic stop motion to stop the reel immediately when the skein is complete, or if the thread should break.

2.2.1.2 Balance, having a sensitivity of 5 mg and a capacity of 50 g to determine the total mass of the sizing skeins.

2.2.1.3 Scale, of the quadrant or other suitable type, having the following capacity and sensitivity for determining the mass of the individual sizing skeins.

Capacity	Sensitivity	
	dtex	denier
40	0.28	0.25
80	0.56	0.5
160	1.1	1.0
400	2.8	2.5

2.2.2 Number and size of test specimens. If the thread under test is 35 dtex (33 denier) or finer, test 200 specimen skeins, each of 450 m in length. If the thread under test is 36 dtex (34 denier) or coarser, test 400 specimen skeins, each of 112.5 m in length.

2.2.3 Procedure. Divide the sizing skeins into 10 groups. Determine the mass of each skein of a group separately on the scale and each group of skeins in the balance. The number of skeins in a group and the graduation of the scale of the balance is determined by the size of thread under test, as given in Table 2.

If the sum of the masses of the individual skeins in a group differs from the group mass by more than the difference specified in Table 2, redetermine the masses.

2.2.4 Calculation and expression of results. Indicate the number of skeins of each decitex or denier using a frequency distribution table. Calculate the standard deviation using the formula:

$$s = \sqrt{\left\{ \frac{\sum_1^n f_i (t_i - M)^2}{N} \right\}}$$

where

N is the number of skeins;

M is the arithmetic mean of the sizes of N skeins;

$t_1, t_2, t_3, \dots, t_i \dots t_n$ are the sizes of the individual skeins;

$f_1, f_2, f_3, \dots, f_i \dots f_n$ are their respective frequencies.

Calculate and express the results to two decimal places.

2.3 Maximum deviation test

2.3.1 Apparatus. The apparatus is as given in 2.2.1.

2.3.2 Number and size of test specimens. The number and size of specimens are as given in 2.2.2.

2.3.3 Procedure. Follow the procedure given in 2.2.3.

2.3.4 Calculation and expression of results. If the thread under test is 35 dtex (33 denier) or finer, calculate the difference between the average size and the following:

- a) the average of four coarsest size specimens;
- b) the average of four finest size specimens.

If the thread under test is 36 dtex (34 denier) or coarser, calculate the difference between the average size and the following:

- c) the average of eight coarsest size specimens;
- d) the average of eight finest size specimens.

In either case, take the larger of the two differences as representing maximum deviation and express this to one decimal place.

2.4 Average size test

2.4.1 Apparatus

2.4.1.1 Conditioning oven, with forced ventilation and positive valve control which is capable of drying the specimen skeins at 140 °C. It is equipped with a balance so arranged as to allow the mass of the skeins to be determined while they are suspended within the drying chamber, with an accuracy of ± 0.01 g. The skein holder is of a type which ensures free access of the dry air to all skeins.

2.4.1.2 Sizing reel. See 2.2.1.

2.4.2 Procedure

NOTE See 2.2.3.

Place the 200 skeins in the conditioning oven and dry them to constant mass as determined by two successive weighings at 5 min intervals. Carry out the first weighing at the end of the first 10 min of drying. Take the second weighing as the dry mass provided the loss between the first and second does not exceed 0.25 % of the total first dry mass. If the loss between the first and second weighings exceeds 0.25 %, weigh the skeins at 5 min intervals until the loss between two successive weighings is within 0.25 %.

2.4.3 Expression of results. Calculate the conditioned average size of all the sizing skeins and express in decitex or denier, to two decimal places.

2.5 Cohesion test

2.5.1 Principle. The degree of agglutination of cocoon filaments forming a silk thread is determined.

Table 2 — Mass determination of skeins (raw silk)

Size		Number of skeins in a group	Graduation of scale for mass determination				dtex/denier difference	
			One skein		Group			
dtex	denier		dtex	denier	dtex	denier	dtex	denier
35 or finer	33 or finer	20	0.56	0.5	0.56	0.5	1.7	1.5
36 to 55	34 to 49	40	1.1	1.0	2.2	2.0	4.4	4.0
56 to 109	50 to 99	40	2.2	2.0	2.2	2.0	9.0	8.0
110 or coarser	100 or coarser	40	5.6	5.0	2.2	2.0	21.0	19.0

2.5.2 Apparatus

2.5.2.1 Cohesion tester, consisting of a framework on which a continuous thread of raw silk is wound zigzag between 20 hooks, 10 on each side of the frame, under constant and uniform tension in such a way that the thread can be subjected to a friction action at 20 different places simultaneously and the number of strokes can be recorded automatically. The total load to be applied for tension is 180 g. The maximum rate of friction is 140 strokes per minute.

2.5.3 Number and preparation of test specimens. Test 20 specimens of thread, ensuring that these are free from any defect of cleanness or pronounced evenness in the portions to be tested.

2.5.4 Atmosphere for testing. Carry out the test in the standard temperate atmosphere for testing textiles as defined in BS 1051.

2.5.5 Procedure. Mount the thread on the tester and set the machine in operation. Stop the machine at intervals of 10 strokes and inspect the thread closely for open places, until 10 different open places each of 6 mm or more in length are observed. Record the total number of strokes which have been applied to the thread.

2.5.6 Calculation and expression of results. Using the records of the tests on 20 specimens calculate the average number of strokes applied to each and express the result as an integer.

3 Methods of test for doupion raw silk

3.1 Winding test

3.1.1 Principle. Doupion raw silk threads are wound for a set period and the number of threads is determined.

3.1.2 Apparatus. The apparatus is as given in 2.1.2.

3.1.3 Number of test specimens. Test 20 skeins.

3.1.4 Procedure. Wind 10 sample skeins from the outer surface and an additional 10 skeins from the inner surface of the skeins, at an average winding speed of 110 m/min.

The time of winding should be 30 min in 89 dtex (79 denier) or finer, 20 min in 90 dtex to 176 dtex (80 to 159 denier) and 10 min in 177 dtex (160 denier) or coarser, after a preliminary winding operation of 5 min.

3.1.5 Expression of results. Record the total number of breaks and stops without breakage counted for each skein, using a table of frequency distribution, and the total number of breaks and stops without breakage for the 20 skeins during the period of winding.

3.2 Size uniformity

3.2.1 Apparatus. The apparatus is as given in 2.2.1¹⁾ provided that the balance for determining the total mass of the sizing skeins has the capacity and sensitivity given below:

Capacity	Sensitivity
g	mg
100	5
1 000	50

3.2.2 Number and size of test specimens. Test a total of 80 sizing skeins out of 20 sample skeins, taking four sizing skeins of 225 m each from each sample skein (a total length of 18 000 m).

3.2.3 Procedure. Divide the total sizing skeins into four groups of 20 sizing skeins each. Determine the mass of each individual sizing skein of a group separately on a quadrant scale, and then obtain the mass of each group of skeins as a whole by an analytical balance. The graduation of the scale for determining the mass of each individual skein shall be as shown in Table 3 and that for a group of skeins shall be 1 dtex or 1 denier.

If the sum of the masses of the individual skeins of a group should differ from the mass of the group of skeins as a whole by more than the difference as shown in Table 3, redetermine the mass of the individual skeins and the group of skeins as a whole.

Table 3 — Mass determination of skeins (doupion raw silk)

Graduation of scale for mass determination	dtex or denier difference		Size	
	dtex	denier	dtex	denier
1	3	3	36 or finer	33 or finer
2	7	6	37 to 109	34 to 99
5	16	14	110 to 219	100 to 199
10	30	27	220 or coarser	200 or coarser

¹⁾ The apparatus should be capable of ensuring the accurate measurement of 225 m lengths without the threads being superimposed.

3.2.4 Calculation and expression of results. Indicate the number of skeins of each decitex or denier using a frequency distribution table.

The size uniformity range can be obtained by the following formula:

$$R = \frac{C - F}{M} \times 100$$

where

R is the size uniformity range;

C is the average size of the five coarsest sizes;

F is the average size of the five finest sizes;

M is the average size of the total sizing skeins.

Express the result of the size uniformity range test as an integer.

3.3 Average size test

3.3.1 Apparatus. The apparatus is as given in 2.4.1.

3.3.2 Number and size of test specimens. The provisions are as given in 3.2.2.

3.3.3 Procedure. After completing the size uniformity range test described in 3.2, carry out the procedure as described in 2.4.2 using the total sizing skeins.

3.3.4 Expression of results. Express the average size by the conditioned average size of the total sizing skeins, recorded in decitex or denier, as an integer.

4 Determination of nep content of card web (cotton system)

4.1 Introduction

Small fibre entanglements with a well defined and comparatively dense central core known as neps are a detrimental feature of processed cotton and man-made staple fibres, and the assessment of their frequency of occurrence in card webs is often necessary for purposes of quality control.

NOTE For cotton, a nep may consist solely of fibres, or of fibres attached to a fragment of seed coat; pieces of seed without attached fibres are not neps.

The counting of neps presents several practical difficulties associated with their somewhat nebulous structure. Particularly in card webs, about half the specks or entanglements observed are indubitably neps; the remainder require close inspection and more critical judgment to decide whether they should be classified as nep. Limitation of the part of the card web under examination at a given instant to a small area enables judgment to be made more critically and with less fatigue than if many neps in a large area were examined together.

Constancy of judgment is also maintained better if, instead of the actual number of neps being counted, each area is classed as “with nep” or “without nep” and the nep frequency calculated subsequently from the proportions of the two classes by an appropriate mathematical transformation. This procedure reduces the number of occasions when a decision is required on a doubtful nep, because such a classification is necessary only for those areas containing a single doubtful nep in isolation.

This method of assessment of nep content was developed essentially for cotton card webs and has been used satisfactorily in many surveys of carding performance. It can be applied also to webs of man-made staple fibres, alone or in mixtures with cotton, processed on the cotton system. The main disadvantage of this method is that recognition of neps is partly subjective. However, its adoption has been found to improve markedly the accuracy of nep counts made by the same observer over a period and to reduce differences between the test levels of different observers working in association with each other.

4.2 Principle

Specimens of web are extracted on flat supports and covered with templates containing a number of small holes or cells of equal cross-sectional area. For each specimen a count is made of the number of cells containing nep. The average number of cells with nep per template is converted into neps per unit area of web on the assumption, which holds closely in practice, that nep distribution is of the Poisson type.

4.3 Apparatus

4.3.1 *Set of templates and set of rigid specimen supports*, of the same superficial dimensions. Each template consists of a rigid, fairly thin, rectangular sheet containing a suitable number of small holes or cells of equal cross-sectional area. It is convenient to have circular holes spaced closely together in rows. The templates should be black. Black is generally a suitable colour for the supports but with brightly dyed fibres a contrasting colour may be found preferable. Difficulties in counting neps are reduced by having holes of circular shape. Practical considerations of specimen removal generally limit the number of holes per template to about 20 to 40; hence the overall superficial dimensions of a template should not be markedly in excess of 150 mm × 300 mm. When making counts, it is desirable that few, if any, of the templates observed should have all the cells containing nep; counts are generally made satisfactorily if the average number of cells with nep per template is not greatly in excess of half the total number of cells per template. If the nep density is much higher, the numbers of cells with nep per template may be reduced to a lower level by reducing the cell diameter. It is commonly found that cells of about 600 mm² in area are suitable for use in making counts on most samples of cotton web.

4.3.2 *Smooth, rigid, thin stick or strip*, about 300 mm long.

4.3.3 *Examining bench*, with good general illumination.

4.4 Test specimens

4.4.1 Preparation

4.4.1.1 Take test specimens generally without stopping the card and without breaking the sliver. Take the stick in one hand and a support in the other. Break part of the web with the stick, place the support underneath an undamaged portion of the web and lift up, making the web up as the sample is removed. Place a template on the support to preserve the specimen extracted. Take care to avoid stretching or folding the web, to make correction for variation in mass of web on the support unnecessary.

4.4.1.2 Take specimens of web from each side and from the middle of each card; the total number of such sets of three test specimens depends upon the accuracy required. For most purposes 25 to 50 templates are necessary for the collection of an adequate test sample in order to permit counts to be made on a minimum of 1 000 cells. For example, when following the procedure of 4.6.2 with a test sample of web mounted under 36 templates each of 34 holes, i.e. total cells 1 224, random sampling variation leads to a standard error of not less than 5 % in the estimate of the mean value of neps per cm² for material containing about 35 neps/cm². The method of selecting the various test specimens to form a representative test sample depends upon the purpose and nature of the test. For example, when comparing two cards, sets of three specimens might be selected from both cards at equal intervals throughout the stripping cycle, and this procedure repeated several times at equal intervals throughout the grinding cycle.

4.4.2 *Reference test specimens*. In order to maintain a uniform level of counting over a period, it is desirable to have a minimum of three permanent reference test specimens covering the range of neppiness likely to be encountered. A sheet of glass shall be placed over each template and, together with the under-laying support, bound to it with adhesive tape. Nep counts for each such reference shall be counted before the examination of each set of test specimens; if a count different from the reference is obtained, the observer should re-count the reference (if necessary several times) to adjust his level of classification to the adopted standard.

4.5 Test procedure

Arrange in random order all the test specimens to be examined at a given time in order to reduce the effects of variations in the classification.

NOTE Even when collected on different occasions, a batch of specimens should be counted in one examining period by the observer, since the results for batches of specimens examined on different occasions by different operators are subject to greater error. Randomization of the order of inspection may be facilitated by numbering the templates and duplicating the numbers on pieces of card.

After mixing the numbered cards, (see note) by shuffling or otherwise, draw them one at a time to decide the order of examination of the specimens.

Inspect each test specimen in turn on the illuminated bench. Record for each template the number of cells containing one or more neps.

4.6 Calculation and expression of results

4.6.1 Calculation

4.6.1.1 Arrange the recorded observations into homogeneous groups, the test specimens in each group originating from one particular set of constant carding conditions.

NOTE For example, a group might consist of several sets of three specimens, each set taken across one particular card in rapid succession from one particular part of the stripping cycle. In surveys, when test specimens may be taken at intervals throughout the stripping and grinding cycles of several cards, "constant carding conditions" may be represented only by groups of three test specimens taken within a short time interval from different positions across a given card.

4.6.1.2 Calculate the average number, A , cells containing nep per template for each nominally homogeneous group of test specimens.

4.6.1.3 Convert the average number of cells with nep per template to number of neps, n , per unit area of card web, using the conversion formula:

$$n = \frac{\log C - \log (C - A)}{0.4343} \times \frac{(\text{unit area of web})}{(\text{area of cell})}$$

where

C is the total number of cells in each template;

A is the average number of cells containing nep.

4.6.1.4 Where appropriate, determine the average of the estimates, n , of values for neps per unit area of card webs, derived for each group of test specimens.

4.6.2 Particular procedures for cotton card web

4.6.2.1 For assessing the neppiness of cotton card web, it is common practice to use templates with $C = 34$ holes, each of 6.45 cm^2 area. For such templates, Table 4 may be used to convert number of cells with nep/645 cm^2 of web, n .

Table 4 — Nep content of web

Number of cells with nep	Neps/645 cm^2 of web, n	Number of cells with nep	Neps/645 cm^2 of web, n
1	3	15	58
2	6	16	64
3	9	17	69
4	12	18	75
5	16	19	82
6	19	20	89
7	23	21	96
8	27	22	104
9	31	23	113
10	35	24	122
11	39	25	133
12	44	26	144
13	48	27	158
14	53	28	173

4.6.2.2 For many purposes the transformation of values for cells with nep to neps per 645 cm^2 of web is made for each individual test specimen and not for the averages of group specimens. This procedure results in a bias that may be appreciable for values of n that are large compared with the corresponding value of C . Nevertheless, the greater flexibility of manipulation of such results may outweigh the disadvantages of this bias, the magnitude of which is much smaller than differences that arise commonly between cards engaged on the same types of production.

4.6.2.3 For convenience in comparing the behaviour of cards of different widths producing sliver of different linear density, use is commonly made of the nep count, N . The nep count is defined as the number of neps per 645 cm^2 of card web forming a silver of standard hank 0.12 (4.92 ktex) on a card 101.6 cm wide. It may be calculated from the following equation:

$$\begin{aligned} N &= \frac{n \times \text{silver hank}}{0.12} \times \frac{\text{card width}}{40} \\ &= 0.21 \times n \times \text{silver hank} \times \text{card width} \\ &= \frac{0.123 \times n \times \text{card width}}{\text{silver linear density}} \end{aligned}$$

4.6.2.4 For some purposes the neps per 645 cm^2 of web, n , may be converted into neps per gram of web by the equation:

$$\text{neps/g} = 0.67 \times n \times \text{silver hank} \times \text{card width (in cm)}$$

5 Determination of nep content of combed worsted slivers

5.1 Introduction

Methods of test for nep content have been investigated for many years. Early work showed large variations in methods used by different laboratories, and it became clear that consistent results could not be expected from methods which allowed personal assessment of the size of fault to qualify as a nep. Therefore significant between-laboratory variations will sometimes occur, and wherever possible it is suggested that a ball of well-gilled combed silver should be prepared and tested from time to time as a control.

This method is applicable to combed worsted slivers of linear density greater than about 5 ktex (g/m).

5.2 Principle

Successive draws of fibre from the silver are passed slowly over an illuminated slit, the total number of neps is counted, and afterwards the draws are weighed together. A nep is excluded from the count if its core area appears smaller than the area of a mark of 0.53 mm diameter on a comparator slide. The result is expressed as the number of neps per unit mass of silver.

5.3 Apparatus

5.3.1 *Nep-counting desk*, comprising a uniformly illuminated area, approximately $15 \text{ cm} \times 1.5 \text{ cm}$ (see Figure 1). The level of illumination should be such as to give a reading of about 32 lx above threshold on a photometer placed 10 cm above the area.

The angle of inclination of the desk top should be about 20° to the horizontal, and the desk may be either fitted with legs or fixed to a stand on an existing low table. To obtain the illuminated slit and at the same time a surrounding surface on which white fibres can easily be seen, the desk top may be covered with a black rubber mat, the slit being cut in it to coincide with the centre of the ground glass screen.

5.3.2 *Comparator slide*, a microscope slide with a circular mark of diameter 0.53 mm. The mark may be made by rotating a diamond or masonry drill on a new slide with light pressure and then verifying the diameter of the mark microscopically by a calibrated stage or eyepiece graticule.

5.3.3 *Grip*, for taking fibre draws (a letter grip with jaws about 150 mm wide is suitable).

5.3.4 *Balance*, accurate to $\pm 0.01 \text{ g}$.

5.4 Atmosphere for conditioning and testing

There is no evidence that the number of neps counted is affected significantly by variations in temperature and relative humidity, but the sample should preferably be conditioned and weighed in the standard temperate atmosphere for testing textiles (see BS 1051). Development of static electricity on the fibre in atmospheres of low relative humidity may prove troublesome when the draws are taken.

5.5 Test specimens

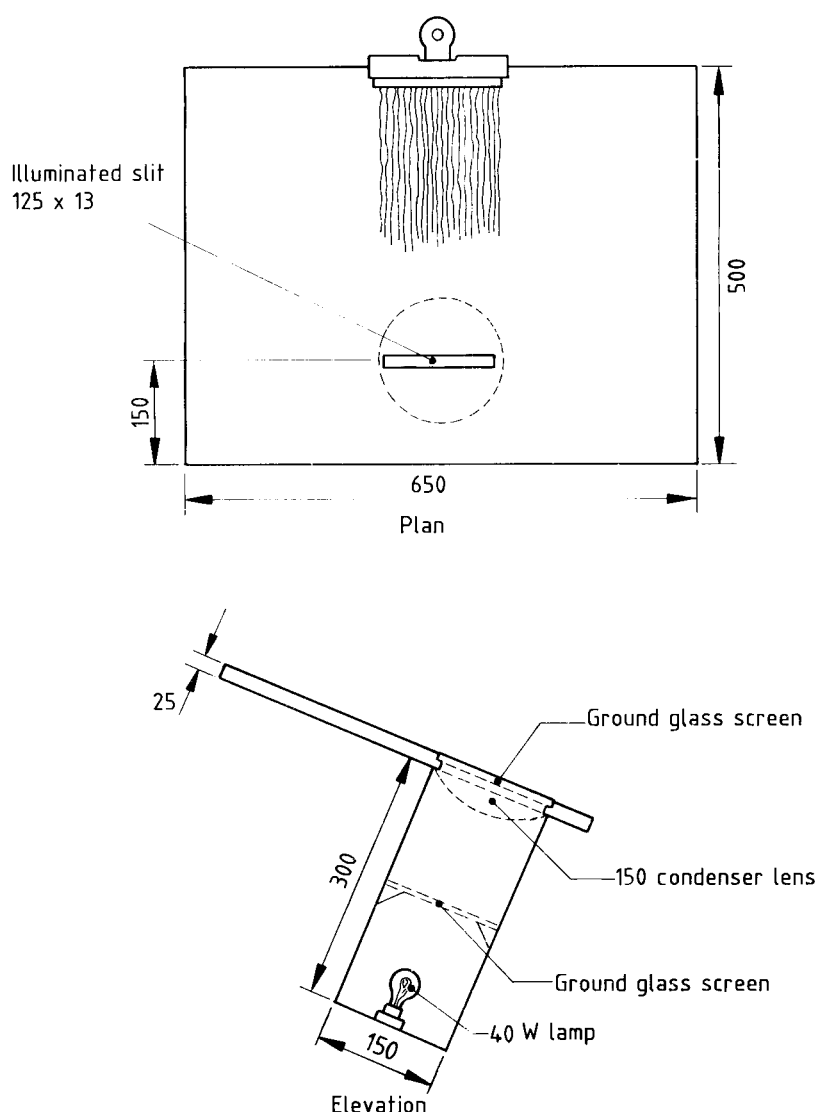
A test specimen is composed of fibre draws taken consecutively from the length or lengths of sliver constituting the laboratory sample (see 5.6.1) and should comprise a total mass of at least 14 g. As far as possible this mass is disposed throughout the available material. For example, from two balls of silver, about 3.5 g should be taken from inside and outside of each ball to give a total of 14 g.

The amount of silver examined will determine the accuracy of the nep count. In deciding this, it should be remembered that, because the distribution is substantially of the Poisson type²⁾, the 95 % confidence limits of the total number of neps n counted in a length of sliver will be approximately $\pm 2\sqrt{n}$.

5.6 Procedure

5.6.1 Take a length of silver from the laboratory sample, part it by hand, and remove and discard about 10 draws by gripping the exposed fibre ends, holding the silver at a distance from the parted end greater than that of the longest fibre. Open out the silver to a width of about 120 mm and clip it to the top centre of the viewing desk so that the prepared end lies just above the illuminated slit as shown in Figure 1.

5.6.2 By means of the grip (5.3.3), take draws of fibres from the prepared end of silver and pull them across the illuminated strip. Count and record the neps as they appear, observing the following rule:



All linear dimensions are in millimetres.

Figure 1 — Nep-counting desk

²⁾ See ANDERSON, S.L. and STUBBS, R.; *J. Text. Inst.*, 1960, **51**, T1055.

Only neps of core size which appear larger than the engraved mark on the comparator slide (5.3.2) are included in the count.

In doubtful cases, the mark is viewed alongside or on top of the nep core under examination and a decision is then made.

5.6.3 Remove the fibres from the grip, count the neps in the parts formerly hidden in the grip, and retain all the fibres.

5.6.4 Take further draws, count the neps n in the way described in 5.6.2 and 5.6.3, and retain the fibres examined.

5.6.5 Determine the combined mass of the fibres in all the draws examined to the nearest 0.01 g.

5.7 Calculation and expression of results

Record the following quantities:

- a) the total number of neps counted;
- b) the mass of the test specimens of silver examined.

Calculate the number of neps per 10 g of sliver to the nearest whole number.

6 Determination of yarn diameter (projection method)

6.1 Introduction

This method gives an estimate of the diameter of the body of a yarn excluding the outstanding hairs. The projected diameter is a measure of the covering power of the yarn. The variability of the results is a measure of yarn irregularity.

The method is clearly unsuitable for yarns which are not approximately circular in cross section. Both staple fibre yarns with exceptionally low twist and continuous filament viscose yarns with low twist which become tape-like on passing over a yarn guide would give misleading results.

6.2 Principle

The magnified silhouette of a short length of the yarn under test is thrown on a ground-glass scale, and the width of the image is measured.

6.3 Apparatus

6.3.1 Yarn diameter projector. Each division of the scale of this instrument corresponds to 0.025 mm on the yarn.

6.3.2 Means for providing the standard temperate atmosphere for testing textiles as specified in BS 1051 (optional, not essential) in which to condition and test the specimens.

6.4 Test specimens

No fewer than five packages of the yarn shall be made available for test, and sufficient yarn shall be required from each to give a total of 200 readings in approximately equal numbers for each of the packages at an average interval of about 30 cm. If the yarn to be tested is in short lengths, e.g. a thrum of warp, these may be knotted together to give the required length of yarn, which may then be most conveniently handled in the form of a hank and run from a hank holder.

6.5 Procedure

Condition the specimens and carry out the tests in the standard temperate atmosphere for testing textiles (see BS 1051) if means for providing this are available.

Mount the package so that the yarn can be drawn off freely, either over-end or sideways, whichever is the normal manner, and pass the yarn through a light drag, such as a small ball-drag, before threading it through the copper guide tubes of the yarn projector from the right hand side. A clear image of the yarn should then be seen on the screen of ground glass bearing the scale. Pass the free end of the yarn through the disc-drag at the left side of the instrument.

Draw the yarn through by the left hand, and adjust the position of the scale by the right hand so that the zero coincides with the lower edge of the yarn image. Take the reading of the upper edge. When measuring the diameter of the image, measure only the solid body of the yarn and ignore any fibres standing off the yarn.

Measure diameters at 200 randomly spaced places in the yarn. To do this, draw a length of the yarn (15 cm to 45 cm) through the instrument, and measure the diameter at the point where the yarn stops, no matter whether that place is a very thick or a very thin place; repeat this procedure 200 times.

6.6 Expression of results

Ascertain the mean of the 200 readings giving the mean diameter in 0.025 mm. Divide the readings into groups of 10 and find the range in each group. From these figures calculate the mean range.

The standard deviation of diameter, x , expressed as a percentage, is calculated from the equation:

$$x = \frac{\text{mean range}}{\text{mean diameter} \times 3.08} \times 100$$

NOTE It should be noted that, except with a very compact yarn, different observers do not obtain identical estimates of yarn diameter owing to the personal error involved in estimating the amount of extraneous fibre. For this reason, yarns that are to be compared should be measured by the same observer.

7 Determination of the irregularity of yarn (by variability of masses of 25 mm lengths)

7.1 Principle

A spun yarn is not uniform along its length, but contains thick and thin places. Its irregularity is measured by the standard deviation of the masses of 25 mm lengths of the yarn. A number of 25 mm lengths of the yarn are cut and weighed, and the variability of the masses of these 25 mm specimens is calculated.

7.2 Apparatus

7.2.1 25 mm roller apparatus. A steel roller, 25 mm circumference, 250 mm long with a groove about 2.5 mm wide and 3 mm deep for a length of 125 mm. It is threaded for the remainder of its length and rotates in a fixed nut in a small stand. A handle enables the roller to be rotated by hand. The small stand carrying the roller is held firmly on to the wooden base carrying the disc-drag by means of a clip, and a small guide enables the yarn to be led to the roller after passing through the disc-drag. A velvet-covered pad about 120 mm × 25 mm is provided and is of such a shape that it can be wedged underneath the roller to retain the yarn after cutting.

7.2.2 Microbalance of a sensitivity appropriate to the range of linear densities to be examined and preferably of the direct-reading type.

7.2.3 Safety razor blade and holder.

7.2.4 Pair of forceps

7.2.5 Means for providing the standard temperate atmosphere for testing textiles specified in BS 1051 (optional, not essential) in which to condition and test the specimens.

7.3 Method A. General irregularity on 200 continuous 25 mm lengths from fabric

NOTE The instructions given below refer to the determination of the irregularity of the warp yarn; the procedure for finding the irregularity of the weft yarn is similar.

7.3.1 Test specimens. Select a strip of fabric at least 25 mm warp-way, and containing approximately 200 warp threads. Cut the sample along two picks which are slightly less than 25 mm apart, so that if the warp threads were removed from the sample and straightened out they would have an average length very nearly equal to 25 mm.

7.3.2 Procedure. Adjust the scale of the microbalance so that the reading is zero when the pan is empty. Remove each of the 25 mm lengths of warp yarn from one end of the strip by means of the forceps and place them gently in the pan of the microbalance. Take the reading when the oscillations of the balance have ceased. It is convenient to note the reading and, before writing it down on the test sheet, to remove the specimen and place the next length in the balance pan. The short pause while the first reading is being taken down will enable the balance to become steady, so that the second reading can be taken immediately. Take 200 such readings and record them as 20 groups of 10 each for convenience in calculation (see 7.5).

7.4 Method B. Local and general yarn irregularity, on twenty 250 mm lengths

7.4.1 Test specimens

7.4.1.1 Yarn from fabric. Select a strip of fabric approximately 300 mm long warp-way and containing about 30 warp threads. Remove 20 of these threads and knot them together to form a continuous length; the knots shall be at least 275 mm apart. The length of yarn so obtained is most easily handled if it is wound on a bobbin.

7.4.1.2 Yarn from a package. Remove pieces of yarn 300 mm long from the package at irregular intervals of about 2 m; knot 20 of these together to form a continuous length as in 7.4.1.1 winding the yarn on to a convenient holder. If more than one package is included in the sample available, take the 300 mm lengths in equal numbers from as many of the packages as possible.

7.4.2 Procedure. Mount the small package of yarn obtained by either of the methods described in 7.4.1.1 or 7.4.1.2 so that the yarn may be freely withdrawn; pass the end of the yarn through the disc-drag device, through the guide and on to the 25 mm roller. Wind the yarn on to the roller in such a way that, as the roller moves along its screwed portion, the yarn will fill up the plain portion. Remove the roller from the stand and place the velvet pad underneath the roller, then cut the yarn along the groove by means of the razor blade.

Weigh the 25 mm lengths thus obtained in the manner described in 7.3, leaving the pad in position to retain the yarn.

Ensure that the ten 25 mm lengths, the masses of which form a column of readings, are all from one of the 300 mm lengths of yarn, so that, finally, each of the 20 columns of 10 readings corresponds to one of the 300 mm lengths of yarn in the original fabric or package. Discard the remainder of the yarn.

NOTE Lengths of yarn containing knots should not be weighed.

7.5 Expression of results

NOTE 1 This is applicable to both methods.

Find the mean of the whole 200 readings, giving the mean mass, and the mean of the ranges in the groups of 10, giving the mean range. (The range in each group is the difference between the highest and lowest readings in that group.)

The percentage irregularity of 25 mm mass, m , is calculated from the equation:

$$m = \frac{\text{mean range}}{\text{mean mass} \times 3.08} \times 100$$

The figure obtained by method B is a measure of the local irregularity, and this is the figure normally quoted without special description. The general irregularity should be found by taking the range in rows across the columns referring to single ends. This figure is comparable to that of method A.

To obtain the percentage irregularity of the single components of a two-ply yarn from that of the two-ply yarn, multiply the percentage irregularity of the two-ply by $\sqrt{2}$.

NOTE 2 The local irregularity is that between consecutive elements in one end of yarn and is a feature of importance often justifying the labour of the test by 25 mm masses. Variation between ends of packages can better be determined by linear density, if the material is available.

The general irregularity confuses these two sources of variation but is useful when a combined measure is desired, particularly with reference to the patchy appearance of fabric.

8 Determination of the compacting quality of yarn (brass bobbin test)

8.1 Principle

The yarn is wound at a controlled tension into the cylindrical space within a stoutly built brass bobbin. The length and mass of the yarn that fills the bobbin are determined, and from the mass of the yarn and the volume of the bobbin space the specific volume of the yarn wrapping is calculated.

8.2 Apparatus

8.2.1 Brass bobbin, consisting of two stout metal flanges 70 mm in diameter which can be secured with a fixed separation. The distance between the flanges may be varied by the use of different sizes of spacer washer. The inward turned lips of the flanges form a narrow gap through which the yarn can pass to the wider space inside. The capacity of the bobbin at each spacing should be measured for each instrument and recorded to an accuracy of 0.25 %. A suitable bobbin has three spacer washers corresponding to the following bobbin capacities.

Spacer number	Capacity cm ³
—	5
1	10
2	15
3	20

The size of spacer used between the flanges shall be determined by the linear density of the yarn. The smallest capacity is suitable for all yarns finer than 60 tex. For coarser yarns the spacer that will permit the winding of at least 40 m shall be used.

8.2.2 Ball drags or other means of applying a constant known tension.

8.2.3 Tension measurer

8.2.4 Length measurer

8.2.5 Means for driving the brass bobbin, via a belt and the pulley which is integral with one flange of the bobbin, at a speed of about 120 r/min.

8.2.6 Balance, accurate to 0.01 g.

8.2.7 Means for providing the standard temperate atmosphere for testing specified in BS 1051, in which to condition and test the specimens.

8.3 Test specimens

Yarn from any type of freely running package may be tested, provided that knots are not present in abnormal numbers. For most yarns about 4 g of yarn is required from each of three packages. For coarse yarns three or four times this mass may be required.

8.4 Procedure

Place the chosen spacer between the flanges and press the removable flange firmly against the washer and tighten the locking nut.

Pass the yarn through a bank of ball drags or an alternative tensioning device, round the wheel of a length measurer, through a tension measurer, and into the brass bobbin. Wrap by hand several turns of yarn round the core of the bobbin and cut off the loose end close to the bobbin flange.

Adjust the tensioning mechanism, in a trial run if necessary, so that the tension on the running thread as shown by the tension measurer is equal to $0.75 \times \text{tex}$ of the yarn (see note). Drive the bobbin until the space, including that between the flange lips, is full of yarn. 50 cm of yarn of 14.5 tex to 7.4 tex is sufficient to make the difference between the bobbin being obviously not full and the yarn overflowing the narrow space between the lips. When the bobbin is full, separate the flanges and remove the winding by cutting. Weigh the yarn to an accuracy of 0.01 g. Record the mass of the yarn, the reading of the length measurer, and the tension on the yarn during winding. Make a winding from each of the three packages.

NOTE A different winding tension may be used if this appears to be more appropriate to the conditions of use; for example the tension measured at a particular winding frame for lace loom brass bobbins might be chosen.

8.5 Calculation and expression of results

8.5.1 Specific volume. Divide the known volume of the bobbin capacity (in cm³) by the mass of the yarn wrapping (in g) to obtain the specific volume. Calculate this value for each wrapping separately and determine the mean of the three specific volume figures quoted to two decimal places.

NOTE Tests have shown that the tension of winding has a large effect on the measured specific volume. For average grey yarns a 10 % variation in a tension of approximately one hank mass produces a change in measured specific volume of about 3 %. Care should be taken, therefore, to ensure that the tension of winding is close to the chosen standard.

8.5.2 Length of yarn in the bobbin. Quote the average length of the three wrappings to the nearest metre and state the volume of the bobbin capacity.

9 Determination of snarling twist

9.1 Principle

The “snarling twist” is a measure of the torsional strain, in turns per centimetre, that can be recovered in a short time, when the yarn is released from constraint. “Liveliness” in free lengths of yarn is usually undesirable because of the difficulties which arise in processing. This test gives a useful indication of this tendency. The measure of the snarling (or free) twist in a yarn is determined by allowing a loop, formed by bringing the two ends of a known length of yarn together, to twist on itself and counting the number of turns in the loop.

9.2 Apparatus

9.2.1 Board, 110 cm × 5 cm × 2.5 cm, fitted at one end with a detachable bulldog clip and at the other with a short vertical peg (about 0.3 cm diameter), so that the distance from the clip to and around the peg, and back to the clip, is 200 cm.

9.2.2 Silver can (any other convenient form of draught shield may be used).

9.2.3 Hook, from which the bulldog clip can be hung, mounted in any convenient manner at a distance of about 110 cm from the bottom of a silver can.

9.2.4 Wire paper clip, “slide on” type, 1.8 cm long by 0.6 cm wide.

9.2.5 Piece of thin postcard or filing card, 4 cm × 4 cm, which together with the paper clip has a mass of 1 ± 0.25 g.

NOTE It would be reasonable to adjust the mass of the clip and vane to the linear density of the yarn; but, for the same yarn, the effect of increasing the mass on the measured snarling twist is at first so small that a constant mass of 1 ± 0.25 g may be used for all cotton yarns from 5 tex to 40 tex.

9.2.6 Means for providing the standard temperate atmosphere for testing textiles specified in BS 1051, in which to condition and test the specimens.

9.3 Test specimens

Take 20 specimens in about equal numbers from five or more packages. Specimens from the same yarn package shall be separated by intervals of several metres.

9.4 Procedure

Condition the yarn packages and carry out the tests in the standard temperate atmosphere for testing textiles.

Mount the yarn package so that the yarn can be withdrawn readily, either over-end or sideways, whichever is the normal manner. Withdraw and discard a length of several metres from the package and grip the remaining end of yarn between the fingers to ensure that untwisting does not occur. Pass the yarn through the wire paper clip and grip it in the bulldog clip when in position on the mounting board; then draw it round the peg and back to the bulldog clip, in which it is again gripped with the yarn just taut. Remove the loop from the peg and draw the wire clip with the cardboard vane now attached to the end of the loop. Remove the bulldog clip from the board and, with the vane held in the other hand, hang the clip on the hook fixed above the silver case. Allow the loop with the vane hanging from it to hang freely in the silver can. When rotation ceases, count the number of turns in the loop; do this either by removing the twist by hand or, more conveniently, by transferring the vane to the rotatable jaw of a twist testing machine. Record the direction of the twist in the loop according to the S and Z convention.

9.5 Expression of results

Divide the number of turns in the snarled loop by the length of the loop (100 cm) and express the resultant figure as snarling turns per centimetre.

10 Determination of lea strength and lea count of spun yarns (mean and variability)

10.1 Principle

The lea strength is the tensile strength of a skein of 80 turns, comprising 109.7 m of yarn. It is the accepted trade measure of the strength of many yarns.

The lea strength is probably the most useful single index of yarn strength since it depends upon variability as well as single thread strength. The product of count and strength is a measure of the strength quality of the yarn which is much less dependent upon yarn count than the lea strength and is a convenient means of comparing yarns which differ in count.

A lea of the yarn under test is wound into a skein of 1 370 mm girth, and broken on a lea tester. This gives the “lea strength” of the yarn. The linear density of the yarn is found by weighing the broken lea.

10.2 Apparatus

10.2.1 *Power-driven lea tester of appropriate range* (a dual range instrument will cover practically the whole range of strengths met with in practice) set to operate at a rate of traverse of the hook of 305 mm/min.

10.2.2 *Wrap reel* of 1 360 mm in circumference.

10.2.3 *Direct reading linear density balance* or other balance accurate to $\pm 0.25\%$.

10.2.4 *Means for providing the standard temperate atmosphere for testing textiles specified in BS 1051*, in which to condition and test the specimens.

10.3 Test specimens

Take 20 packages, from each of which a complete lea may be withdrawn. If 20 packages are not available a smaller multiple of four packages may be used, provided that in taking 20 leas equal numbers can be taken from each package of a group of four, e.g. eight packages, three leas from each of four packages and two leas from each of the other four packages.

10.4 Procedure

Condition the yarn packages and carry out the tests in the standard atmosphere for testing (10.2.4).

Mount the package so that the yarn may be withdrawn from it either over-end or sideways, whichever is the normal manner. Pass the yarn over guide bars to the wrap reel in such a way that the tension in the running yarn is sufficient to straighten it but not high enough to cause serious stretching; the tension should be preferably between one-third and two-thirds of the mass of a hank of the yarn. (See BS 2010 for a more refined method of ensuring correct tension in reeling.)

Wind a lea of yarn at a steady speed and knot together the two ends of yarn, taking care that the knotted turn is similar in tension to the others. Then remove the lea from the wrap reel as a flat tape and transfer it to the hooks of the lea strength tester, taking care not to bunch the turns together nor twist the band of threads.

Set in motion the bottom hook of the testing machine and, when the lea is completely broken, take the dial reading of the machine. Remove the broken lea from the hooks and weigh it on the direct reading linear density balance or on an analytical balance if a direct reading balance is not available.

Test each of the 20 leas in this way, except that if an analytical balance is being used for weighing it is more convenient to retain the broken leas in numbered packets and to weigh them after all the strength tests have been made.

If a measure of linear density variability is not required, the weighing of individual leas may be dispensed with, and the 20 leas may be weighed together. A bulk weighing of the 20 leas may also be used as a check on the mean mass obtained by weighing the individual leas.

10.5 Calculation and expression of results

When the weighings are made on an analytical balance, calculate the linear density of the yarn in the cotton system from the formula:

$$\text{linear density (cotton system)} = \frac{64.8}{\text{mass of one lea in grams}}$$

Do this for each of the leas examined, and determine the mean linear density from the results for the individual leas. Compare this with the result from bulk weighing. The two results should be in close agreement.

Find the mean of the breaking load results.

To obtain a measure of the variability of the strength or of the linear density of the leas, divide the results into groups of four so that each result in the group is for a lea from a different package, and the range of linear density in each group is found. The mean ranges of breaking load or of linear density are then found, and expressed as percentages of the mean strength or mean linear density.

The results obtained in the tests give:

- a) the mean lea strength;
- b) the mean lea linear density;
- c) the percentage ranges of strength in groups of four;
- d) the percentage ranges of lea linear density in groups of four.

From the first two results the lea linear density strength product may be calculated.

11 Constant tension winding test for yarn

11.1 Principle

A constant tension is maintained in a span of 30 cm of the running yarn and the breakage rate is found. From the breakage rate at each of two tensions an estimate of the tension that will give nine breaks per 1 000 m is obtained.

11.2 Apparatus

11.2.1 *Constant tension winding tester*

11.2.2 *Yarn winding drum*, preferably power driven with a surface speed of 55 m/min.

11.2.3 *Means for providing the standard temperate atmosphere for testing textiles specified in BS 1051*, in which to condition and test the specimens.

11.3 Test specimens

Yarn from any type of package may be tested. The test requires about 10 hanks of yarn, and it is preferable that this quantity should be available in about equal lengths from 10 packages.

11.4 Procedure

11.4.1 *Operating the instrument.* With the package mounted so that the yarn can be withdrawn in the manner appropriate to its use, pass the yarn through the guide eye at the left hand side of the instrument, under the spring-loaded disc tensioner and round the cylindrical part of the lower pulley in a clockwise direction. Then take the yarn over the top pulley (attached to the balance beam) and round the cone which forms the front half of the lower pulley. Make three-quarters of a turn round this cone and take off the yarn through the right hand guide eye to the winding drum. Place weights on the weight hangar to the value of twice the tension at which the yarn is required to run.

When threading the instrument it is advisable to depress the beam on to its front stop by hand, releasing the beam gently immediately the yarn is running. Then adjust the spring tensioner so that the balance beam floats freely between its two stops.

11.4.2 *Determining the winding tension.* The aim is to find the tension at which there is an average of about nine breaks for 1 000 m of yarn. If single-thread strength tests have been made on the yarn, make an estimate for a trial using the formula:

tension =

$$\text{average single thread strength} \times \left(1 - \frac{\sigma}{30}\right)$$

where σ is the percentage standard deviation of the single thread breaking load results.

If single-thread tests have not been made, use one of the following tensions, according to the type and quality of yarn:

	Hanks
145 dtex and coarser American type yarns	8 or 9
145 dtex to 74 dtex Egyptian type yarns	9 to 10
74 dtex and finer Sakel type yarns	10 to 12
medium and fine plied yarns	14 to 16

NOTE 1 These figures are given only for the purpose of assisting in the selection of a winding tension and should not be regarded as standard tensions.

The force to be applied to the hanger of the instrument should be equal to twice the tension required in the yarn and may be obtained by the use of suitable weight-pieces. (A mass of 100 g gives a force of 98 N.)

Having estimated the winding tension, examine its suitability by carrying out a trial test. From each of the 10 packages wind 200 m of yarn at the estimated winding tension. Record the number of breaks that occur for each package and find the total number for the 2 000 m of yarn. Discontinue the trial if more than 18 breaks have been obtained before five packages have been tested, providing that 200 m have been taken from each of two packages. If 18 breaks or more have been obtained in less than five packages, or less than nine breaks have been obtained in the 2 000 m from the 10 packages, the estimated winding tension has been too high or too low respectively, so carry out a second estimate and trial test.

Base the calculation of the tension for the second trial on the assumption that a 10 % change in tension doubles or halves the breakage rate.

NOTE 2 The second trial will generally give a suitable tension for the first winding test.

11.4.3 Testing the yarn. With the instrument set to give the tension found by trial, record the reading of the length indicator and run yarn from one package through the instrument until five breaks have occurred. Record the reading of the length indicator for each break. Do not record a break if it occurs within the first 5 m of yarn after starting up the instrument. Test four further packages in the same way so that a total of 25 breaks is obtained. Calculate the number of breaks per 1 000 m from the following formula:

$$\text{number of breaks per 1000 m} = \frac{25 \times 1000}{\text{lengths for 25 breaks}}$$

NOTE Each new package begins with a forced break or cut. Statistically, the length between this point and the first break is an average equal to half the average length of yarn between breaks. The five breaks from one package occur in a length of yarn equal to $4\frac{1}{2}$ times the average interval between breaks, and the total of 25 breaks from the five packages corresponds to $22\frac{1}{2}$ intervals.

Carry out a second winding test on the remaining five packages at a tension determined from the results of the first winding test. Decrease or increase the tension according to whether the first winding test gave more or less than nine breaks per 1 000 m as follows:

Result of first winding test	Change of tension
5 to 7 breaks per 1 000 m	Increase by 15 %
7 to 9 breaks per 1 000 m	Increase by 10 %
9 to 14 breaks per 1 000 m	Decrease by 10 %
14 to 18 breaks per 1 000 m	Decrease by 15 %

11.5 Calculation of results

The purpose of the calculation is to obtain an estimate of the tension that will give nine breaks per 1 000 m from the tensions and breakage rates of the two winding tests. Development work on this instrument has shown that the best estimate is obtained by assuming that the logarithm of the breakage rate is linearly related to the tension and the following formula is used:

$$t = t_1 + (t_2 - t_1) \frac{\log 9 - \log n_1}{\log n_2 - \log n_1}$$

where

t is the estimated tension to give nine breaks per 1 000 m;

n_1 and n_2 are the numbers of breaks per 1 000 m found in the winding tests at tensions t_1 and t_2 respectively.

11.6 Expression of results

Express the estimated tension, in newtons, to give nine breaks per 1 000 m to an accuracy of 1 %.

NOTE For the routine control of one yarn quality it may be sufficient to carry out one winding test at a tension previously determined from experience. The results would then be expressed as the number of breaks per 1 000 m.

When it is desired to know the cause of weakness in a yarn this test provides a suitable method of finding the weakest places. The broken ends of the yarn may be collected for examination by suitable techniques.