# 7
# Serviceability

## 7.1 Introduction

A garment is considered to be serviceable when it is fit for its particular end use. After being used for a certain length of time the garment ceases to be serviceable when it can no longer fill its intended purpose in the way that it did when it was new. The particular factors that reduce the service life of a garment are heavily dependent on its end use. For instance overalls worn to protect clothing at work would be required to withstand a good deal of hard usage during their lifetime but their appearance would not be considered important. However, garments worn purely for their fashionable appearance are not required to be hard wearing but would be speedily discarded if their appearance changed noticeably. An exception to this generalisation is found in the case of denim where a worn appearance is deliberately strived for.

If asked, many people would equate the ability of a fabric to 'wear well' with its abrasion resistance, but 'wear', that is the reduction in serviceable life, is a complex phenomenon and can be brought about by any of the following factors:

1 Changes in fashion which mean that the garment is no longer worn whatever its physical state.
2 Shrinkage or other dimensional changes of such a magnitude that the garment will no longer fit.
3 Changes in the surface appearance of the fabric which include: the formation of shiny areas by rubbing, the formation of pills or surface fuzz, the pulling out of threads in the form of snags.
4 Fading of the colour of the garment through washing or exposure to light. The bleeding of the colour from one area to another.
5 Failure of the seams of the garment by breaking of the sewing thread or by seam slippage.

6 Wearing of the fabric into holes or wearing away of the surface finish or pile to leave the fabric threadbare. Wearing of the edges of cuffs, collars and other folded edges to give a frayed appearance.
7 Tearing of the fabric through being snagged by a sharp object.

These changes are brought about by the exposure of the garment to a number of physical and chemical agents during the course of its use. Some of these agents are as follows:

1 Abrasion of the fabric by rubbing against parts of the body or external surfaces.
2 The cutting action of grit particles which may be ingrained in dirty fabrics and which may cause internal abrasion as the fabric is flexed.
3 Tensile stresses and strains which occur as the garment is put on or taken off and when the person wearing it is active.
4 The laundering and cleaning processes which are necessary to retain the appearance of the garment.
5 Attack by biological agents such as bacteria, fungi and insects. This is a particular problem for natural materials.
6 Degradation of the fabric by contact with chemicals which can include normal household items such as bleach, detergents, anti-perspirants and perfumes.
7 Light, in particular ultra-violet light, can cause degradation of polymers leading to a reduction in strength as well as causing fading of colours.
8 Contact of the garment with sharp objects leading to the formation of tears.

The above causes of wear are often acting at the same time. For instance, chemical or bacterial attack may so weaken a fabric that it can then easily fail through abrasion or tearing. Laundering of a fabric taken together with the abrasion that it encounters during use may lead to much earlier formation of pills or failure through abrasion than would be predicted from any pilling or abrasion tests undertaken on the new material.

## 7.2 Snagging

A snag is a loop of fibre that is pulled from a fabric when it is in contact with a rough object. Snags detract from the appearance of the fabric but do not reduce any of its other properties. Fabrics made from bulked continuous filament yarns are particularly susceptible to the formation of snags although woven fabrics with long floats can also suffer from this problem.

### 7.2.1 Mace snagging test

The mace snagging test [1] is a comparative test for the snagging propensity of knitted fabrics of textured polyester yarn originally developed by ICI to test Crimplene yarns. In the test a metal ball fitted with spikes bounces randomly against a sleeve of the test fabric as it rotates. The spikes only catch loops of thread that are lying in a particular orientation so that it is important to test both directions of a fabric.

Four specimens, each one measuring 203 mm × 330 mm are tested; two with their long direction aligned with the length of the fabric and two with their long direction aligned with the fabric width. A seam is marked on the back of the fabric 16 mm from the shorter edge. The fabric samples are then folded face to face and sewn along the seam to form a tube. The tube is turned inside out so that the face of the fabric is on the outside. It is then slid over the cylinder of the machine and secured at each end with a rubber ring.

A mace is placed on each of the four fabric samples so that the chain holding it passes around the guide rod as shown in Fig. 7.1 and 7.2. The machine is then set to run for 600 revolutions (10 min).

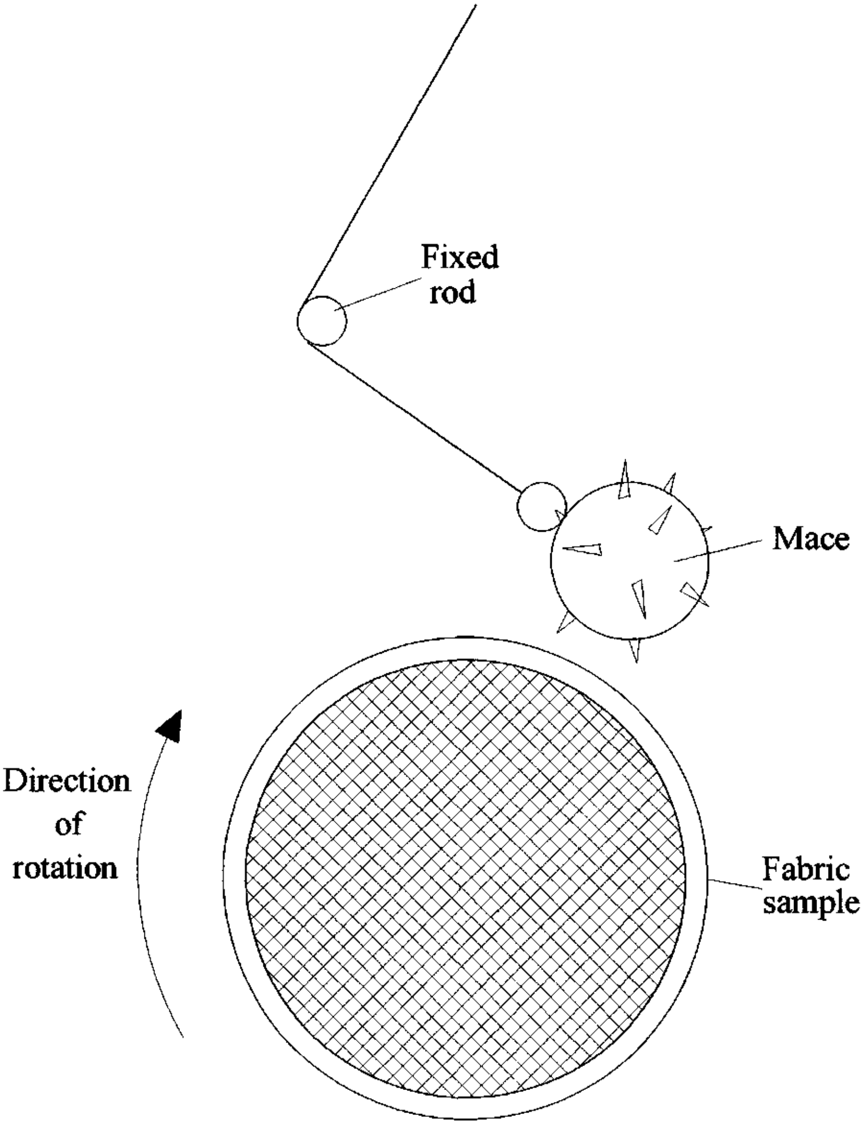
When the test is complete the surface appearance of the specimen is compared with a set of photographic standards and given a rating from 5 (no snagging) to 1 (severe snagging).

## 7.3 Pilling

Pilling is a condition that arises in wear due to the formation of little 'pills' of entangled fibre clinging to the fabric surface giving it an unsightly appearance. Pills are formed by a rubbing action on loose fibres which are present on the fabric surface. Pilling was originally a fault found mainly in knitted woollen goods made from soft twisted yarns. The introduction of man-made fibres into clothing has aggravated its seriousness. The explanation for this is that these fibres are stronger than wool so that the pills remain attached to the fabric surface rather than breaking away as would be the case with wool. Figure 7.3 shows a pill on a cotton/polyester fabric.

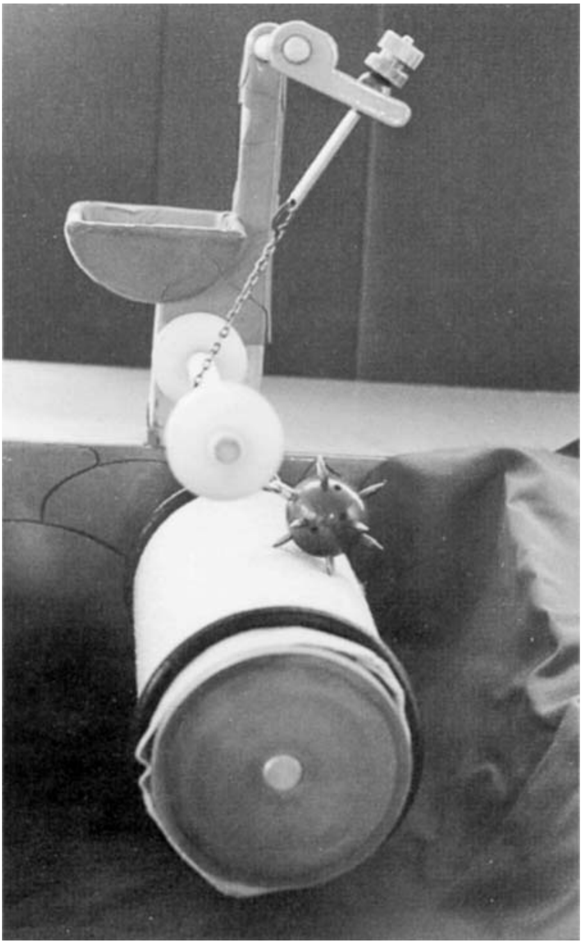
The initial effect of abrasion on the surface of a fabric is the formation of fuzz as the result of two processes, the brushing up of free fibre ends not enclosed within the yarn structure and the conversion of fibre loops into free fibre ends by the pulling out of one of the two ends of the loop.

Gintis and Mead [2] consider that the fuzz formation must reach a critical height, which is dependent on fibre characteristics, before pill formation can occur.




7.1 The mace snagging test.

The greater the breaking strength and the lower the bending stiffness of the fibres, the more likely they are to be pulled out of the fabric structure producing long protruding fibres. Fibre with low breaking strength and high bending stiffness will tend to break before being pulled fully out of the structure leading to shorter protruding fibres.



7.2 One station of a mace snagging tester.

The next stage is the entanglement of the loose fibres and the formation of them into a roughly spherical mass of fibres which is held to the surface by anchor fibres. As the pill undergoes further rubbing, the anchor fibres can be pulled further out of the structure or fatigued and eventually fractured depending on the fibre properties and how tightly they are held by the structure. In the case of low-strength fibres the pills will easily be detached from the fabric but with fabrics made from high-strength fibres the pills will tend to remain in place. This factor is responsible for the increase in the propensity for fabrics to pill with the introduction of synthetic fibres.

Low twist factors and loose fabric structures such as knitwear have a rapid fibre pull-out rate and long staple length resulting in the development

7.3 A pill ×50.

of numerous large pills. The life of these pills depends on the balance between the rate of fibre fatigue and the rate of roll-up. Pill density can either increase steadily, reach a plateau or pass through a maximum and decrease with time depending on the relative rates of pill formation and pill detachment. The pill density is also governed by the number of loose fibre ends on the surface and this may set an upper limit to the number of pills that will potentially develop. This has important implications for the length of a pilling test because if the test is carried on too long the pill density may have passed its maximum. Fibres with reduced flex life will increase the rate of pill wear-off.

Because the fibres that make up the pills come from the yarns in the fabric any changes which hold the fibres more firmly in the yarns will reduce the amount of pilling. The use of higher twist in the yarn, reduced yarn hairiness, longer fibres, increased inter-fibre friction, increased linear density of the fibre, brushing and cropping of the fabric surface to remove loose fibre ends, a high number of threads per unit length and special chemical treatments to reduce fibre migration will reduce the tendency to pill. The presence of softeners or fibre lubricants on a fabric will increase pilling. Fabrics made from blended fibres often have a greater tendency to pill as it has been found [3] that the finer fibres in a blend preferentially migrate towards the yarn exterior due to the difference in properties.

The amount of pilling that appears on a specific fabric in actual wear will vary with the individual wearer and the general conditions of use. Consequently garments made from the same fabric will show a wide range of pilling after wear which is much greater than that shown by replicate fabric specimens subjected to controlled laboratory tests.

Finishes and fabric surface changes may exert a large effect on pilling. Therefore, with some fabrics, it may be desirable to test before as well as after laundering or dry cleaning or both.

### 7.3.1 Pilling tests

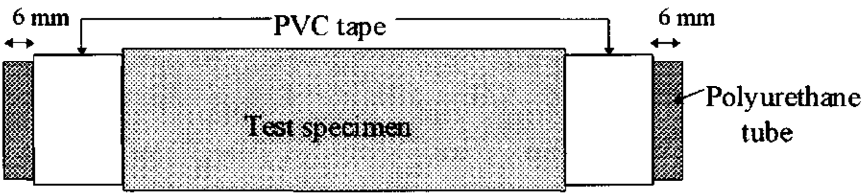
After rubbing of a fabric it is possible to assess the amount of pilling quantitatively either by counting the number of pills or by removing and weighing them. However, pills observed in worn garments vary in size and appearance as well as in number. The appearance depends on the presence of lint in the pills or the degree of colour contrast with the ground fabric. These factors are not evaluated if the pilling is rated solely on the number or size of pills. Furthermore the development of pills is often accompanied by other surface changes such as the development of fuzz which affect the overall acceptability of a fabric. It is therefore desirable that fabrics tested in the laboratory are assessed subjectively with regard to their acceptability and not rated solely on the number of pills developed. Counting the pills and/or weighing them as a measure of pilling is very time consuming and there is also the difficulty of deciding which surface disturbances constitute pills. The more usual way of evaluation is to assess the pilling subjectively by comparing it with either standard samples or with photographs of them or by the use of a written scale of severity. Most scales are divided into five grades and run from grade 5, no pilling, to grade 1, very severe pilling.

#### *ICI pilling box*

For this test [4] four specimens each 125 mm × 125 mm are cut from the fabric. A seam allowance of 12 mm is marked on the back of each square. In two of the samples the seam is marked parallel to the warp direction and in the other two parallel to the weft direction. The samples are then folded face to face and a seam is sewn on the marked line. This gives two specimens with the seam parallel to the warp and two with the seam parallel to the weft. Each specimen is turned inside out and 6 mm cut off each end of it thus removing any sewing distortion. The fabric tubes made are then mounted on rubber tubes so that the length of tube showing at each end is the same. Each of the loose ends is taped with poly (vinyl chloride) (PVC) tape so that 6 mm of the rubber tube is left exposed as shown in Fig. 7.4. All four specimens are then placed in one pilling box. The samples are then

*Table 7.1* Pilling grades

| Rating | Description | Points to be taken into consideration |
|---|---|---|
| 5 | No change | No visual change |
| 4 | Slight change | Slight surface fuzzing |
| 3 | Moderate change | The specimen may exhibit one or both of the following:<br>(a) moderate fuzzing<br>(b) isolated fully formed pills |
| 2 | Significant change | Distinct fuzzing and/or pilling |
| 1 | Severe change | Dense fuzzing and/or pilling which covers the specimen. |




7.4 The preparation of a pilling sample.

tumbled together in a cork-lined box as shown in Fig. 7.5. The usual number of revolutions used in the test is 18,000 which takes 5 h. Some specifications require the test to be run for a different number of revolutions.

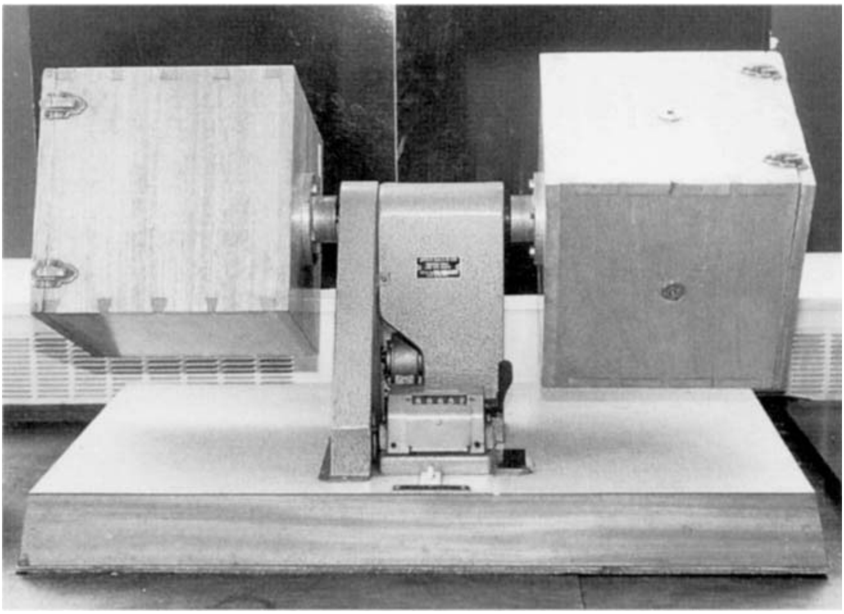
### Assessment

The specimens are removed from the tubes and viewed using oblique lighting in order to throw the pills into relief. The samples are then given a rating of between 1 and 5 with the help of the descriptions in Table 7.1.

### *Random tumble pilling test*

In this test [5] fabric specimens are subjected to a random rubbing motion produced by tumbling specimens in a cylindrical test chamber lined with a mildly abrasive material. In order to form pills that resemble those produced in actual wear in appearance and structure, small amounts of grey cotton lint are added to each test chamber with the specimens.

Three samples each 105 mm square are cut at an angle of 45° to the length of the fabric. The edges of the fabric samples are sealed by a suitable rubber adhesive to stop them fraying. All three samples are then placed in one test chamber which has been fitted with a fresh cork liner and 25 mg of the cotton lint is added. The machine is run for 30 min periods during which



7.5 A pilling box.

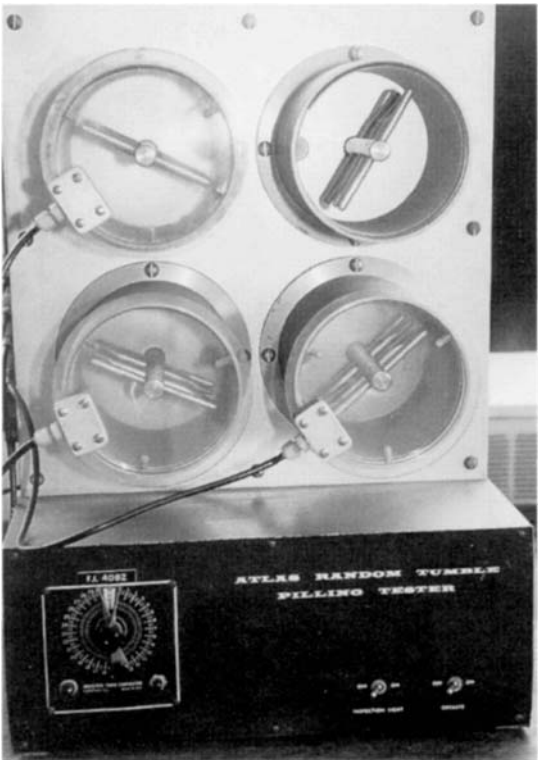
time the samples are tumbled by an impeller in the centre of the chamber. After each 30 min cycle the fabric is assessed and the chamber cleaned out and loaded with a fresh supply of lint. The number and timing of the cycles depend on the type of fabric being tested and would be laid down in the relevant specification. Figure 7.6 shows the chambers of a random tumble pilling tester.

In order to assess the amount of pilling on the fabrics they are placed in a suitable viewing cabinet which illuminates the pilled surface with light at a low angle so throwing the pills into relief. The fabric samples are assessed by comparing them with a set of photographic standards (ASTM or other), the rating being a subjective one using the following scale:

5 – no pilling
4 – slight pilling
3 – moderate pilling
2 – severe pilling
1 – very severe pilling

*Pilling test Swiss standard*

This test [6] uses the standard Martindale abrasion tester which is fitted with special large specimen holders and also has the driving pegs fitted at



7.6 The random tumble pilling tester.

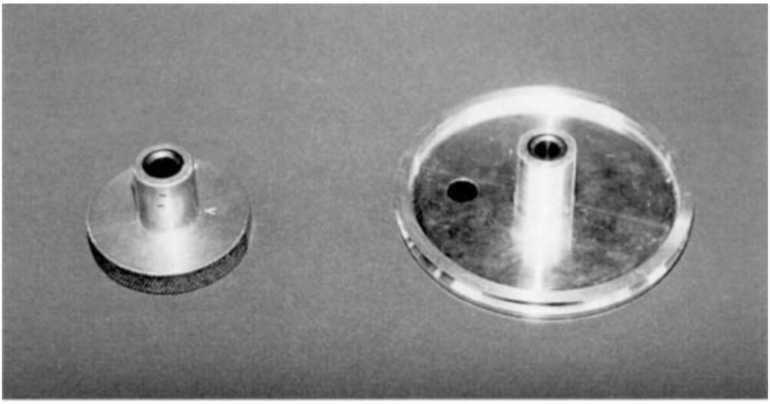
a smaller radius in order to give a reduced specimen movement. The specimen holders are shown in Fig. 7.7 alongside the standard abrasion holder for comparison. The specimen under test is rubbed against a sample of the same fabric at a low pressure and then assessed for pilling in the normal way.

Two pressures are used depending on the type of fabric being tested:

- 6.5 cN/cm$^2$ woven and upholstery fabrics — extra weight in holder
- 2.5 cN/cm$^2$ knitted fabrics — holder only

Method

In the test three pairs of samples each 140 mm in diameter are cut from the fabric. One sample of each pair is mounted on the lower holder of the Martindale in place of the standard abradant. The other sample is mounted in the special pilling holder with a felt pad underneath. The sample is held in place by a large O ring. The sample holder is then mounted on the



7.7 A Swiss pilling holder compared with a standard holder.

machine in the normal way using a spindle but with no weight on the top of the spindle. Woven and upholstery fabrics require an extra circular weight placed in the top of the sample holder.

Three pairs of samples are tested as follows:

- One pair for 125 rubs.
- One pair for 500 rubs.
- One pair for 4 × 500 rubs, the specimens being brushed every 500 rubs to remove loose material. This pair forms the main assessment.

Assessment

Each pair of specimens is assessed and the grade is noted against the number of rubs although the final pair constitutes the main assessment.

Pilling is graded on a 5-point scale. If the degree of pilling is different on the upper and lower specimens then the upper specimen is assessed:

Grade 5 No or very weak formation of pills
Grade 4 Weak formation of pills
Grade 3 Moderate formation of pills
Grade 2 Obvious formation of pills
Grade 1 Severe formation of pills

*Other Martindale pilling tests*

A number of pilling tests have been designed around the standard Martindale abrasion tester. In most of these the fabric under test is mounted both in the holder and on the baseplate so that it is rubbed against itself. The fabric from the holder is the one that is usually assessed. Most test methods use the bare spindle without added weights but they differ in the number of rubs given to the sample. The results can then be assessed against a set of photographic standards. The advantage of these methods is that they are much quicker than the pill box.

## 7.4 Abrasion resistance

### 7.4.1 Factors affecting abrasion resistance

The evidence concerning the various factors that influence the abrasion resistance of fabrics is contradictory. This is because the experiments have been carried out under widely different conditions in particular using different modes of abrasion. Therefore the results are not comparable and often opposing results have been reported. The factors that have been found to affect abrasion [7, 8] include the following.

*Fibre type*

It is thought that the ability of a fibre to withstand repeated distortion is the key to its abrasion resistance. Therefore high elongation, elastic recovery and work of rupture are considered to be more important factors for a good degree of abrasion resistance in a fibre than is a high strength.

Nylon is generally considered to have the best abrasion resistance. Polyester and polypropylene are also considered to have good abrasion resistance. Blending either nylon or polyester with wool and cotton is found to increase their abrasion resistance at the expense of other properties. Acrylic and modacrylic have a lower resistance than these fibres while wool, cotton and high wet modulus viscose have a moderate abrasion resistance. Viscose and acetates are found to have the lowest degree of resistance to abrasion. However, synthetic fibres are produced in many different versions so that the abrasion resistance of a particular variant may not conform to the general ranking of fibres.

*Fibre properties*

One of the results of abrasion is the gradual removal of fibres from the yarns. Therefore factors that affect the cohesion of yarns will influence their abrasion resistance. Longer fibres incorporated into a fabric confer better abrasion resistance than short fibres because they are harder to remove from the yarn. For the same reason filament yarns are more abrasion resistant than staple yarns made from the same fibre. Increasing fibre diameter up to a limit improves abrasion resistance. Above the limit the increasing strains encountered in bending counteract any further advantage and also a decrease in the number of fibres in the cross-section lowers the fibre cohesion.

*Yarn twist*

There has been found to be an optimum amount of twist in a yarn to give the best abrasion resistance. At low-twist factors fibres can easily be removed from the yarn so that it is gradually reduced in diameter. At high-twist levels the fibres are held more tightly but the yarn is stiffer so it is unable to flatten or distort under pressure when being abraded. It is this ability to distort that enables the yarn to resist abrasion.

Abrasion resistance is also reported to increase with increasing linear density at constant fabric mass per unit area.

*Fabric structure*

The crimp of the yarns in the fabric affects whether the warp or the weft is abraded the most. Fabrics with the crimp evenly distributed between warp and weft give the best wear because the damage is spread evenly between them. If one set of yarns is predominantly on the surface then this set will wear most; this effect can be used to protect the load-bearing yarns preferentially. One set of yarns can also be protected by using floats in the other set such as in a sateen or twill weave. The relative mobility of the floats helps to absorb the stress.

There is an optimum value for fabric sett for best abrasion resistance. The more threads per centimetre there are in a fabric, the less force each individual thread has to take. However, as the threads become jammed together they are then unable to deflect under load and thus absorb the distortion.

## 7.4.2 Abrasion tests

*Factors affecting abrasion tests*

Very many different abrasion tests have been introduced [7, 8]. Poor correlation has been found both between the different abrasion testers and between abrasion tests and wear tests [8, 9]. The methods that have survived to become standards are not necessarily the 'best' ones. Among the factors which can affect the results of an abrasion test are the following.

Type of abrasion

This may be plane, flex or edge abrasion or a combination of more than one of these factors.

### Type of abradant

A number of different abradants have been used in abrasion tests including standard fabrics, steel plates and abrasive paper or stones (aluminium oxide or silicon carbide). The severity as well as the type of action is different in each case. For the test to correspond with actual wear in use it is desirable that the abrasive should be similar to that encountered in service. An important concern is that the action of the abradant should be constant throughout the test. It is likely that the abradant itself will wear during the test thus changing its abrasive properties. Equally it can become coated in material from the abraded sample, such as finishes which can then act as lubricants so reducing its effectiveness.

### Pressure

The pressure between the abradant and the sample affects the severity and rate at which abrasion occurs. It has been shown that using different pressures can seriously alter the ranking of a set of fabrics when using a particular abradant [8]. Accelerated destruction of test samples through increased pressure or other factors may lead to false conclusions on fabric behaviour. For instance accelerated tests do not allow for any relaxation of fibres and fabrics a factor which can be expected during normal use.

### Speed

Increasing the speed of rubbing above that found in everyday use also brings the dangers of accelerated testing as described above. A rise in temperature of the sample can occur with high rubbing speeds; this can affect the physical properties of thermoplastic fibres.

### Tension

It is important that the tension of the mounted specimen is reproducible as this determines the degree of mobility of the sample under the applied abradant. This includes the compressibility of any backing foam or inflated diaphragm.

### Direction of abrasion

In many fabrics the abrasion resistance in the warp direction differs from that of the weft direction. Ideally the rubbing motion used by an abrasion machine should be such as to eliminate directional effects.

### Method of assessment

Two approaches have been used to assess the effects of abrasion:

1. Abrade the sample until a predetermined end-point such as a hole, and record the time or number of cycles to this.
2. Abrade for a set time or number of cycles and assess some aspect of the abraded fabric such as change in appearance, loss of mass, loss of strength change in thickness or other relevant property.

The first approach corresponds to most people's idea of the end point of abrasion but the length of the test is indeterminate and requires the sample to be regularly examined for failure in the absence of a suitable automatic mechanism. This need for examination is time consuming as the test may last for a long time. The second approach promises a more precise measurement but even when the sample has rubbed into a hole the change in properties such as mass loss can be slight.

However none of the above assessment methods produces results that show a linear or direct comparison with one another [8]. Neither is there a linear relationship between successive measurements using any of these methods and progressive amounts of abrasion.

### *Martindale*

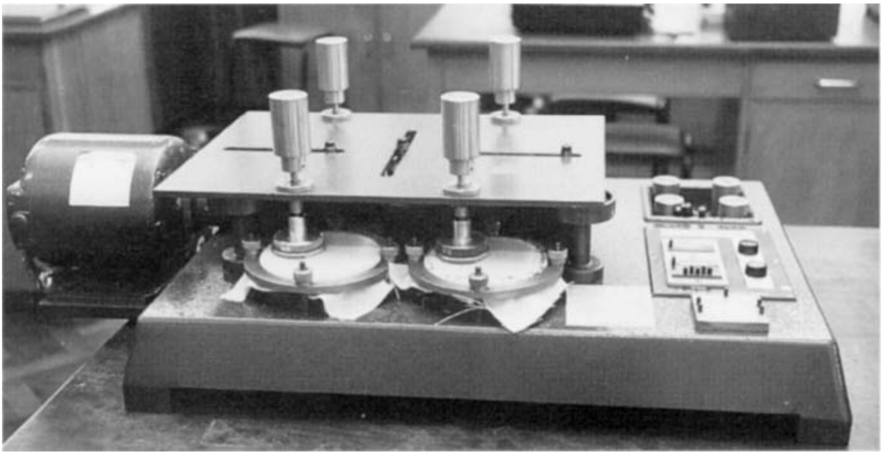
This apparatus [10] is designed to give a controlled amount of abrasion between fabric surfaces at comparatively low pressures in continuously changing directions.

The results of this test should not be used indiscriminately, particularly not for comparing fabrics of widely different fibre composition or construction.

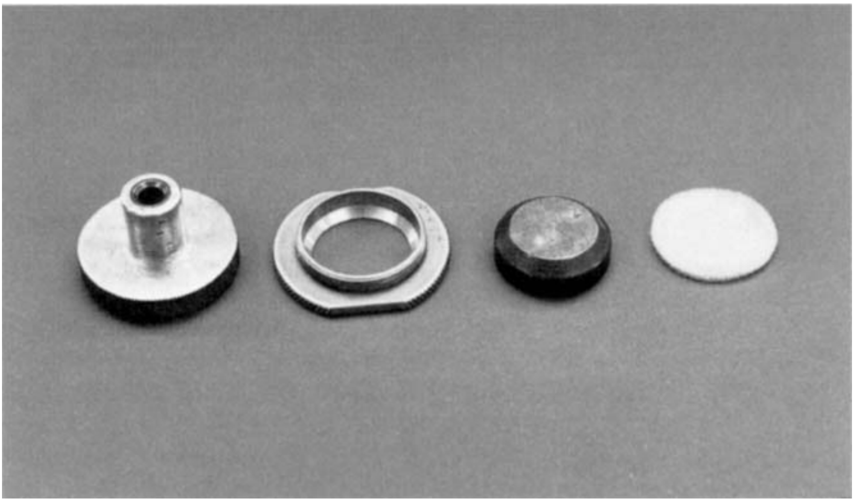
In the test circular specimens are abraded under known pressure on an apparatus, shown in Fig. 7.8, which gives a motion that is the resultant of two simple harmonic motions at right angles to one another. The fabric under test is abraded against a standard fabric. Resistance to abrasion is estimated by visual appearance or by loss in mass of the specimen.

### Method

Four specimens each 38 mm in diameter are cut using the appropriate cutter. They are then mounted in the specimen holders with a circle of standard foam behind the fabric being tested. The components of the standard holder are shown in Fig. 7.9. It is important that the mounting of the sample is carried out with the specimens placed flat against the mounting block.

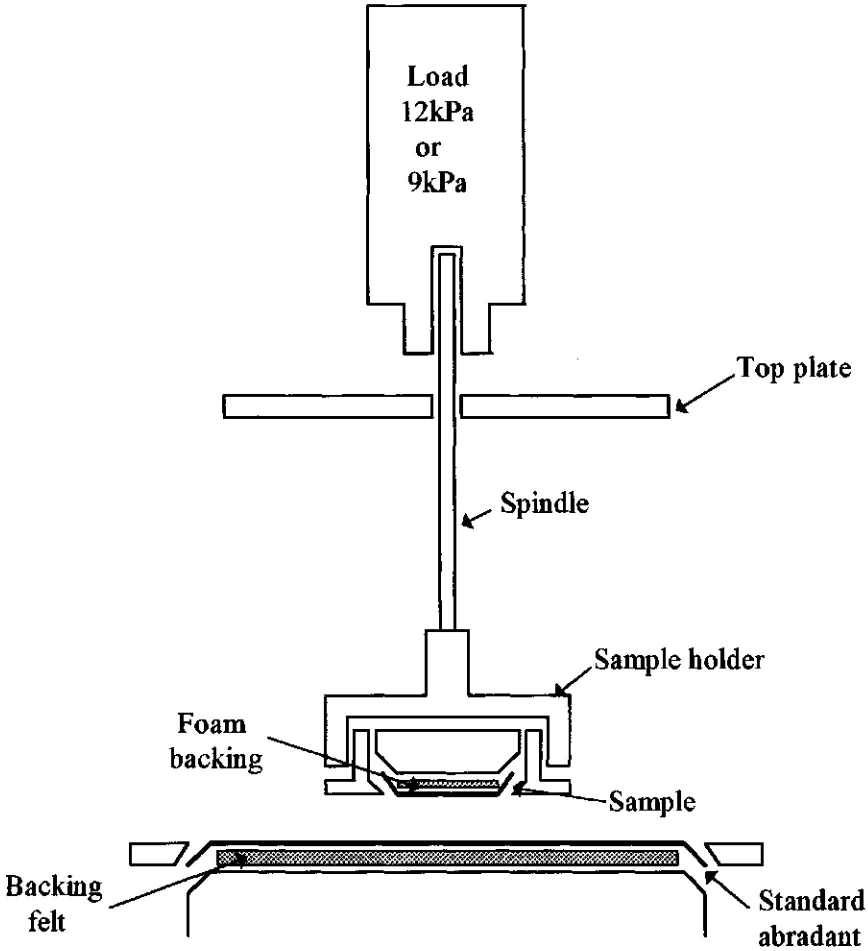


7.8 The Martindale abrasion tester.



7.9 A standard holder for the Martindale abrasion test.

The test specimen holders are mounted on the machine with the fabric under test next to the abradant. A spindle is inserted through the top plate and the correct weight (usually of a size to give a pressure of 12 kPa but a lower pressure of 9 kPa may be used if specified) is placed on top of this. Figure 7.10 shows the sample mounted in a holder. The standard abradant should be replaced at the start of each test and after 50,000 cycles if the test is continued beyond this number. While the abradant is being replaced it is




7.10 One station of a Martindale abrasion tester.

held flat by a weight as the retaining ring is tightened. Behind the abradant is a standard backing felt which is replaced at longer intervals.

### Assessment

The specimen is examined at suitable intervals without removing it from its holder to see whether two threads are broken. See Table 7.2 for the time lapse between examinations. If the likely failure point is known the first inspection can be made at 60% of that value. The abrading is continued until two threads are broken. All four specimens should be judged individually.

*Table 7.2* Inspection intervals for Martindale abrasion test

| Estimated number of cycles | Intervals for inspection |
|---|---|
| Up to 5,000 | Every 1,000 |
| Between 5,000 and 20,000 | Every 2,000 |
| Between 20,000 and 40,000 | Every 5,000 |
| Above 40,000 | Every 10,000 |

The individual values of cycles to breakdown of all four specimens are reported and also the average of these.

### Average rate of loss in mass

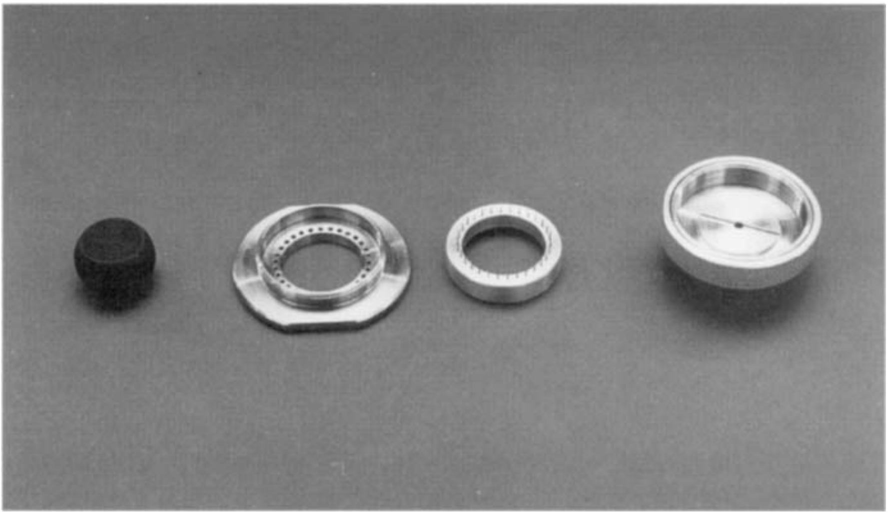
This is an alternative method of assessing abrasion resistance which requires eight specimens for the test. Two of these are abraded to the end-point as described above and then the other pairs are abraded to the intermediate stages of 25%, 50% and 75% of the end point. The samples are weighed to the nearest 1 mg before and after abrasion so that a graph can be plotted of weight loss against the number of rubs. From the slope of this graph, if it is a straight line, the average loss in mass measured in mg/1000 rubs can be determined.

### *Abrasion resistance for hosiery*

This test makes use of a modified specimen holder for the Martindale abrasion tester, which stretches the knitted material thus effectively accelerating the test. The holder, shown in Fig. 7.11, takes a standard size 38 mm diameter sample which is held to size by a pinned ring. A flattened rubber ball is pushed through the sample as the holder is tightened thus stretching it. The holder is then mounted on the Martindale with a 12 kPa weight and the test carried out as normal. The sample is inspected at suitable intervals until a hole appears or the material develops an unacceptable level of thinning.

### *Accelerotor*

The Accelerotor abrasion tester [11] has an action that is quite different from most other abrasion testers. In the test an unfettered fabric specimen is driven by rotor inside a circular chamber lined with an abrasive cloth.

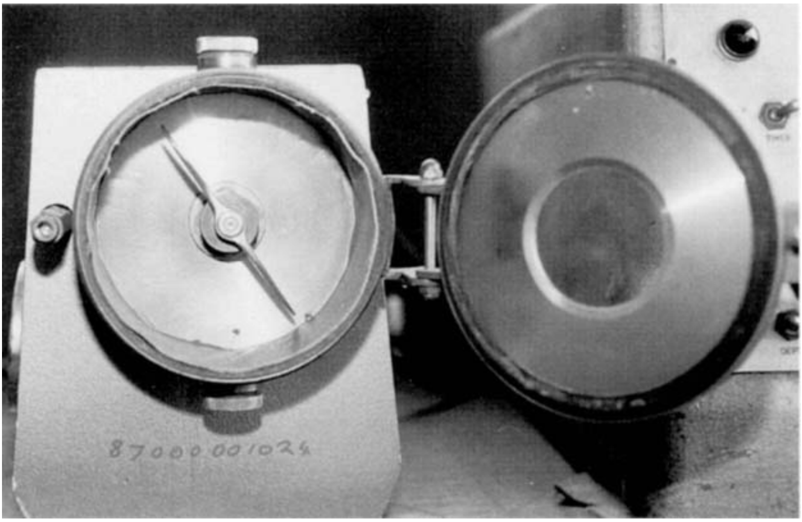


7.11 A sock abrasion test holder.

The apparatus, shown in Fig. 7.12, is fitted with a variable speed drive and a tachometer to indicate the rotation speed. The sample suffers abrasion by rubbing against itself as well as the liner. Evaluation is made either on the basis of the weight loss of the sample or on the loss in grab strength of the specimen broken at an abraded edge. In each case three specimens are tested.

For evaluation by weight loss, square specimens are cut with pinking shears, the size of specimen being determined by the cloth weight. The cut edges are coated with adhesive to prevent fraying and allowed to dry. The specimens are conditioned and then weighed to ±0.001 g. Each specimen is then placed in the Accelerotor and run for the desired time at the selected speed. It is then taken out from the machine, any loose debris removed, conditioned and weighed again. The percentage weight loss for each specimen is then calculated.

For evaluation by loss in strength, specimens measuring 100 mm × 300 mm are used in order to provide two grab test samples. Each specimen is numbered at both ends and then cut in half. One half is used for determining the original grab strength and the other half for determining the grab strength after abrading. The half to be abraded has its edges adhesive coated as above. It is then folded 50 mm from the short edge making it into a 100 $mm^2$ square. This flap is stitched down to the main body so that the folded edge will be abraded during the test. The sample is then run in the Accelerotor under the chosen conditions and the stitching removed.



7.12 The Accelerotor abrasion tester.

The breaking strength is then determined by the grab method (described in Chapter 5), making sure that the worn edge is in the portion being tested. The breaking strength of the matching original is also determined and the percentage loss in breaking strength of each pair of specimens is calculated.

### *Taber abraser*

In this instrument [12] the fabric is subjected to the wear action of two abrasive wheels which press onto a rotating sample. The wheels are arranged at diametrically opposite sides of the sample so that they are rotated in the opposite direction by the rotation of the sample. The abrading wheels travel on the material about a horizontal axis which is displaced tangentially from the axis of the test material, so resulting in a sliding action of the abrasive on the sample. This gives rise to an X pattern of wear caused by the tracks of the two abrasive wheels being displaced relative to each other. Debris from the abrasive action is removed during the test by a vacuum nozzle.

The wheels normally used for testing textiles are the rubber base resilient type composed of abrasive grains embedded in rubber. These are made in different abrasive grain sizes. The loads used can be 125, 250, 500 or 1000 gf (1.23, 2.45, 4.9 or 9.81 N).

Evaluation can be by: (1) the number of cycles to a visual end-point, that is a predetermined point at which the material has undergone a marked change in appearance such as removal of the pile or when it has broken down physically; (2) residual breaking load; the breaking load of the abraded sample is measured using a gauge length of 25 mm (1 in), making sure that the abraded part of the sample is between the jaws; or (3) percentage loss in breaking load, obtained by calculating the breaking load after abrasion as a percentage of the breaking load of the original fabric.

## 7.5 Wearer trials

The main purpose of laboratory tests is to obtain prior knowledge of the performance of textile products in service. The assumption is made that when such tests are carried out, there is some relationship between the results of the laboratory tests and the performance of the items in use. In order to design laboratory testing procedures that correlate with end use performance the conditions of actual use must be carefully analysed so that they can be simulated as closely as possible in a controlled setting. Since actual wear is such a complex phenomenon, however, laboratory tests are usually designed to evaluate only one or a limited number of variables at a time.

In a wearer trial the product (garment, furnishing, carpet etc.) is used in the 'normal' manner and a report is made at intervals on its behaviour. When comparing these trials with laboratory testing there are certain important differences.

In general user trials are not widely used in industry. Wearer trials are more usually carried out by large organisations, for example BTTG, IWS, Courtaulds and ICI, very often using their own staff as garment users. The trials are often used to compare a new material or process against one that is known to be satisfactory in service. The cost of user trials may be very high and as a result they are most used for fairly low-priced but common articles, for example, socks, tights, tea-towels, shirts, children's trousers, blazers and sheets, rather than for carpets or furniture.

### 7.5.1 Advantages of wearer trials

1 In a wearer trial the material receives treatment similar to that experienced in normal wear. For example clothing breaks down due to a combination of loading, flexing, pilling and rubbing together with the effect of light, perspiration and bacteria. These causes can interact to produce a more rapid breakdown than would be the case with any of the indi-

vidual causes. It may not be possible to imitate the normal wear pattern in a laboratory.

2 A wearer trial tests all the components which make up a garment such as buttons, sewing thread, seams, lining and cuffs. Laboratory tests on the separate components may not show faults due to making up.

### 7.5.2 Disadvantages of wearer trials

1 Wearer trials are difficult to control and organise as it is necessary to rely on the user to treat the article normally and to report accurately and at the required time on its performance. It is quite possible that in a large trial some garments may be untraced at the end of the work because of people moving, losing interest or the article may become lost or destroyed.

2 Wearer trials are expensive because of the cost of producing garments from a fabric rather than testing the fabric itself. Parallel trials may also be needed using control garments if, for instance, an improved product is to be compared with a standard product. There are also the personnel costs to be considered in collecting, assessing and distributing articles.

3 It is impossible to achieve 'normal wear'. The intensity of wear depends on a large number of factors: the type of employment of the wearer, for instance manual workers may put more strain on their clothes than office workers, and the cleanliness of the working environment also plays a part; the size and weight of the person, in that a large person may be expected to put a higher stress on certain parts of a garment, and closeness of fit of the garment is a related factor; the individual habits of the wearers, for instance they may ride a bicycle to work so causing extra wear on trousers; the time of year – items such as pullovers will be worn more often in the cold months. The weather also influences the wearing of other garments at the same time as the test garment so having an effect on the pilling performance of the test garment for instance.

4 One of the main problems in conducting wearer trials is that of finding suitable groups of people who live similar lives, come together on a regular basis and who will co-operate. It is not possible to select 50 people at random from the phone book as they would never be seen again after handing out the garments. Suitable groups of people include: police officers, nurses, post-office staff, boarding school pupils, prisoners and students.

5 In a trial the garments are usually examined and assessed at regular intervals. These assessments cannot be destructive as the garments have to be worn again, so they have to be subjective. Ideally an individual trial would finish at some definite change in property such as the appear-

ance of a hole but the criteria for judging that the end of a garment's useful life has been reached are not usually as definite as this and involve a judgement as to what is unacceptable. Therefore there is a serious problem with the accuracy and reproducibility of these assessments and their relationship with laboratory tests.

6 The most serious problem with wearer trials is that they take a very long time to complete as their time span must be similar to that of the life expectancy of the article being tested and are therefore no use if rapid results are required.

### 7.5.3 Advantages of laboratory tests

1 They are rapid. Most tests can be completed within a day.
2 They are designed to give objective results. A numerical result or rating allows one fabric to be ranked as being better or worse than another fabric even when the differences between them are small.
3 The tests are under the direct control of the tester. This allows the conditions of test to be exactly specified and factors other than those under test to be kept constant.
4 They can be reproduced. An identical test carried out on the same fabric should ideally give the same result in any laboratory and with any operator.

### 7.5.4 Disadvantages of laboratory tests

1 Laboratory tests can only imitate wear conditions
2 For a complete evaluation of a fabric it is necessary to use a large range of expensive equipment.
3 Laboratory tests are rapid because many of them aim to accelerate the natural causes of wear. Speeding up a test may give false results, for example the continuous action of abrasion tests may cause heating of the material which is not present in normal use.

### 7.5.5 Design of trials

In planning a trial a balance has to be struck between what should be done and what can be done. It is convenient to issue garments for a certain number of days then collect, inspect and wash them all under identical conditions. This eliminates any possibility of differences in performance which are due to different washing conditions. Alternatively, users may be left to wash the garment in their normal way as well as wearing it, making out a report at intervals. This of course introduces further variables but may be considered closer to 'normal' use. It is important in such tests that the person wearing the garment should not know the details of composition, etc.

The US Standard for wearer trials [13] has the following recommendations: that control garments are used which have a known wear performance history. It is not possible to ensure that wearer trials undertaken at different times have the same severity as the people who undertake the trial and their circumstances can change. It is not possible to repeat a wearer trial as each one is different.

1 Decide on the garment that is to be tested.
2 Define the object of the test and the information that is to be obtained. For instance: the performance properties to be evaluated, the areas of garments to be examined, how the performance will be evaluated and what scale is to be used for this. Decide in advance what ratings for these properties will constitute satisfactory or unsatisfactory performance.
3 Establish the percentage of specimens that must fail in order to constitute overall unsatisfactory performance. The test is terminated when this point has been reached.
4 Establish the number of wash/wear cycles that will constitute satisfactory performance.
5 Define the wear – laundering cycle (or other method of refurbishing) by the number of hours worn or by the number of wearings before laundering and the method of laundering.
6 Decide on the number of participants.
7 Permanently label each garment with a code to identify the wearer and garment, keep new garment for comparison purposes.
8 Issue garments with instructions.
9 Evaluate after each wash/wear cycle and record ratings.

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