Quality Assurance and Quality Control

QA is a program for the systematic monitoring and evaluation of the various aspects of a project, service or facility to ensure the standards of quality are being meet. A part of quality management focused on providing confidence that quality requirements will be fulfilled.

QC concerned with sampling, specification & testing and with the organization, documentation and release procedures which ensure that the necessary and relevant tests actually carried out and the materials are neither released for use, nor products are used for sale and supply until their quality has been satisfactory. Adequate facilities, trained personnel and approved procedures must be available for sampling, inspecting and testing of starting materials, packaging materials and intermediate bulk and finished products.

Quality Assurance	Quality Control
The goal is to develop a process so that **defects do not arise** during production	It identifies the **defects after the product** is produced but is not yet released or is still in the production phase
Preventive/Proactive Technique. Aims to **prevent** defects	Corrective/Reactive Technique. Aims to **identify** and fix defects
Defines standards and procedures that need to be adhered to in order to meet **customer requirements**	Ensure the standards are followed while **working on the product**
Activities are determined **before** production work begins and performed while the product is being developed	Activities are performed **after** the product is developed
Is for **entire** life cycle	Is for **testing** part
Makes sure quality team **is doing** the right thing in the right way	Makes sure that whatever the quality team **has done** is as per the requirement or expectation
Is a **managerial** tool and duty of complete **project** team	Is a **corrective** tool and duty of the **testing** team
Process oriented exercise and normally human based checking	**Product** oriented exercise and normally computer-based execution
Done **before** QC	Done **only after** QA and time consuming.
Comes under the category of **verification**	Comes under the category of **validation**
Helps **build processes** and involves processes managing quality	Implement the **existing processes** and used to verify the quality of the product
Statistical technique used on QA is known as Statistical Process Control **(SPC)**	Statistical technique used on QC is known as Statistical Quality Control **(SQC)**
Example: **Quality Audit**	Example: **Inspection and Testing**

Offline and Online Quality Control

To maintain quality, a manufacturer conducts offline quality control tests in the product design phase to reduce the deviation of the target product, whereas online quality control is conducted during the production process phase in which issues are anticipated an corrected to avoid any out of control manufacturing.

Offline Quality Control: This type of quality control consists of laboratory tests which are done by stopping the production process. Example: Checking of count and TPI variation

Online Quality Control: This type of quality control is performed in process stage i.e. without stopping the production process, during the production running time, the machine automatically tests the variation and takes immediate step to rectify the variation. Example: Roving tension control device in simplex frame.

Standardization body
BSTI
Functions
ISO
Benefits & Standard
Popular Standard
AATCC
Test Method & Activits
BSI
DIN

STANDARDS

Standard:

A standard is a document that provides requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose.

There are several renowned standardization bodies like

A. BSTI
B. ISO
C. AATCC
D. BSI
E. DIN

Standardization body
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BSTI

Bangladesh Standards and Testing Institution (BSTI), the only National Standards body of Bangladesh, is playing an important role in developing and Promoting industrial Standardization. The BSTI is a body corporate and its administrative Ministry is the Ministry of Industries. The institution so formed has become member of the International Organization for standardization (ISO) in 1974.

Only the standards approved, and passed by the institution are called Bangladesh Standards. As a rule, the Bangladesh Standards are voluntary.

Standardization body
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BSTI

The main functions of BSTI

- BSTI is entrusted with the responsibility of formulation of national Standards of industrial, food and chemical products keeping in view the regional and international standards.
- BSTI is responsible for the quality control of the products which are ensured as per specific national standards made by the technical committees formed by BSTI.
- BSTI is also responsible for the implementation of metric system and to oversee the accuracy of weights and measures in the country.

Standardization body
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ISO

ISO is an independent, non-governmental international organization with a membership of 162 national standards bodies. Its Central Secretariat is based in Geneva, Switzerland. Today it have members from 162 countries and 3368 technical bodies to take care of standard development. More than 150 people work full time for ISO's Central Secretariat in Geneva, Switzerland.

ISO has published more than <u>20500 International Standards</u> and related documents, covering almost every industry, from technology, to food safety, to agriculture and healthcare. ISO International Standards impact everyone, everywhere.

Standardization body BSTI Functions ISO Benefits & Standard Popular Standard AATCC Test Method & Activits BSI DIN	**ISO** **What are the benefits of ISO International Standards?** ISO International Standards ensure that products and services are safe, reliable and of good quality. For business, they are strategic tools that reduce costs by minimizing waste and errors and increasing productivity. They help companies to access new markets, level the playing field for developing countries and facilitate free and fair global trade. **How does ISO develop standards?** ISO standards are developed by the people that need them, through a consensus process. Experts from all over the world develop the standards that are required by their sector. This means they reflect a wealth of international experience and knowledge.

Standardization body BSTI Functions ISO Benefits & Standard Popular Standard AATCC Test Method & Activits BSI DIN	**ISO** Popular standards ISO 9000 - Quality management ISO 14000 - Environmental management ISO 22000 - Food safety management ISO 26000 - Social responsibility ISO 20121 - Sustainable events ISO 27001 - Information security ISO 45001 - Occupational Health and Safety

Standardization body BSTI Functions ISO Benefits & Standard Popular Standard AATCC Test Method & Activits BSI DIN	**AATCC** Founded as the American Association of Textile Chemists and Colorists (AATCC), the Association continues to evolve to meet the needs of those in the ever-changing textile and materials industries. AATCC has served textile professionals since 1921. Today, the Association provides test method development, quality control materials, education, and professional networking for a global audience. ◻Members Members are Employees of textile, apparel, and home goods manufacturers; ◻Dye and chemical manufacturers; ◻Testing laboratories; ◻Consumer and retail organizations; ◻State and federal government agencies; and ◻Colleges and universities. AATCC has thousands of individual and corporate members in more than 60 countries world wide.

Standardization body BSTI Functions ISO Benefits & Standard Popular Standard AATCC Test Method & Activits BSI DIN	**AATCC** **Test Methods** AATCC is internationally recognized for its standard methods of testing fibers and fabrics to measure and evaluate such performance characteristics as colorfastness, appearance, soil release, dimensional change, and water resistance. New and updated test methods are published annually in the *AATCC Technical Manual*. **Activities** Today, the scope of AATCC reaches far beyond chemists and colorists. Workshops, conferences and publications address topics ranging from design technology to composite materials science.

Standardization body	BSI
BSTI Functions ISO Benefits & Standard Popular Standard AATCC Test Method & Activits BSI DIN	BSI British Standards is the UK's national standards organization that produces standards and information products that promote and share best practice. The BSI was founded in 1901 and subsequently received a Royal Charter which meant that it became the recognised national body responsible for the development and agreement of standards. This was done in response to the demand from buyers that products would meet defined specifications and performance measures. It serves the interests of a wide range of industry sectors as well as governments, consumers, employees and society overall, to make sure that British, European and international standards are useful, relevant and authoritative.

Standardization body	DIN
BSTI Functions ISO Benefits & Standard Popular Standard AATCC Test Method & Activits BSI DIN	DIN is a private organization that is registered as a non-profit association. The DIN Presidial Board is responsible for standardization policy and makes business and financial policy decisions for DIN and its subsidiary and associated companies either directly or through its commissions.

Standardization body	ASTM
BSTI Functions ISO Benefits & Standard Popular Standard AATCC Test Method & Activits BSI DIN	American Society for Testing and Materials

Fabric Dimension

Consideration before Going to Test

Standard Conditioning (Atmospharic and Relaxation)

British = Full fabric has to be relaxed

ISO = a piece of fabric testing then corrections to be made

Fabric Length

Fabric length is the distance from end to end, along the selvedge of a fabric

Fabric Length Measurement

Pre work: Condition, Relaxation, Crease, Tension

Three Methods

1. By Using measuring table
2. By Using measuring scale
3. By Using a measuring machine (Trumeter)

Fabric Width

Fabric width is the distance from the outside of one selvedge to another measured perpendicular to the length of the fabric(selvedge of the fabric)

Pre Work is must

Indian Standard suggests => 5 measurement at pointsevenly space along the length of fabric

British Standard suggests => 10 measurements at roughly equal distance throught the full length of the piece. If full lenth is not availble, a sample length of not less than one yard should be used and its width meaasued at three places. Then mean..

Fabric Width Measurement

- Right angle to selvedge
- 5 times or 10 times
- Avg
- Round off (to nearest 1 mm for width upto 50 cm inclusive)
  (to nearest 5 mm for the width upto 100 cm inclusive)
  (to nearest 10 mm for teh width over 100 cm)

For Narrow Fabric with irregular sedvedge, at least two reading
For continuous measuring, a pair of photo electric cells is used and data recorded on chart

Points to be considered

- If wavy selvedge are present (due to weft tension variation or weave effect), max and min widths should be recorded, and wavy selvedge reported.

- If full width of the fabric is requried, include selvedge.

- If width of the body is required, ignore selvedge.

Fabric Thickness

For measuring the thickness of a wire or a plate, calipers or micrometers are used. But the use of these things for the measurement of thickness of fabric is not possible, since fabrics are liable to compress during measuring. Therefore, the measurement of fabric thickness demands an accuracy.

The following points need to be considered in fabric thickness measurement

1. Shape and size of the pressure foot:

Normally a circular foot of diameter 3/8 inch is used. The ratio between the foot diameter to the cloth thickness should not be less than 5:1.

2. Shape and size of the anvil:

If the anvil is of circular type its diameter should be at least two inch greater than the pressure foot. When the sample is larger than the anvil a smooth plane board may conveniently surrounded the anvil for suitable support for the cloth.

3. Applied pressure:

Suitable weight may be added to the pressure foot and preferred pressure may be applied.

4. Velocity of pressure foot:

The pressure foot should be lowered on to the sample very slowly (at a rate of 2/1000 inch per sec) and carefully.

5. Time:

The thickness is read from the dial of the instrument only when the pointer ceased variations and not earlier.

6. Indication of thickness:

Usually, a clock type dial gauge is built into the thickness tester. It should be rigidly mounted in a suitable frame. After setting the dial to zero, the instrument must be capable of measuring to an accuracy of 1% for fabrics over 0.1 millimetre in thickness and to 0.001 mm of fabrics which are not excluding 0.1 millimetre in thickness.

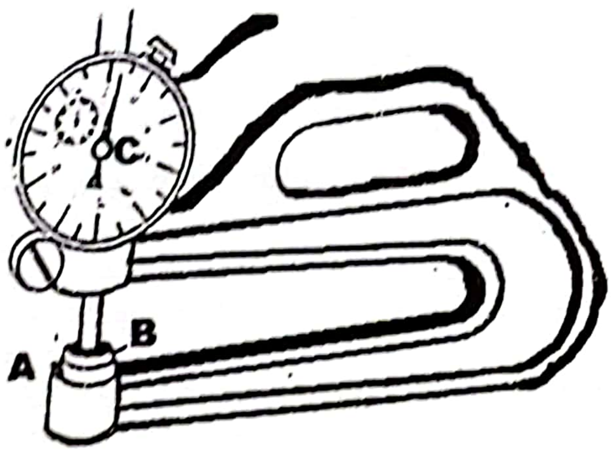


Fig: The Fabric Thickness Tester (A Anvil, B Presser Foot, C Pointer)

Method of Measuring Fabric Thickness

1. The presser foot and anvil are cleaned by a clean paper.
2. If required, weights are added to presser foot and the gauge is set to read zero.
3. No specimen preparation is required. But selvedges and creased areas should be avoided.
4. If possible, the cloth may be conditioned for about 24 hours in standard atmosphere.
5. At least, thickness is measured at 5 places and the mean value is reported.
6. In test report, details of the pressure, size of presser foot and the time should be given.

Fabric Thickness is mainly used

- for checking the conformity to the specifications

- in the study of fabric properties such as thermal insulation, resilience, dimensional stability, fabric stiffness, abrasion etc

- in the study of fabric geometry.

Yarn Crimp in Fabric

Due to the interlacement of warp and weft thread, a certain amount of waviness is imparted to the warp and weft threads in a fabric. This waviness is called crimp.

- ✓ It can be in two direction like warp crimp and weft crimp
- ✓ Normally weft crimp is higher than warp crimp [As warp yarns work in group during fabric formation]
- ✓ It is expressed in percentage. For a normal fabric, warp crimp is about 3%, and weft crimp is about 5%

Mathematically, Crimp = $\frac{l-p}{p} \times 100\%$

Here, l = Straightened thread length

p = The distance between the ends of the thread while in cloth (crimped length or length in fabric)

For warp and weft crimp we can use suffix 1 and 2.

The Measurement of Crimp Percentage

From the definition of the crimp two values must be known. These are l and p. In order to straighten the thread, tension must be applied, just sufficient to remove all the crimps without stretching the yarn. The standardized tension as per British standards are given below-

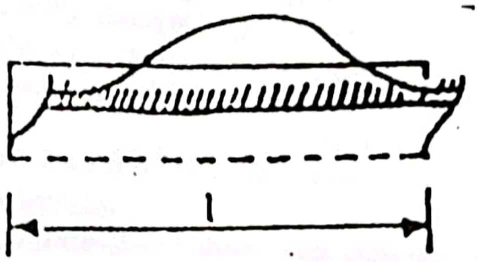
Yarn	**Count**	**Tension (gm)**
Cotton	Finer than 7 tex	0.75 tex
	Coarser than 7 tex	0.20 tex + 4
Woolen and Worsted	15-60 tex	0.20 tex + 4
	60-300 tex	0.07 tex + 12
All Man-made continuous filament	All counts	Tex/2

The principle of yarn crimp determination is very simple. With a fine pen and a ruler, lines are drawn on a piece of cloth at a known distance. Some of the threads are raveled out, the yarns are straightened without stretching and the stretched length is noted and from that crimp is calculated. The difficulty lies in the straightening of the Year Without stretching it. To do this, the following three methods are available-

1. **Straighten by hand;** This is inaccurate since we do not know the force applied.
2. **Straighten by a standard weight;** This is satisfactory if we know what weight to use.
   - Shirley Crimp Tester
   - Digital Crimp Tester (Heal's Instrument)
   - WIRA Crimp Tester etc
3. **Determine the straightened length from the load-elongation curve;** This is most accurate method.

Specimen Preparation:

Rectangular strips are carefully marked on the cloth and each strip is cut in the form of a flap. From each strip 10 threads will be removed. Normally, 3 strips in warp way and 3 strips in weft way are cut.

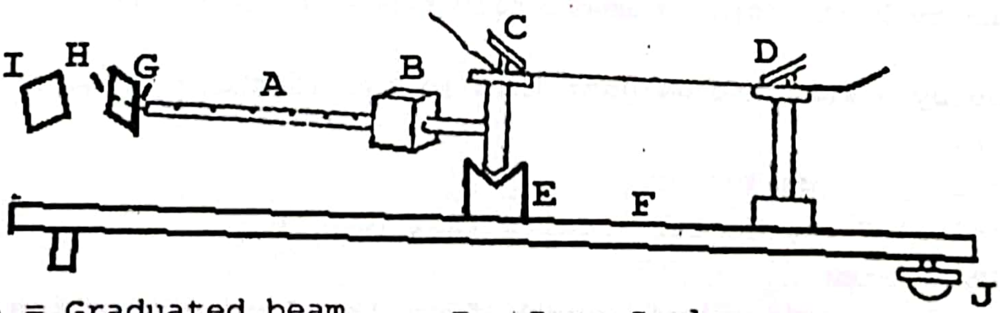


Removal of the Threads from the Flap:

The central part of the first thread is separated form the flap by means of a needle, but the two extreme ends are left secured. One end is then removed and place in the clamp of the tester and the other end is removed and placed in the second clamp. By this method, there will be no loss in the twist of the yarn and also due to minimum handling, there will be no stretch in the yarn.

Shirley Crimp Tester

The instrument consists of a scale fixed on a base. At one end of the base, V grooves are provided to support the balancing head and a mirror at the other end. At one end of the balancing head, a fixed clamp is provided and at its other end on the frame, index lines are marked. Another movable clamp is provided on the base and can be slide over the scale. Tension weight is provided on the balancing head to change the tension according to the yarn count. Tension scale is marked in two ranges, 0-35 gms and 0-175 gms.



A = Graduated beam
B = Tension weight
C = Fixed Jaw
D = Movable Jaw
E = V-Groove
F = Base Scale
G = Datum mark on the beam
H = Datum mark on the frame
I = Mirror
J = Levelling Screw

Fig: Shirley Crimp Tester

Procedure:

The counts of the warp and weft yarns are first determined and the correct tension is calculated. The sliding weight on the balancing head is adjusted to the required tension. The yarn sample si prepared as above and one end of the yarn is carefully inserted in the clamp such that the end of the yarn is in line with the rear edge of the clamp.

With the movable jaw set to a length somewhat less than the estimated length of the yarn, the other end of the yarn is inserted into it. The movable jaw is then moved slowly to the right until the index marks on the balancing head and the frame are in line. Then the length of the yarn corresponding to the red mark on the movable grip is noted from the base scale.

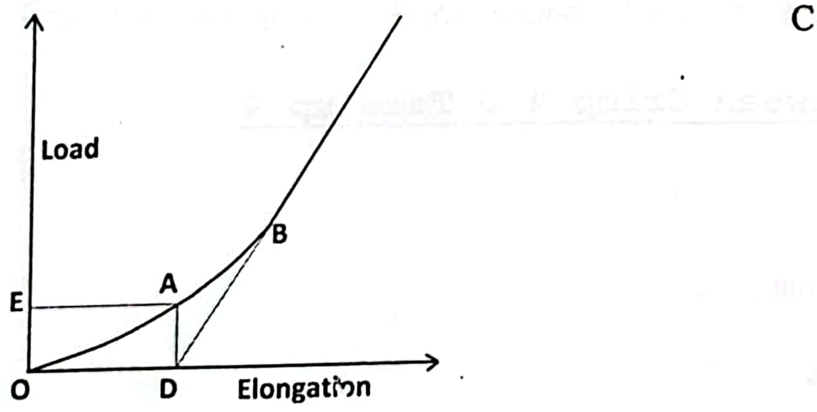
Then, the crimp can be calculated by putting l and p into the formula.

Digital Crimp Tester

Follow the link https://www.youtube.com/watch?v=bYtTLMSRYt8&t=336s

Load-Elongation Curve Method

Parallel ink lines are marked on a piece of cloth p distance apart. Five yarns are unraveled and one is tested at a time. The yarn is clamped at one of the ink spots and the yarn is allowed to hang vertically in front of the scale. A small clamp of known weight is hung on the yarn at the other ink spot. At this load, the elongation is read. Successively small loads are applied and the elongation at each new load is noted. Then a curve is drawn by taking the elongation value on the X- axis and the load values on the Y- axis.



In this curve, there is a curved portion OB and straight portion BC. The region OB represent the removal of the crimp. The region BC represent the stretch of the yarn. If there were no crimp, the curve would be all the straight-line DC. Therefore, the distance OD represents the elongation of the yarn due to the removal of crimp. Then the original length P plus the value OD is the length of the yarn before weaving is equal to L. So, L = P + OD

Then, the crimp can be calculated by putting l and p into the formula.

Influence of Crimp on Fabric Properties

1. Thickness
2. Resistance to Abrasion
3. Shrinkage
4. Fabric behaviors during tensile testing
5. Faults in Fabric
6. Fabric Design
7. Fabric Costing
8. Let off and take up speed variation

Take up Percentage

Take up percentage or crimp rigidity is a measure of the ability of textured yarn to receive from stretch and is related to the bulking properties of the yarn.

Take up percentage, $T = \frac{l-p}{l} \times 100$

Where, T= Take up percentage.
l = Length of yarn before weaving.
p = Length of yarn in fabric after weaving.

Relation between Crimp % & Take up %

Crimp Percentage, $C = \frac{l-p}{p} \times 100$ .... (1)

& *Take up percentage*, $T = \frac{l-p}{l} \times 100$ .... (2)

From eqation (1), $C = \frac{l-p}{p} \times 100$

=> $\frac{l-p}{p} = \frac{C}{100}$ .... (3)

=> $\frac{l}{p} - 1 = \frac{C}{100}$

=> $\frac{l}{p} = \frac{C}{100} + 1 = \frac{C+100}{100}$ .... (4)

From equation (2),

$$\Rightarrow \quad T = \frac{l-p}{l} \times 100$$

$$\Rightarrow \quad T = \frac{\frac{C}{100}}{\frac{C+100}{100}} \times 100 \qquad \textit{[Using equation (3) and (4)]}$$

$$T = \frac{100C}{100+C}$$

Similarly, following equation can be developed

$$C = \frac{100T}{100-T}$$

These two are the equations on the relationship between Crimp% & Take up%

Mathematical Problems

1. To produce 5000 m of fabric with 3% warp crimp, how many yards of each warp yarn will require?

2. Let you have 24″ × 20cm dimension fabric sample. Calculate the warp crimp and weft crimp when length of yarn is 62 cm and 21.1 cm respectively.

3. To produce 1500 yards of woven fabric having warp crimp 4% & weft crimp 6% of specification $\frac{114 \times 90}{20 \times 18} \times 56''$, how many cones of weft yarn will you require if the weight of each cone is 1.5 lb.

4. If the crimp% is 4.5% for warp of a fabric, then what will be its take up percentage.

5. Calculate crimp% and take-up% of woven fabric when its straightened length of yarn is 13 m and length of the warp yarn in fabric is 12.6 m.

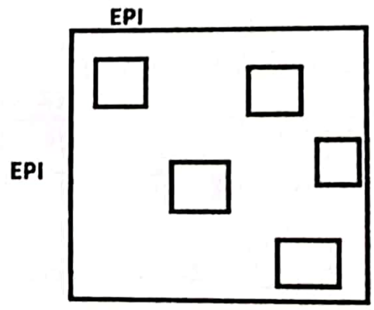
Threads/Inch in the Cloth or Fabric Count
Thread Density
Sett (Woven)

For Woven Fabric: In Warp, EPI
In Weft, PPI

For Knit Fabric: wpi, cpi

Determination of Threads per inch

1. Use of Counting Glass (Pick Glass)
2. Traversing Thread Counter
3. Fabric Dissection (Unravelling the cloth)
4. Parallel Line Grating
5. Tapper Line Grating



Method of Using Counting Glass

- Powerful Light Source and Table
- 5 Different palces has to be checked (Should not be same thread twice)
- Should avoid Selvedge

=> If the thread/inch is fewer than 25, No. of thread per 3 inch is taken and then divide the value by 3

=> If the fabric is less than 3", then Total threads has to be counted and then divide by the fabric width.

=> For Pile fabrics, Ground and pile has to be checked saperately

=> Denotaion should be 100 × 80. Should not be like 8,000

Problem 01:

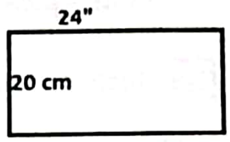
Here, Length in Fabric, P = 5000 m
Straightened Lenght, L = ?
Crimp, C = 3%

We Know, $C = \dfrac{L - P}{P} * 100\ \%$

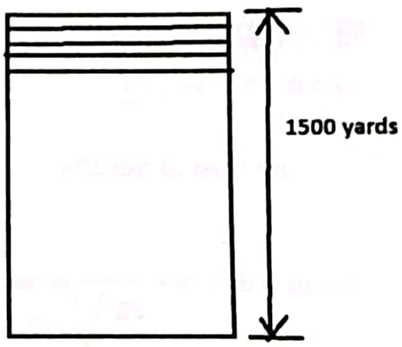
$=> L = CP/100\% + P$

$= (3\% * 5000m\ /\ 100\%) + 5000m$
$= 5150\ m$ (Ans)

Problem 02: Do



Problem 03 :



1500 yards = 1500 * 36 inch = 54000 inch

Total No. of Picks = 54000 * 90
= 4860000

Straightended length of each picks = $\dfrac{6\% * 56\ inch}{100\%}$ + 56 inch

= 59.36 inch

Total length of weft yarn = 4860000 * 59.36 * (1/36) yards
= 8013600 yards

Total weight of weft yarn = $\dfrac{8013600}{840 * 18}$ lb

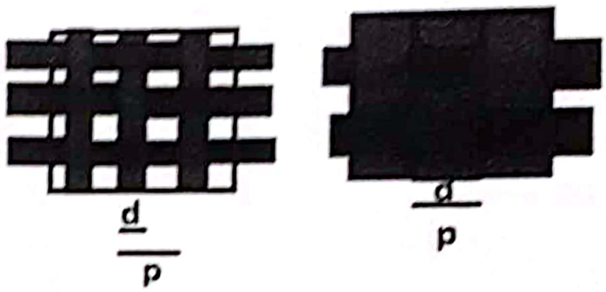
= 530 lb

No. of cones = 530/1.5 = 353.33

= 354 (round up)

No. of cones
354 (Ans)

Cloth Cover



$d = 1/28\sqrt{Ne}$ inch

Cover = d/p

P = thread spacing

d = dia of the yarn

p = 1/n

n= thread density

$$\text{Cover} = d/p = \frac{1}{28\sqrt{Ne}} * \frac{}{1/n} = \frac{n}{28\sqrt{Ne}}$$

Warp cover, K1 and Weft Cover, K2

Total Cover = $\boxed{K1 + K2 - K1 * K2}$

where, $K1 = \frac{n}{\sqrt{Ne}}$

Therefore, Cloth Cover, Kc = K1 + K2 - (K1 * K2 / 28)

Relative Cloth Cover =

[Relative warp Cover + Relative weft cover]-[Relative warp cover × Relative weft cover]

$$= \frac{K_1}{28} + \frac{K_2}{28} - \frac{K_1}{28} \times \frac{K_2}{28}$$

$$= 1/28\, [K_1 + K_2 - (K_1 K_2/28)]$$

Cloth Cover, $K_c = K_1 + K_2 - (K_1 K_2/28)$

K_1 = Warp Cover Factor
K_2 = Weft Cover Factor

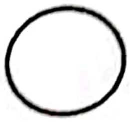
GSM Areal Density

1. $GSM = \dfrac{w * 10000}{A}$

w= weight in gm
A = Area in cm ^{2}

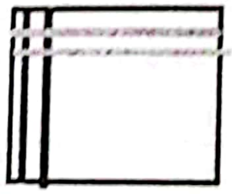
2. GSM = w * 100

w = weight of the GSM cutter sample in gm



3. GSM

1m



1m

weight of warp yarn = EPI * (39.37) * 1 * 1.0936 * (1/(840 * Ne)) * 453.6 gm

$$= 23.25 \frac{EPI}{\text{Warp Yarn Ne}}$$

Exactly, $23.25 * \dfrac{EPI}{\text{Warp Ne}} (1 + C1\%)$

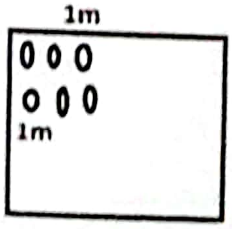
$$\boxed{GSM = \left(\frac{EPI * (1 + C1\%)}{\text{Warp Ne}} + \frac{PPI * (1 + C2\%)}{\text{Weft Ne}} \right) * 23.25}$$

25.50

4. GSM (Knit Fabric)

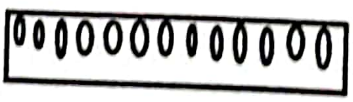
$$\boxed{GSM = \frac{wpi * cpi * \text{loop lenght in mm}}{\text{Yarn count in Ne}} * 0.9158}$$

1m



(wpi * 39.37) * (cpi * 39.37) * (l) * 10 * (1/2.54) * (1/36) * (1/(840*Ne)) * 453.6 gm

Loop Length Testing



= Total length of yarn in a course of number of loops(wales)
/
No of wales

Fabric Strength

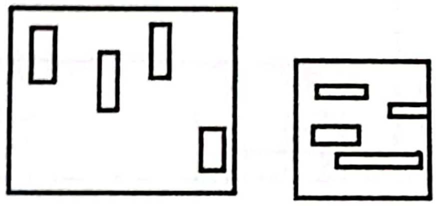
Why to Test Fabric Stregth?

How to check fabric Strength?

Tensile Strength Dress Material such as shirting, suiting,
Tearing Strength Ribbon, tapes, bandage cloth, insulating tapes etc
Bursting Strength Parachute cloth, filter cloth, now-wovens, nets and knitted fabrics
Wear and abrasion Workman's cloth

Tensile Strength

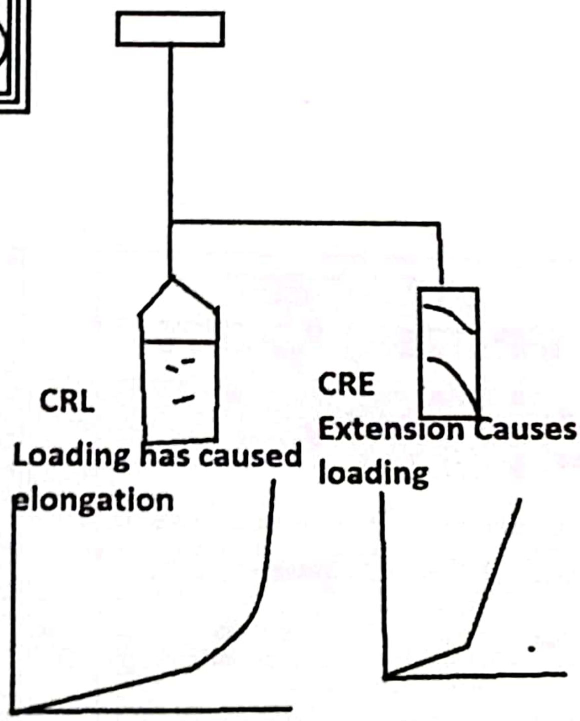
Sample preparation:



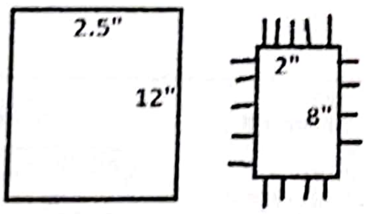
Three tests can be done

1. Ravelled Strip method
2. Cut Strip method
3. Grab method

CRL and CRE

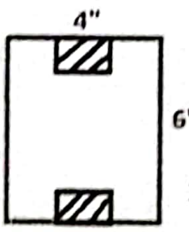


1. Ravelled Strip Method



2. Cut Strip Method

3. Grab Method



12 inches per minute

10/12/

- Strength
- Tensile Strength Testing
- Strip Test
- Grab Test Method
- Grab Test Method (Procedure)
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- Methods of measuring Tear Strength
- Bursting Strength Testing
- The Hydraulic bursting tester

STRENGTH

Before any strength test of fabric is done the end use has to be clarified so that a good idea of the fabric performance can be determined.

The strength of the fabric may be determined from the following 3 approaches.

1. 1. Its resistance to a tensile force.
2. 2. Its resistance to a tearing force.
3. 3. Its resistance to a bursting force.

- Strength
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TENSILE STRENGTH TESTING

The breaking strength is a measurement of the resistance of the fabric to a tensile load or stress in either warp or weft direction.

To measure the breaking strength, there are three tests that may be used. They are-

1. Ravelled Strip Method
2. Cut Strip method(You will see it in BV)
3. Grab method.

- Strength
- Tensile Strength Testing
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- Grab Test Method
- Grab Test Method (Procedure)
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STRIP TEST (BRITISH) BS 2576

In This Method a Fabric Strip is extended to its breaking point by a suitable mechanical means which can record the breaking load and extension.

Five Fabric Sample both in warp and weft direction are prepared with each not containing the same longitudinal thread.

Samples are prepared 60 mm * 300 mm and then frayed to get 50mm wide specimen.

The Rate of Extension is set to 50 mm/min and gauge length is 200 mm

- Strength
- Tensile Strength Testing
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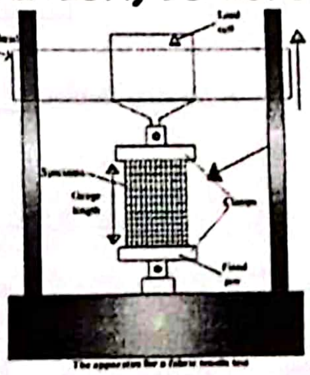
STRIP TEST (BRITISH) BS 2576



- Strength
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STRIP TEST (BRITISH) BS 2576

Any breaks that occur within 5mm of the jaws or at loads substantially less than the average should be rejected.

The mean breaking force and mean extension% of initial length are reported.

Samples are cut (60mm * 300 mm) parallel to warp/weft

Frayed the threads from both sides of the width to bring down to 50 mm wide.

For havilly milled fabrics, no fraying is done (50 mm * 300 mm)

- Strength
- Tensile Strength Testing
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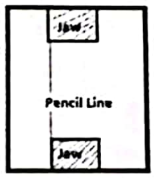
GRAB TEST METHOD

It is a tension test on the fabric in which only a part of the width of the specimen is gripped in the clamps. For example, if the specimen width is 4 inches and the width of the jaw is 1 inch, the specimen is gripped centrally in ht clamps.



- Strength
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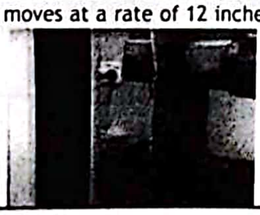
GRAB TEST METHOD

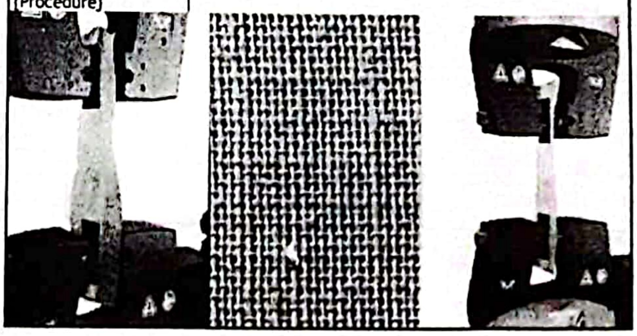
Test samples of size 4 × 6 inches are cut from the master sample. The 6 inch length is parallel to the yarn to be tested and it is dependant on the gauge length.

In setting the testing instrument, the clamps must be set 3 inches apart. The lower jaw moves at a rate of 12 inches per minutes.



- Strength
- Tensile Strength Testing
- Strip Test
- Grab Test Method
- Grab Test Method (Procedure)

GRAB TEST METHOD (ASTM D4632)



GRAB TEST METHOD {PROCEDURE}

1. Inspect the tester for correct size of the clamps, distance between the clamps etc.
2. If stress strain chart can be made in the instrument, the position of pen on the chart is set properly.
3. Place the sample in the clamps. It is important that the same ends are caught by both the clamps.
4. Apply the load to the sample by screw mechanism. When the sample breaks, reverse the movement of the lower clamp and raise the pen from the chart, if it is used.
5. Record the breaking strength and return the pendulum to the zero position.

Five breaks are made for warp and weft breaking strength.

❑Strength
❑Tensile Strength Testing
❑Strip Test
❑Grab Test Method
❑Grab Test Method {Procedure}
❑Comparison between Strip Test and Grab Test
❑Tearing Strength Testing
❑Methods of measuring Tear Strength
❑Bursting Strength Testing
❑The Hydraulic bursting tester

COMPARISON BETWEEN STRIP TEST AND GRAB TEST

During the grab test, as some loose fabric is supporting the specimen on both sides of the jaws, the strength obtained in grab test will be more.

The preparation of sample in grab test is much easier as there is no use of ravelling operation to remove the threads. Hence it is suitable for routine work and not for research work.

❑Strength
❑Tensile Strength Testing
❑Strip Test
❑Grab Test Method
❑Grab Test Method {Procedure}
❑Comparison between Strip Test and Grab Test
❑Tearing Strength Testing
❑Methods of measuring Tear Strength
❑Bursting Strength Testing
❑The Hydraulic bursting tester

TEARING STRENGTH TESTING

The tearing strength is a measure of the resistance to tearing of either the warp or weft series of yarns in a fabric.

A fabric which tears easily is regarded as an inferior product. The amount of resistance of a fabric to tearing is often important and particularly in fabrics like, bandage cloth, adhesive tapes, military fabrics etc.

❑Strength
❑Tensile Strength Testing
❑Strip Test
❑Grab Test Method
❑Grab Test Method {Procedure}
❑Comparison between Strip Test and Grab Test
❑Tearing Strength Testing
❑Methods of measuring Tear Strength
❑Bursting Strength Testing
❑The Hydraulic bursting tester

METHODS OF MEASURING TEAR STRENGTH

a. The Tongue Tear Test
b. The Tongue Double Rip Test
c. Trapezoid Tear Test
d. Ballistic Tear Test (The tearing tests described above are normally done at a slow rate of jaw separation, but in practice tears are produced accidentally and at a relatively high speeds. The rapid action of the ballistic test may, therefore, provide a better method which is more approximate to actual tearing of a fabric. The ballistic tester records the energy required to break the specimen)
e. Wing Rip Tear Test

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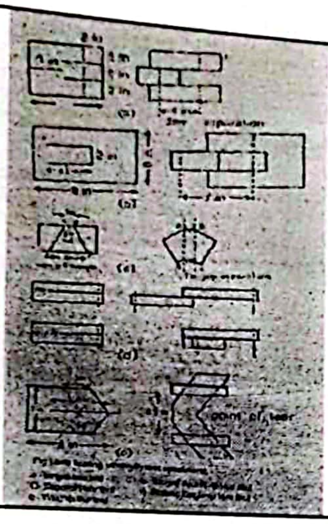

METHODS OF MEASURING TEAR STRENGTH

- Strength
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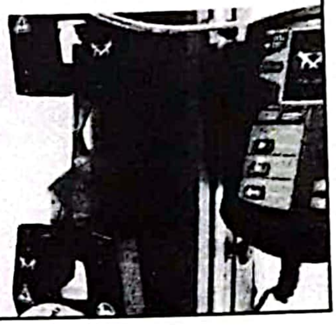
TEARING STRENGTH TESTER (ASTM D2261)



- Strength
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TEARING STRENGTH TESTER (BALLISTIC TEAR TEST)

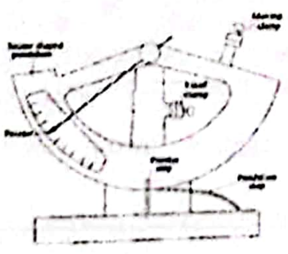

Figure: Elmendorf tear test.

- Strength
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BURSTING STRENGTH TESTING

Bursting Strength is the strength of a fabric against a multidirectional flow of pressure.

The Bursting test measures a composite strength of both warp and weft yarns simultaneously and indicate the extent to which a fabric perpendicular to the surface of the fabric.

The reason for this method of tearing may be due to the material in use is stressed in many directions simultaneously. Filter cloths, sacks, nets and parachute cloths are examples for fabric stressed in all direct on. Also knitted fabrics can not be easily' tested in strip form and fabrics without well defined direction like felted cloth or bonded fabrics may be conveniently tested on a bursting strength tester.

- Strength
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- Grab Test Method (Procedure)
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- Methods of measuring Tear Strength

- Bursting Strength Testing
- The Hydraulic bursting tester

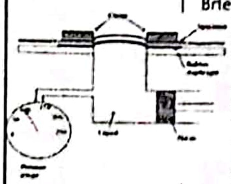
THE HYDRAULIC BURSTING TESTER

Principle: The pressure in a liquid is exerted in all directions and this phenomenon of a liquid is used for testing bursting strength in Hydraulic bursting strength tester.

Sample Size: The specimen for this test should be cut so that the sample is ½ inch greater in diameter than the outside diameter of the clamp ring. Ten specimens are chosen avoiding inclusion of the same ends in the different specimens.

Instrument Criteria: The instrument used for testing bursting strength should have a constant rate of speed and must be capable of giving a uniform displacement of 6±0.25 cubic inches per minute. For proper operation, the machine must be stopped at the instant of rupture in order to avoid additional application of pressure and load on the specimen.

THE HYDRAULIC BURSTING TESTER



Procedure:

Briefly the specimen is clamped by a ring over a thin flexible rubber diaphragm as shown in fig which itself is clamped over a circular hole in the upper face of a reservoir. The liquid used may be water or glycerin. The pressure in the liquid is increased, by valves or screw-driven piston. Due to increase in pressure, the diaphragm bulges, taking with it the specimen. At some point the fabric bursts, and the pressure at that point is indicated by the pressure gauge.

Since the rubber diaphragm requires a certain pressure to stretch it, corrections are made by doing a blank test, i.e. noting the pressure required to distend the diaphragm the same amount without the presence of fabric.

- Strength
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WOUNDED BURSTING STRENGTH TEST

In the Test Specimen, if cuts by chisel for ½ inch is made (either in warp or in weft direction or in both) or if a ¼ inch hole is punched and then the same test is carried out, then it is called wounded bursting strength test.

FABRIC TENSILE STRENGTH DEPENDS ON

- Raw material.
- Yarn strength (twist: more twist for more strength)
- Fabric construction (*weave*: plane weave is stronger than floats-satin, sateen which are weaker, *Density*: low density cause weave slippage which result in seam slippage).
- Finish applied (resin finish improves weave slippage).
- Adverse of "finishing" process.

Stiffness

Fabric Stiffness indicates the resistance of the fabric to bending and it is a key factor in the study of handle and Drape. It is a fabric property to describe resistance against deformation. In case of yarn, subjected to a tensile force or pull, stiffness is the ability to resist elongation and in case of circular bending of textile, resistance to multidirectional bending.

Methods of Measuring Fabric Stiffness

1. By the thickness of a folded sample
2. By the sag of projecting strip of sample-Cantilever test
3. By the length of a Heart loop (Heart loop test)
4. By means of a Flexometer
5. By means of a Planoflex
6. By the moment of rotation

The cantilever Test is the preferred method because it is simple to carry out. However, it is not suitable for testing fabrics which are very limp and which have a marked tendency to curl or twist at a cut edge. For these types of fabrics, the Heart-Loop test may carry out. The unit of stiffness is gm/denier per elongation

These methods measure the **Bending Length** of fabric, and from this the **Flexural Rigidity** and **Bending Modulus** can be calculated.

Bending Length (C)

Bending Length is also called as Drape Stiffness. This is the length of fabric that will bend under its own weight to a definite extent. It reflects the stiffness of a fabric when bend in one plane under the force of gravity and is one component of drape.
A rectangular strip of fabric is mounted on a horizontal platform and slided until the fabric overhangs like a cantilever, as shown below-

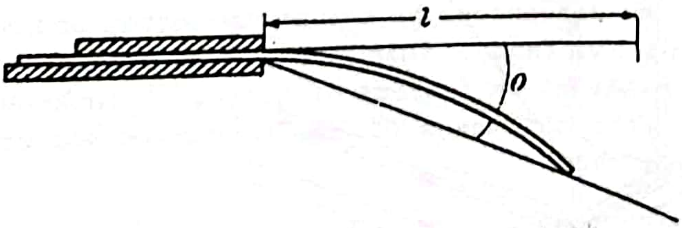


Figure . Fabric stiffness, cantilever principle

The length of overhang l when it is depressed under its own weight and the angle between the line joining the tip to the edge of the platform θ are measured and from these values, the bending length is calculated-

Bending Length, C = l × $f_1(\theta)$

$$c = l\left(\frac{\cos \frac{1}{2}\theta}{8\tan\theta}\right)^{\frac{1}{3}}$$

Where, l = unsupported fabric length or length of overhang.
θ = the angle between the line joining the tip to the edge of the platform.

The Labour of calculating the function of θ is avoided by consulting a prepared Table. For example, when θ=41.5° then $f_1(\theta)$=0.509. Bending length is calculated for warp and weft way of the fabric.

Flexural Rigidity (G)

Flexural rigidity is a measure of stiffness associated with handle. It is also called Flex Stiffness. This method of testing stiffness shows a close relationship with the personal judgment of stiffness.

It is calculated from the bending length and weight of per square yard of fabric.

Flexural Rigidity, $G = 3.39 \times W_1 \times C^3$ mg/cm

Or $G = W_2C^3 \times 10^3$ mg/cm

Where, W_1=Cloth wt in oz/yd²
W_2=Cloth wt in gm/cm²
C=Bending length

Flexural Rigidity is calculated for warp and weft way of fabric and the overall flexural rigidity is calculated as the geometric mean of those two values.

Overall Flexural Rigidity, $G_o = \sqrt{Gw \times Gf}$

Where, G_w = Warp Flexural Rigidity
G_f = Filling Flexural Rigidity.

Bending Modulus (q)

This value is independent of the dimensions of the strip tested and may be regarded as the intrinsic stiffness. This value may be used to compare the stiffness of the material in fabrics of different thickness values. For this calculation, the thickness of the fabric is measured at a pressure of 1 lb/sq. inch then,

$$q = \frac{732G}{g_1^3} kg/cm^2$$

$$= \frac{12G \times 10^{-6}}{g_2^3} kg/cm^2$$

where **g_1**= Cloth thickness in thousands of an inch. (Thou)
g_2 = Cloth thickness in cm.
G = Flexural rigidity.

Cantilever (Principle) Test

1. The Shirley stiffness tester.
2. The Heart loop tester.
3. The drape meter.

1. The Shirley Stiffness Tester

Basic principle:

[mentioned earlier Bending Length, Flexural Rigidity and Bending Modulus]

Construction:

- The stiffness tester consists of a platform having which is supported by two side pieces made of plastic. Index lines are engraved on these side pieces, inclined at an angle of 41.5° below the plane of the platform surface. At this angle, $f_1(\theta)$ is 0.5.
- A mirror is attached to the instrument to enable the operator to view both index lines from a convenient position.
- A scale is supplied with the instrument to measure the bending length and is graduated in cm of bending length. It also serves as a template for cutting the samples of size.
- This instrument is used in the finishing departments where the control of the process is used and to note the effects of varying the process.

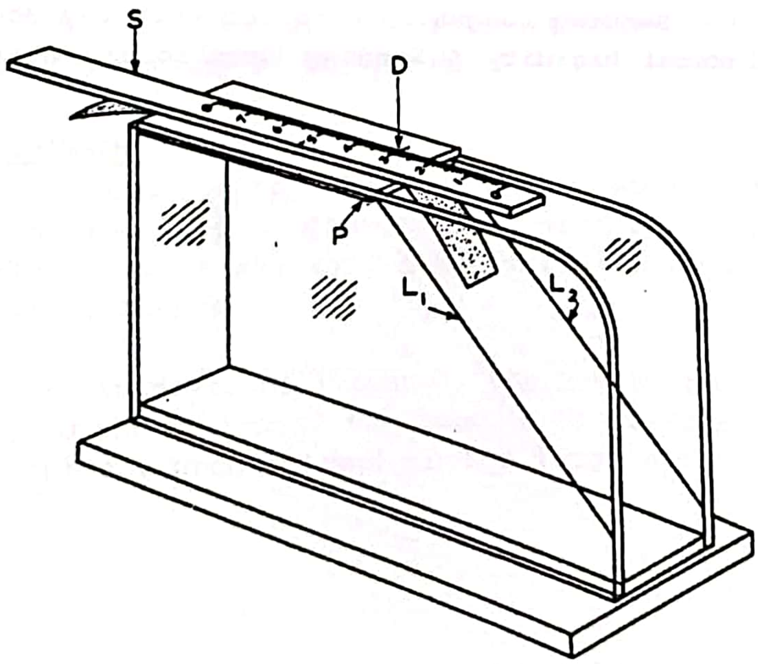


Figure . *Fabric stiffness tester* (From B.S. Handbook No. 11, *Methods of Test for Textiles* reproduced by permission of the British Standards Institution, 2 Park Street, London W.1)

S=Fabric Sample, P=Platform, D=Datum line, L_1 and L_2=Index lines

Sample Preparation:

The sample is conditioned in the standard testing atmosphere and using the template, specimens are cut to the size of 6″ × 1″. Four specimens in warp way and weft way are prepared for the test. If the fabric is not uniform or a high degree of accuracy is required then more samples can be tested. The specimens are cut in such a way that the warp specimens do not contain the same warp yarns and the weft specimens contain different warp yarns. Selvedges, end pieces, crease or folded places must be avoided and the specimens must be handled as little as possible.

Working procedure:

1. The test is carried out in the standard testing atmosphere. The tester is set on a table so that the horizontal platforms are the index line are at eye level.
2. The Specimen is placed on the platform with the template at the top of it so that the leading edges coincide. Both are slowly pushed forward until the leading edges of the specimen and the template project beyond the edge of the platform. With the eye in a position so that the index lines coincide, the sliding of the specimen is stopped when it cuts both index lines.
3. If the specimen has a tendency to twist, the reference point at the centre of the leading edge is taken. For the specimens which twist more than 45°, this method should not be used.
4. Four readings are taken from each specimen, with each side up, first at one end and then the other and again with the strip turned over. Mean values for the **Bending Length** in warp and weft way are calculated and the **Flexural Rigidity & Bending Modulus** are also determined.

$$C = l \times f_1(\theta)$$

$$c = l\left(\frac{\cos \frac{1}{2}\theta}{8 \tan \theta}\right)^{\frac{1}{3}}$$

2. Heart Loop Test

Some Fabrics are too flexible or limp and they will have a tendency to twist or curl when hanging. For this type of fabrics, the heart loop test is recommended. Pierce recommended a method for stiffness called the heart loop method for use of very soft material where the stiffness can be determined by the cantilever principle.

The apparatus used for this test consists of a clamp for hanging the specimens and a scale, suitable mounted, for measuring the length of the specimen.

Sample Preparation:

1. Specimen length for various fabric types

Bending length, cm	Specimen length, cm
Less than 2	15
2 to 3	20
More than 3	at least 25

2. For fabrics having only a slight tendency to curl, a 2.5 cm wide strip is satisfactory. If the tendency to curl increases, the strip width should be increased. However, strip widths of more than about 7.5 cm have not been investigated and should be used with caution.

3. Test Specimen are cut from the samples 5 cm longer than the specimen length selected to allow for clamping at the edges. Four specimens in warp way and four specimens in weft way are prepared. If the fabric is not fairly uniform or if greater precision is required, a greater number of specimens should be tested.

Procedure:

The free ends of the specimen are mounted in a clamp in the apparatus so that the loop is free to hang vertically. A stiff fabric will hang as first figure and very limp fabric will hang vertically as shown in the right figure.

After an interval of 1 minute, the distance between the top edge of the clamp to the bottom of the loop, l is measured. In this test, stiffness is inversely proportional to the length, l.

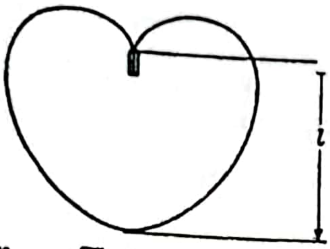


Figure . The heart-loop test (stiff fabric)

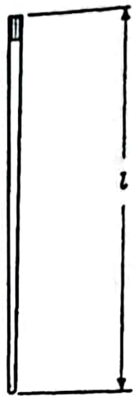


Figure The heart-loop test (limp fabric)

Then the specimen is removed form the clamp, turned over and the experiment is repeated and the length l is measured again.

The above procedure is repeated for all the test specimens and the average length l is calculated for all the warp and weft specimens. The length l is called as loop length, measured in cm.

A strip of fabric of length L is folded back on itself and is very stiff then length of loop would be 0.1337L but if the fabric is completely limp and the clamps were very thin, the length of loop would be 0.5L.

The bending length is calculated from the formula-

$$C = l_0 \, f_2(\theta)$$

Where $\theta = 32.85° \times \dfrac{d}{l_0}$

$d = l - l_0$

l=Actual length of loop (Loop Length)

$l_0 = 0.1337L$

L=Specimen length

$$f_2(\theta) = \left(\frac{\cos\theta}{\tan\theta} \right)^{\frac{1}{3}}$$

From the value of bending length in warp and weft directions the Flexural Rigidity and Bending Modulus of warp and weft ways are calculated.

3. Drape meter

Drape:

Drape is the property of fabric which indicates the ability of a fabric to assume a graceful appearance in use. It is the opposite characteristically feature of stiffness of the fabric. It is important property of textile materials which allows fabric to orient itself into graceful folds or pleats as a result of force of gravity.

Measurement of Drape:

Drapability of a fabric can be determined using the instrument **Drapemeter** and is expressed in terms of **Drape Co-efficient.**

Drape coefficient, F:

It is the ratio of the projected area of the draped specimen to its undraped area, after deduction of the area of the supporting disk.

Thus, $F = \dfrac{A_s - A_d}{A_D - A_d}$

Where, A_s = The actual projected area of the specimen

A_D = The area of the specimen

A_d = The area of the supporting disk

Description and Working Procedure:

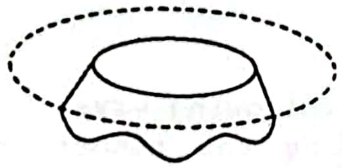


Figure . The Drapemeter. The circular specimen is 'draped' over the circular support

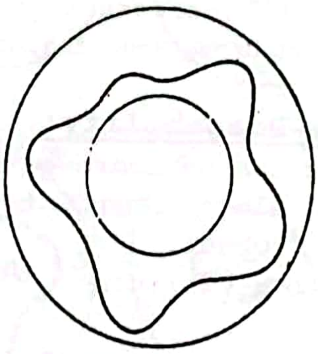


Figure . The Drapemeter. The projected outline of the 'draped' specimen

1. A circular specimen about 10″ diameter is supported on a circular disk about 5″ diameter and the unsupported area drape over the edge as fig(a)
2. If the specimen were, say, a 10 inch dia hard board, no draping would occur and the area of projection from the periphery would equal to the area of the record.
3. When its fabric, it will assume some folded configuration and the shape of the projected area will not be circular but something like the shape as fig (b)
4. The drape is then measured in terms of drape co-efficient, F considering areas.

Note: Instead of the areas of the draped and undraped specimen, their corresponding weights of paper projection can also be taken to calculate the drape co-efficient.

i.e. $$F = \frac{W_S - W_d}{W_D - W_d}$$

Where, W_S= Weight of the paper whose area is equal to the area of A_S

W_D= Weight of the paper whose area is equal to the area of A_D

W_d= Weight of the paper whose area is equal to the area of A_d

Keep in Mind: The Thickness of the paper to trace the outline must be uniform.

The small value of F indicates the better drapability of the fabric and the large value of F indicates the bad drapability.

Weave/PPI	Plain	2/2 Twill	2/2 Warp Rib	2/2 Matt
56	64.6	45.6	46.8	49.2
64	67.6	53.8	51.1	51.8
72	78.8	58.1	54.0	55.1
82	81.6	63.4	62.2	59.6

From the above table, it can be seen that in all the weaves, drape coefficient increases with the increase in picks/inch which shows that the increase in picks/inch reduces the drapability.

Method of Improving the Drapability:

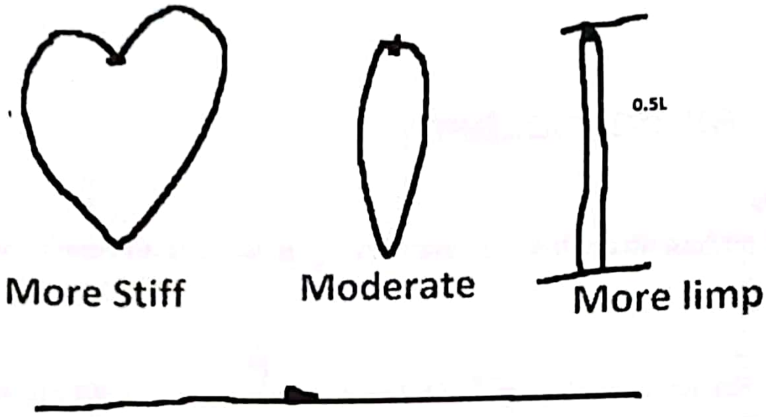
The drapability of a fabric can be improved by the following ways-

1. By providing the more float length by reducing the number of interlacements in the weave repeat.
2. By reducing the number of picks/inch

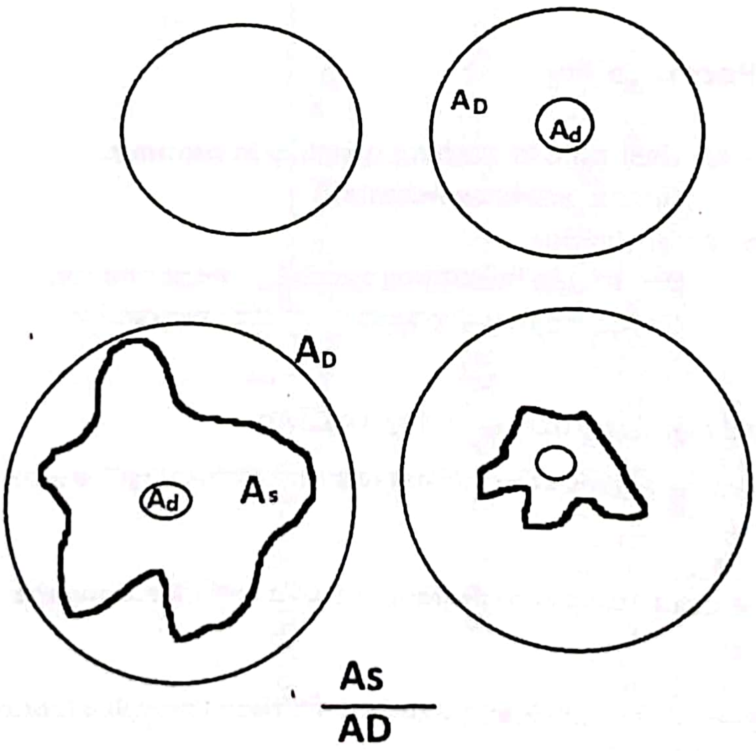
Fabric Handle

1. Fabric handle is concerned with the feel of mtl and so depends On the sense of touch
2. When the handle of fabric is judged the sensation of stiffness or limpness, hardness or softness and roughness or smoothness are all made use of.
3. Mr. Pierce states in the paper of the hardle of cloth as a measurable quality.
4. Fabric handle depends on following factors:

   a. Weight and density.
   b. Surface tension.
   c. Flexibility.
   d. Compressibility.
   e. Resiliency.



Heart Loop Testing Basic Idea



Drape Testing Idea

Air Permeability

Air Permeability:

Vol. of air/sec through 1 cm^2 of fabric at 1 cm Water Pressure head

Air Resistance:

time/cc of air through 1 cm^2 of fabirc at 1 cm Water pressure head

Air Porosity: $\dfrac{\text{Air Space}}{\text{Total Volume of Fabric}}$

Permeability

1. Permeability to Air **Desirable in clothing specially in summer, undesireable overcoating**
2. Permeability to Water Vapour
   Desireable in clothing specially in underwear, Undersireable in covering such as tarpaulins.

Methods of Air Permeability Testing

1. By forcing air through a fabric at a constant rate and measuring the back pressure developed

2. By forcing air through a fabric at a constant pressure and measuring the rate of flow of the air

3. By forcing a known volume of air at a standard pressure through a fabric and measuring the time required

$$\text{Air Permeability} = \frac{\text{Average rate of air flow}}{5.07} \text{ cc/sec/sq cm}$$

$$A = 3.1416 * 0.5 * 0.5 * 2.54 * 2.54 \text{ cm}^2$$
$$= 5.067 \text{ cm}^2$$

$$\text{Air Resistance} = \frac{5.07}{\text{Average rate of air flow}} \text{ sec}$$

Air Permeability and Fabric Properties

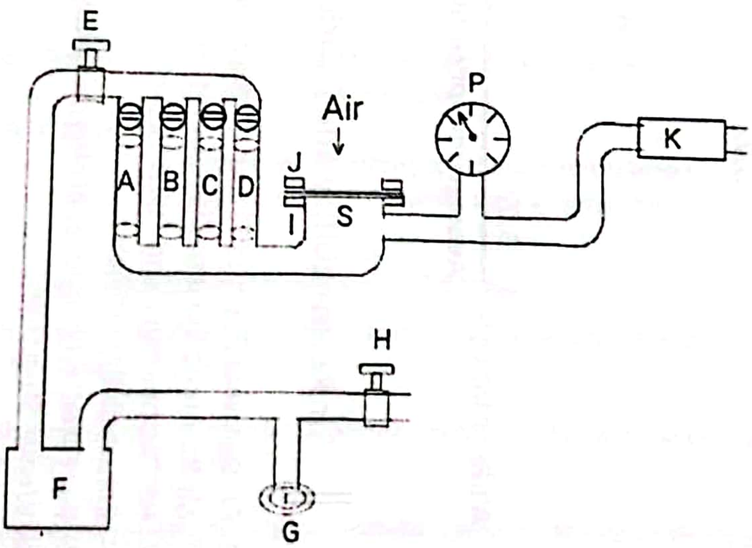
1. Air Permeability and Thermal Properties
2. Air Permeability and Cloth Cover, Yarn Dia
3. Air Permeability and Twist Factor
4. Breathability Indication
5. For Filtration Purpose, Air Permeability is proportional to Efficiency
6. Weave Structure
7. Crimp

Shirley Air Permability Testing Procedure

In this apparatus, Air at Standard Atmospheric condition is drawn from the laboratory through the test specimen S by means of a suction pump A, the rate of flow being controlled by means of the by-pass valve B and the series valve C. The rate of flow is adjusted until the required pressure drop across the fabric is indicated on draught gauge D, graduated from 0 to 25 mm head of water. For fabrics of high resistance, the rate of flow of air through the specimen is inadequate for proper operation of the suction pump; this is overcome by opening the by-pass valve B which supplies air to the pump directly.

(Schematic diagram of Shirley fabric air permeability tester)

A,B,C& D - Rotameter
E - Series valve
F - Reservoir
G - Suction pump
H - By-pass valve
I - Specimen fixing plate
J - specimen clamp
K - Safety valve
S - Test Specimen
P - Draught gauge



For fabric of low resistance, when high rates of flow are attained, valve B is closed or permitted to supply only a small volume of air, fine control is obtained by adjusting valve C. E is a reservoir which smooths out any disturbance due to the varying velocities of the streams of air drawn through the various paths by the pump.

When the required pressure drops, which is normally 1 cm of water, is attained and the indicator of the draught gauge is steady, the rate of flow of air is read off one of the four Rotameters R, selected according to the permeability of the test specimen. The Rotameters are calibrated, at 20° C and 760 mm of mercury, to indicate air flow in cubic centimeters per second and they cover the following range:

R1 0.05-0.5
R2 0.5-3.5
R3 3-35 and
R4 30-350.

It is easy to select the most suitable Rotameter for any fabric. The test is commenced with R4 open and the other Rotameters closed. If the flow is less than 30 cm^3/sec, R3 is opened and R4 closed. This procedure is repeated until the most suitable range for the fabric under test has been selected. To prevent damage to the draught gauge, should the pressure drop across the fabric inadvertently be allowed to exceed the range of the gauge, a safety valve F is provided. .

The test area is 5.07 cm^2, since a 1-inch diameter circle is exposed when the specimen is clamped in the holder. From the readings on the Rotameter either the air permeability or the resistance can be computed. The average rate of flow form five specimens is calculated and by dividing by 5.07 we obtain the air permeability of the fabric in cubic centimeters per second at 1 cm head of water. Alternatively, 5.07 may be divided by the mean flow; this gives the air resistance of the fabric in seconds per cubic centimeter per square centimeter under a pressure of 1 cm of water.

(Schematic diagram of Shirley fabric air permeability tester)

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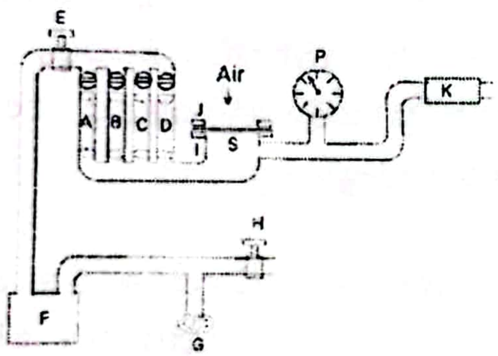

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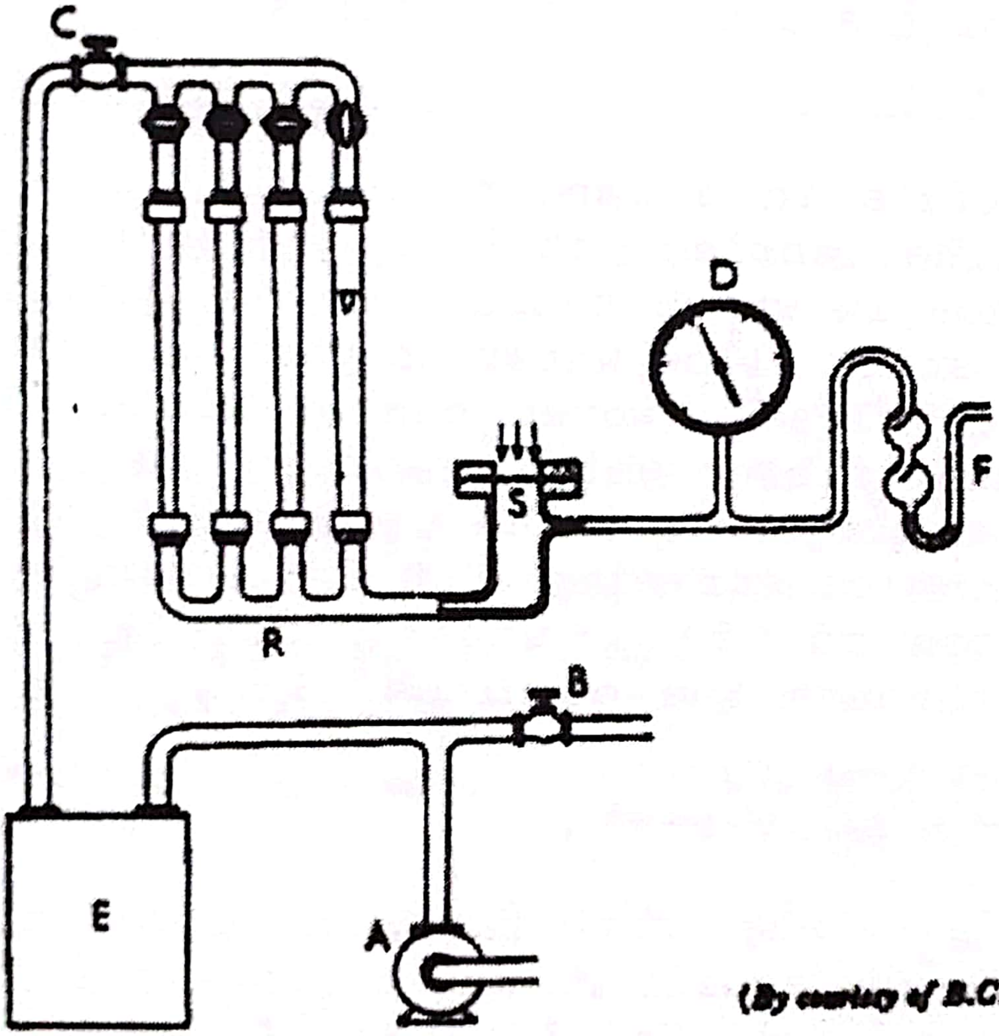


(By courtesy of B.C.I.R.A.)

Figure. The 'Shirley' air permeability apparatus

Water Permeability

Absorbability:
It is the ability of a fabric to take up a liquid. It is a term related to the warmth of a fabric. If a fabric is permeable to air but does not absorb water, evaporation of perspiration takes place from the skin and the skin temperature falls. This is the phenomenon which occurs when nylon fabrics are worn. If the fabric absorbs the perspiration, however, the evaporation takes place from the fabric and not from the skin. Therefore, chilling does not occur.

The following are the ways in which water can pass through a fabric:

1. By wetting the fabrics, followed by capillary action which brings the water to the other side.
2. By the pressure of water, forcing it through the opening of the fabric.
3. By the combination of the above two sections.

Shower proof:
To treat textile materials in a manner to delay the absorption and penetration of water. The fabrics retain a degree of permeability to air. If a fabric is made in which there were no openings between the yarns, the cloth might still allow water to pass, if the water wet the fibres. This happens in closely woven canvas cloth. If a fabric of ordinary weave is made of fibres which had been chemically treated so that they would not be wet by water, the cloth would allow much of the water to roll off without penetrating. But if the water gathered in a thick layer on the cloth of if the water stuck the cloth with much force, it would pass through the openings. This is the case in the shower proof fabrics.

Water Proof:
To treat textile materials, e.g. with fats, waxes or rubber to prevent the absorption of water. The additions may be physical films or coating or may be physically combined. Fabrics treated with such substances have low degree of permeability to air. The following are the examples of water proof fabrics

a) Rubber in ordinary raincoats
b) Bitumen in tarpaulin
c) Waxes in some tent cloth
d) Plastic coated fabrics

Water Repellent:
It is a state characteristic by the non-spreading of a globule of water on a textile material. A water repellent fabric is one that will ~~reset~~ resist absorption and penetration of water for a given period of time, depending upon the length of exposure and the force of water.

Note: A garment is labelled as **shower resistant** will provide protection from light rain but will be penetrated by a heavy rain after 15 minutes. A garment labelled as **rain resistant** will provide protection for a few hours of exposure in a moderate rain.

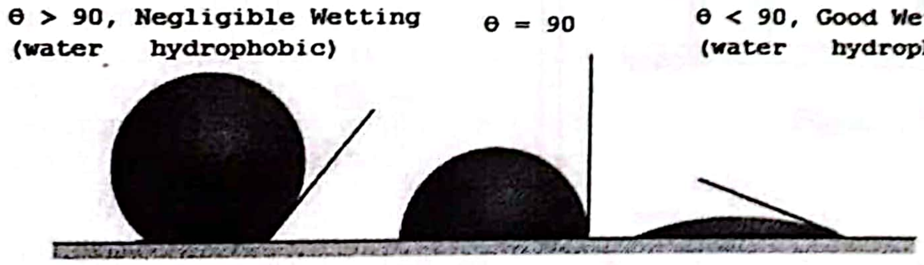
A garment labelled as **storm resistant** will resist water penetration for many hours. There will be an external material in water proof fabrics other than the yarn surface but in the shower proof and water repellent fabrics, wetting will take place after certain interval.

Difference between water proof and water repellent:

Topics	Water proof	Water repellent
Pore in the matl	Filled	Open
Air permeability	Small or nill	Large
Water or vapour permeability	Small or nill	large
Characteristics of goods	Resistance to passage of water even under hydro static head	Resistance to water and rain and spread of water but permits water under hydrostatic head.
Fabric outlook	Fabrics are stiff and not pliable	Fabrics are pliable and are not different from untreated fabrics.

Water retention:
This is the moisture remaining in and on a material after a specified mechanical treatment.

Wettability:
According to British Cotton Industry Research Association (B.C.I.R.A) A drop of water (or sugar solution) is placed on to the specimen fabric which is mounted horizontally. The time taken for the contact angle to drop to 45° is noted. The reciprocal of the time taken is called the wetting velocity or wettability.



Contact Angle (θ):
The angle between the solid surface and the tangent to the water surface as it approaches the solid, the angle being measured in water.

Wetting Time:
The wetting time can be described by a test developed by Baxter and Cassie. A fabric stripe is immersed in water of 20 ° c. Then it is withdrawn from the water at a speed of 8 mm/min. At the start of the test a large receding contact angle is seen but after some time the angle is to decreased to 90 degree. This time is noted by a stop watch. This time taken to decrease the angle to 90 degree is called the wetting time.

Methods of testing

1. The wetting time test.
2. The spray test.
3. The drop test or drop penetration test.
4. The Bundesmann test.
5. Shirley hydrostatic head test.

1. The Wetting Time Test:

In this test, a strip of fabric is lowered in a trough of water and is removed from the water surface from one end of the trough. Distilled water at 20° c is used and the speed of withdrawal of fabric is maintained at 8 mm per minute. In the beginning of the test, a large contact angle is seen and after some time it reduces. The time is noted using a stop watch when the angle drops to 90°. The time to drop to 90° is called the **wetting time**.

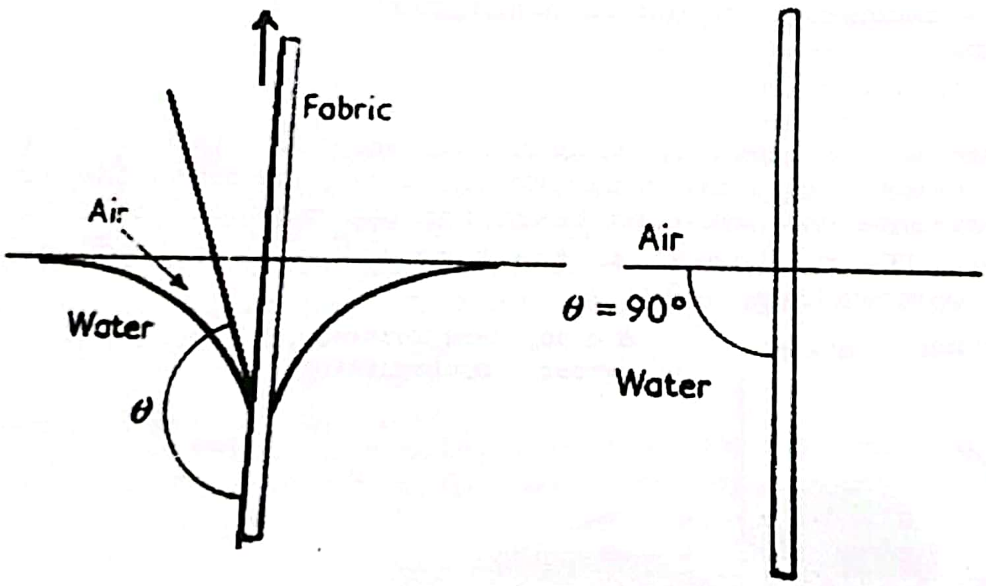


Fig: the wetting time test

This is a very useful method to assess proofing efficiency of fabrics. But for cotton, the method is not so popular, hence other methods are to be considered. The wetting time test is useful for heavy wool cloth.

2. The Spray Test

Construction:

In this test a small-scale mock rain shower is produced by pouring water through a spray nozzle. The water falls on to specimen which is mounted over a 6″ diameter embroidery hoop and fixed at an angle of 45°.

Working Procedure:

To carry out the test, 250 cm^3 of water at 70°F are poured steadily into the funnel. The distance from the bottom of the spray to the centre of the fabric is 6″. After spraying has finished the sample holder is removed and the surplus water removed by tapping the frame six times against a solid object, with the face of the sample facing the solid object. The tapping is in two stages, three taps at one point on the frame and then three times at a point diametrically opposite.

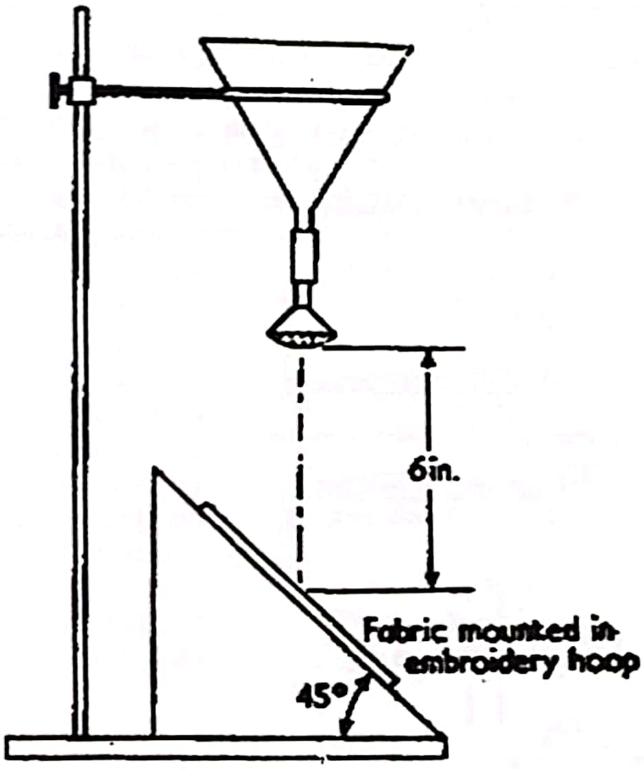


Figure . The spray test

The assessment of the fabric's water repellency is given the **spray rating**. After the removal of the surplus water is accomplished the fabric surface is examined visually by matching against the rating chart of photographs.

The ratings (AATCC) are as follows-

100→No sticking or wetting or wetting of the upper surface.
90→Slight random sticking or wetting of the upper surface.
80→Wetting of upper surface at spray points.
70→Partial wetting of whole of upper surface.
50→Complete wetting of whole of upper surface.
0 →Complete wetting of whole of upper and lower surfaces.

Five tests should be made and the nearest rating assigned to each, since no interpolation is allowed, i.e. a rating for a specimen cannot be 75. The mean of 5 ratings is reported.

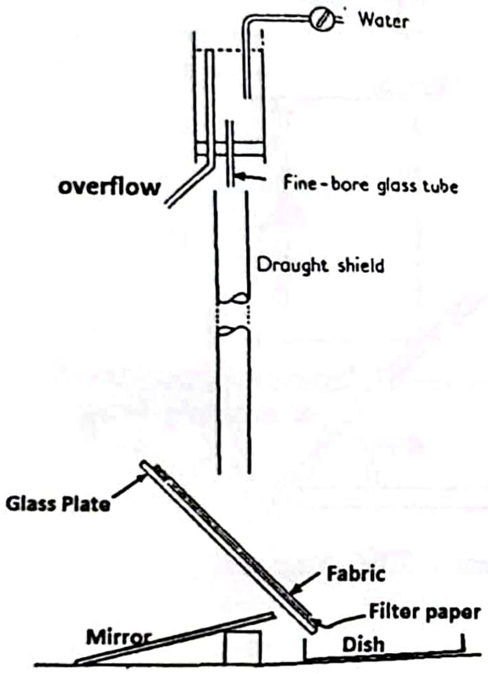
ISO rating ranges from 0 to 5.

3. Drop Penetration Test:

In the initial of wetting, the drops of water pearl of the fabric and after some time the pearling stops, the water enters the pores of the fabric, and becomes wet. Therefore, the drop penetration test is to count the number of drops required to penetrate the fabric to the inner side when all the drops fall on the same spot.

Description:

A fabric sample is clipped onto a glass plate with a piece of filter paper sandwiched between glass and fabric. The frame holds this assembly at an angle of 45° directly under the drop forming apparatus. The drop forming apparatus is a fine bore glass tube to produce a certain number of drops per minute of given size, with a constant head of water so that the size of drop and time of dropping are constant. To ensure that the drops fall onto the same spot, a draught shield is used.



Working:

With the specimen in position the water supply is started and drops begin to fall on the fabric. The end point is reached when the filter paper shows the sign of water. This can be noted on the mirror placed underneath the specimen. The time is measured with a stopwatch. Then water which penetrates the specimen is collected and the time taken to collect 10 cc under specified condition is observed to the nearest second.

Various methods are used to determine the end point with greater precision. The filter paper may be impregnated with a chemical which changes colour when wet e.g. cobalt chloride turns blue or the water can be tinted.

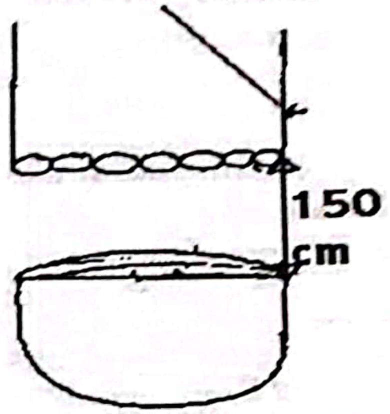
The size of the drop, rate of dropping, height of drop and other dimensions may be changed according to the purpose.

4. The Bundesmann Tester

The Bundesmann tester is quite different from two tests, viz, spray, drop penetration and they are not satisfactory, when fabric are used as a rain coat. The wearer of the fabric walks in the rain continuously exposing fabric for heavy shower and at the same time rubbing because of the movement of the limbs of the body coming into contact with the other side of the fabric. The agitation makes more amount of water to enter the fabric which is not tested in shower proof. The Bundesmann tester satisfies this condition.

Description of the Bundesmann Test:

Fabric speciments are mounted over a special cups or bezels and subjected to a shower of water from a multi-nozzle drop producer. Water which penetrates the fabric is collected in the bezels and measured. The water which is retained by the specimen is also measured. The shower producer is mounted 150 cm above the four bezels. The bezels are mounted on an assembly rotating slowly at 5 rpm. As the fabric circulate in the shower of water, special wipers inside the bezels rub the underside of the specimens in order to reproduce the rubbing action mechanically which occurs in practice. This rubbing action will help the water to penetrate the fabric.



After a 10 minutes shower of controlled severity, the specimens are removed and two values determined.

Penetration:

The water collected in each of the bezels is measured and the mean volume calculated to the nearest milliliter.

Absorption:

From the weight of each specimen before and after the test, the % of water retained by each specimen is calculated as follows-

$$\text{Absorption} = \frac{\text{Weight of water absorbed}}{\text{Original wt of the specimen}} \times 100$$

The mean of the four results is calculated and reported to the nearest 1%.

Points must be considered during testing:

- Temperature of water = 18℃ - 20℃
- pH of water = 6-8
- Rate of flow = 62-68 ml/min per bezel
- Drops to be uniformly spaced and the fabric to be conditioned for at least 24 hours in a standard atmosphere.
- Specimens to be weighted in an airtight container
- Surplus of water to be removed by six sharp shakes.

5. The Penetration of Fabrics by Water Under Pressure

The Pressure required to force water through fabric may be determined and the ability of a fabric to do a particular job can be assessed using the hydrostatic head test.

Hydrostatic Resistance

It is the resistance of fabrics to the passage of water under pressure when the force is applied at right angles to the plane of the fabric.

Description:

The specimen holder consists essentially of a double chambered cell. The internal diameter of the inner chamber A is 5 cm. Circular specimens are clamped between rubber gaskets over the orifice.

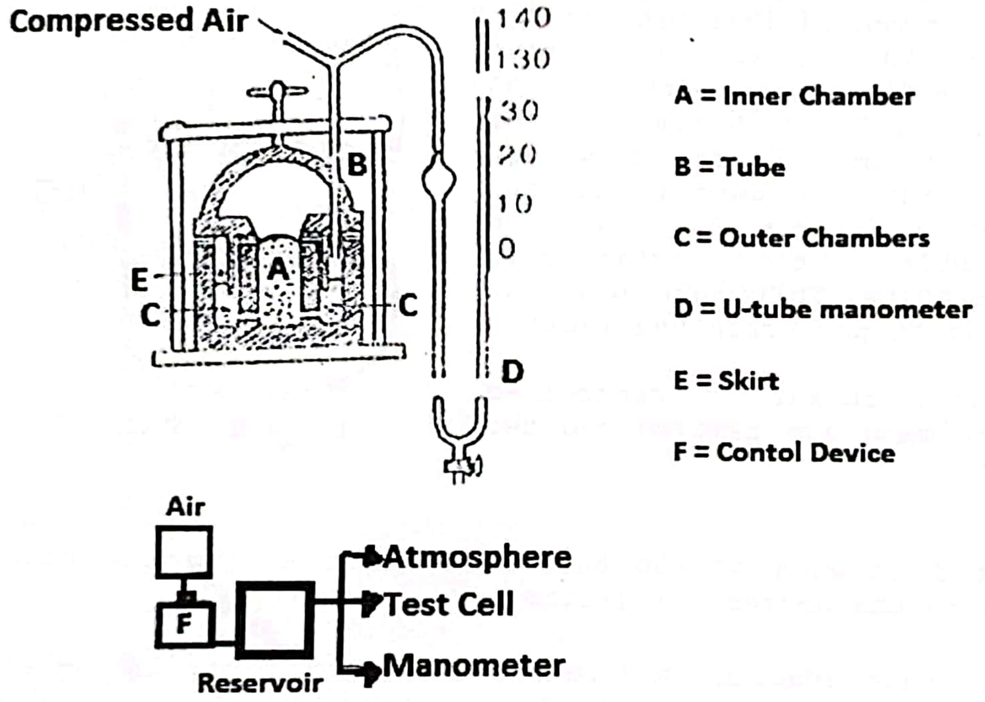


Fig: The hydrostatic head test

Compressed air is passed to the outer chamber C through a tube Brand displaces the distilled water in the outer chamber into the inner chamber.

By that way, water is forced up against the specimen. The clamp is provided with a skirt E to prevent the air leakage across the specimen outer chamber to inner chamber or to the atmosphere. Tube B is connected to a U-tube manometer and the pressure of water against the fabric can be noted on a scale mounted on the arm of the manometer tube.

The air supply is drawn from a reservoir of 3 liters capacity. This reservoir is fed through a flow control device F from a source with pressure ranging from 4 to 20 psi. The flow control device is designed so that it can be set to give the required rate of increase of pressure of 10 cm of water per minute. The rate of loading will be within the specified limits of 10 ± 0.5 cm per minute up to the limit of the instrument. The max head attainable is 150 cm of water.

Procedure:

Circular specimens 6 cm in diameter are out from the fabric to be tested, using a template. The test cell is rinsed with distilled water and filled to approximately 0.3 cm of the top. The inner rubber gasket is thoroughly dried and a test specimen is placed over the orifice and Tightened with a clamp.

Then a control tap is turned to position no 1 to communicate the air supply, manometer and the test cell. The pressure on the under surface of the specimen is allowed to increase at the specified rate of loading until water appears at third place in the specimen, the control tap is immediately turned to position no 2 to allow the air supply and the test cell to discharge to atmosphere. But the manometer retains at the pressure at which breakdown of the test specimen occurred. This value can be noted.

The hydrostatic head can be noted from one arm of the U-tube manometer to the nearest 0.5 cm of water. Then the control tap is turned to position no 3 to discharge the monometer to atmosphere.

Then the test specimen is removed, the used water thrown away, fresh distilled water is poured into the test cell and the operation is repeated for eight samples and the mean value is calculated.

The Water Percolation test:

After being tested in the hydrostatic head apparatus, the samples may be immersed in water for 24 hours and then subjected to a head of 100 cm water. The amount of water which percolates through the fabric in the first 500 sec is collected and measured. The percolation may be expressed thus:

Percolation = w / 3.92   ml/1000 sec at 1 m water head

Where, w is the weight of water in grams collected from four specimens in 500 sec.

This type of test is suitable for measuring the performance of fabrics intended for use as tent cloth, water buckets, etc.

Crease

Crease: This is a fabric defect (undesirable property) evidenced by a break line or mark in a fabric generally caused by a sharp fold. Crease are a fold in a fabric introduced unintentionally. Crease appears when the fabric is distorted in such a manner that part of it is stretched beyond its elastic recovery. During creasing the upper surface of fabric goes on extension and lower surface goes on compression.

Crease Resistance: Crease is a fold in a fabric introduced on intentionally at some stage of processing and the resistance to creasing of textile material during use is known as crease resistance. The crease resistance of wool fibre is very good but for the cellulose material it is not good. Amongst the textile materials the order of diminishing crease resistance is wool, silk, acetate rayon, viscose, rayon, cup ammonium rayon, cotton, flax etc.

Crease recovery: It is the property of a textile material by which it can return to its former shape after being creased. The measure of crease resistance is specified quantitatively in terms of crease recovery angle. The crease recovery of a fabric can be increased by resin treatment.

Difference between crease resistance and crease recovery:

Crease Resistance	**Crease Recovery**
Crease resistance is such a property of fabric that resists fabric from creasing.	Crease recovery is a fabric property that indicates the ability of fabric to go back to its original position after creasing.
Crease resistance is generally measured by bending elasticity.	Crease recovery is the measure of crease resistance specified quantitatively in terms of crease recovery angle.
Crease resistance comes into play before the fabric is creased.	Crease recovery comes into play after the fabric has been creased.
Crease resistance resists the stretching and compression of molecular chain of fibre polymer.	By crease recovery property the stretched or compressed polymer chain comes back to normal position.

Advantages of Resin Treatments:

- Improved resistance to and recovery from creasing.
- Smooth drying properties after laundering.
- Durable effects may be imparted by intermediate mechanical treatment.
- Reduce laundry shrinkage.
- Increase dry tensile strength and greatly increased wet tensile strength of rayon.
- Improved fastness to washing and rubbing of most dyes.
- Decrease water-imbibition and more rapid drying.
- Improved handle and drape of fabrics.
- Increased weight.
- Increase resistance to distortion of fabrics with improved retention of garment shape and freshness.
- Improved resistance to slippage and fraying.
- Vehicle for modern flame-proofing.
- Increased resistance to photo-degradation and weathering.
- Increased resistance to rotting.

Disadvantages of Resin Treatments:

- Lower abrasion resistance for misapplication of the finish.
- Lower tearing strength for misapplication.
- Unpleasant odors under certain condition.

Methods of Measuring Crease Recovery

The Tootal test.
The Shirley crease recovery test.
Continental method.
The L.I.N.R.A sunray crease evaluator.

Shirley Crease Recovery Test:

Crease Recovery is measured quantitatively in terms of crease recovery angle.

Principle: A wrinkle-free rectangular specimen of prescribed dimension is folded in half and compressed under a load for a specified time. The load is then removed and the specimen is allowed to recover for the specified time. The amount of recovery is expressed as the angle between the limbs of the fold which is called the crease recovery angle.

Preparation of Test Specimens: Ten test specimens are cut from the fabric with a template, 2 inch long by 1 inch wide. Using a pair of scissors or blade with their longer side parallel to

warp and weft threads respectively the specimens cut in such a way that no two warp way specimens contain the same set of warp yarns and no two weft way specimens contain the same set of weft yarns. The specimens should not be cut from creased, bend or other deformed parts of the sample and also not from within 2 inches from the selvedges.
Since the moisture present in the fabric influences the results of the tests carried out after conditioning in the standard atmosphere.

Construction:

- The instrument consists of a circular dial, graduated in degrees along its periphery with an accuracy of 0.5 degree which carries the clamp for holding the specimen.
- Directly under the center of the dial is a knife edge and an index line for measuring the recovery angle.
- The scale of the instrument is engraved on the dial.
- Specimen clamp to hold one limb of the specimen in such a way that the fold lies in horizontal line on the axis of the circular scale.
- Leveling screw for leveling the apparatus.

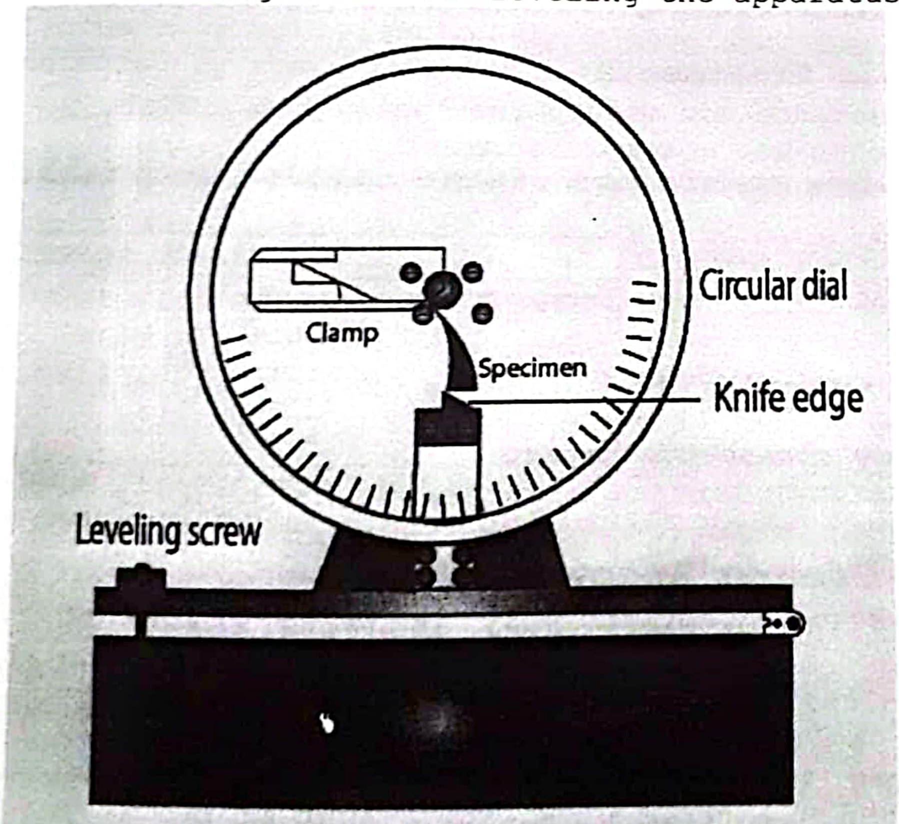


Fig: Crease recovery tester

Working Procedure:

1. A specimen is cut from the fabrics with a template 2 inch long by 1 inch wide.
2. The instrument is levelled with the help of levelling screws.
3. The specimen is folded gently end to end with its edges in one line, with the help of the tweezers. The edges should not be gripped more than 5 mm in the tweezers. The folded specimen is placed on the lower plate of the loading device and 2kg load is applied gently.
4. Half the number of test specimens, both warp and weft, should be folded face to face and other half back-to-back.
5. After 1 min the weight is removed and the specimen transferred to the fabrics clamp on the instrument and allowed to recover from the crease.
6. As it recovers, the dial of the instrument is rotated to keep the free edge of the specimen in line with the knife edge.
7. At the end of time period allowed for recovery, usually 1 min, the recovery angle in degrees is read on the engraved scale.
8. Warp and weft way recovery are reported separately to the nearest degree from the mean value of ten tests in each direction.
9. The test Should include the following:
   a) The types of fabric tested
   b) Number of tests performed
   c) Load Applied
   d) Time of creasing
   e) Time of recovery
   f) Mean crease recovery angle for Warp way specimen and Weft way specimen

Wrinkle: (Many says, same as crease)
Short and Irregular creases
Three dimensional creases
They form when fabric undergo double curvature.

Crease Mark: Crease mark are marks left in a fabric once caused by mechanical damage.

Causes of Crease:
Applied Pressure
Temperature Change
Relative Humidity Change
Poor Construction
Poor fitting garments

Factors of Crease:

Fibre Properties

Co-efficient of Friction (high inter fibre friction will not allow to reshape)

Bending Modulus

Bending Recovery

Fabric Construction

Yarn Construction

Types of weave/knit

Minimizing Crease:

- Using thick fibre
- Discouraging rapid change in Temperature and Relative Humidity
- By using flat seam during sewing
- Treating chemically during finishing

Serviceability, Wear and Abrasion

Serviceability:

An Article which is serviceable is capable of performing useful service; its serviceability ceases when it can no longer do so. It's a relative term. A fabric which is serviceable for one may not be for another. For some fashion concern lady, a dress of 3 months back may be unserviceable although it's still new or not damaged.

However, there are certain factors that limit the serviceability. They are colour, wear, abrasion and time. Usually, time element is the most influencing factor in deciding serviceability.

Purpose of Serviceability Testing:

1. To determine as objectively and precisely as possible whether the application under investigation is a valid and suitable use for the fiber, yarn or fabric, and consequently will have reasonable prospects of commercial success as a long-term proposition. It will be appreciated that this statement applies particularly to the launching of a new fibre, yarn, or fabric, which can bring credit or discredit to the company.
2. To compare a number of different fibers, yarns, or fabrics, as part of market research.
3. To determine the influence of cloth structure and finishing on performance.
4. To asses suitability for purpose in instances where the fabric or article is considered "borderline" by laboratory testing against a performance specification.
5. To determine suitability for making up e.g. seaming properties, pleating and creasing properties.
6. To assist in establishing criteria for laboratory testing and standards performance.

Wear:

Wear is the net result of a number of agencies which reduce the serviceability of an article. It is the amount of deterioration of a fabric due to breaking, cutting, removal of the fibres. Some of the more important agencies are -

- Bending and stretching
- Tearing
- Abrasion
- Laundering
- Cleaning

The nature and type of these agents is so varied in type.

Wear Index (W.I) $= \dfrac{\text{Weight Loss in mg} \times \text{No.of Cycle tested}}{1000}$

If wear index increases, abrasion resistance decreases and vice-versa.

Abrasion:

Abrasion is one aspect of wear and is the rubbing away of the component fibers and yarns of the fabric.

Abrasion may be classified as follows-

1. **Plane or flat abrasion:** A flat area of material is abraded.
2. **Edge abrasion:** This kind of abrasion occurs at collars and folds.
3. **Flex abrasion:** In this case, rubbing is accompanied by flexing and bending.

These three types are only broad divisions and in actual service a complex mixture of some or all types is found.

Points to be consider before abrasion testing:

1. **Condition of specimen:** The fabric will be conditioned and tested in a standard testing atmosphere.
2. **Choice of testing instrument:** Depending upon the types of testing to be done the instrument may be chosen, e.g., Flat abrasion, Flexing Abrasion etc.
3. **Choice of abrasive motion:** The rubbing movement may be reciprocating, rotary or multi-directional.
4. **Direction of abrasion:** When the abrasive motion is unidirectional the abrasion resistance in specific directions can be measured. In many cases differences will be observed between warp way and weft way abrasion resistance. If desired, the direction of abrasion can be at angles to the warp and weft directions.
5. **Choice of abradant:** The severity of the abrasion will vary with the nature of the abradant. Where possible the abrasive qualities of the material used should remain constant during the test and be capable of being reproduced for successive tests. Steel and silicon carbide, for example, will give reasonably constant abrasive qualities. In other instances, the abradant may be a second piece of the tested fabric, a standard worsted or canvas fabric, emery cloth of various grades. With such materials, however, there is the risk of their abrasive properties changing during a test and a tendency for bits of abraded fibre to clog the surface. Some instruments have special methods of removing the link from the abradant.
6. **Backing the specimen:** The hardness of the backing of the specimen may affect the results. In some testes a hard backing is used in others a felt or foam rubber. In one instrument the sample is mounted over an inflated rubber diaphragm.
7. **Cleanliness of the specimen instrument:** The region to be abraded should be handed as little as possible and be free from foreign

matter such as the wax, graphite etc otherwise they will act as lubricants and affect the end-point of test result.

8. **Tension on the specimen:** Variation in the tension on the specimen will alter the result, and therefore, standardized method of mounting the specimen should be used.
9. **The pressure between abradant and specimen:** The severity of the abrasion will obviously be affected by the pressure applied. Here, again suitable standards must be set-up. High pressure will reduce the time taken to reach the end-point of a test but the acceleration of the destruction of the fabric may lead to false conclusion.
10. **The end point of the test:** The end-point may be the completion of a given number of abrasion cycles, the appearance of a hole or broken threads, the rupture of the specimen. Automatic stop motions are often built into the tester so that the motor is switched off as soon as a hole appears or the specimen breaks.

Assessment of abrasion damage:

Several methods of judging the amount of damage are given below-

1. Comparison of abraded specimen with an unabraded specimen.
2. The number of cycles required to produce a hole, broken threads or broken strip.
3. Loss in weight, often plotted against the number of cycles.
4. Change is thickness, e.g., loss of pile height. In some cases, the napping or raising effect of abrasion may cause an increase in thickness particularly in the early stages of a test.
5. Loss in Strength, e.g. tensile, bursting, or tearing strength. The loss may be expressed in percentage of unabraded strength. Some laboratories may determine residual strength after a given number of cycles.
6. Change is other properties, e.g. air permeability, lusture.
7. Microscopic examination of damage of yarns and fibres.

Interpretation of the Result:

No general rule is given on the interpretation of the result from abrasion tests. The effect of special finishing treatments can be assessed by determining the abrasion resistance of the fabric before and after the finishing treatments. It's a series of different tests which are used to make rating of the fabric.

Abrasion testing instruments:

A list of some abrasion testing instruments is mentioned below:

- The Wool Industries Research Association (W.I.R.A.) Abrasion Tester
- The Linen Industries Research Association (L.I.R.A.) Abrasion Tester
- The Taber Abraser (American)
- The Shiefer Machine (American)
- The Wyzenbeek Abrasion Tester (American)
- The Stoll Universal Wear Tester (American)
- The L.I.N.R.A. Wear Tester
- The Accelerotor
- **The B.F.T. Abrasion Testing Machine**
- **Martindale abrasion tester.**

The B.F.T Abrasion Testing Machine

It includes a series of mechanisms to abrade textile materials which provide numerical results which can be correlated with serviceability.

Special Features of this instrument:

1. The end-point of the test is determined automatically by the machine. It stops automatically when the end-point is reached.

2. The abradant used in the various accessories is made of special steel whose abrasive characteristics remain constant and are capable of being reproduced to any specification.

3. The machine is sturdily built and capable of being run smoothly at high speeds for a long time.

4. The result of tests on the machine can be analyzed and expressed numerically and fabrics may be ranked in order of merit.

Construction:

The mechanical parts are mounted on a rigid platform 'P'. A solid aluminum carriage 'C' is given reciprocated motion with a stroke of 1½" at 700 rpm which is achieved by a crank and connecting rod mechanism. A six-digit counter records the number of cycles made. The head 'H' is mounted over the top of the reciprocating carriage 'C' and moves vertically due to parallel link motion. Counter poise weights are employed, so that with no weights on the spigot 'S' the movement is just in balance; hence known vertical loading can be obtained by adding the required weights to the spigot. The control unit and motor are mounted below the platform.

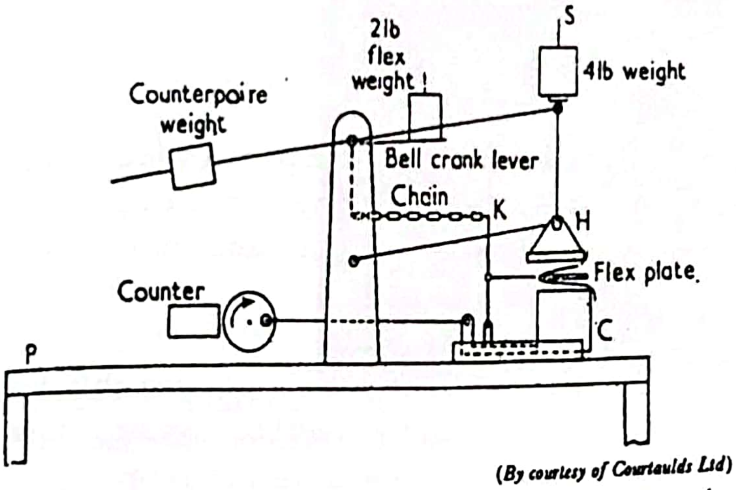
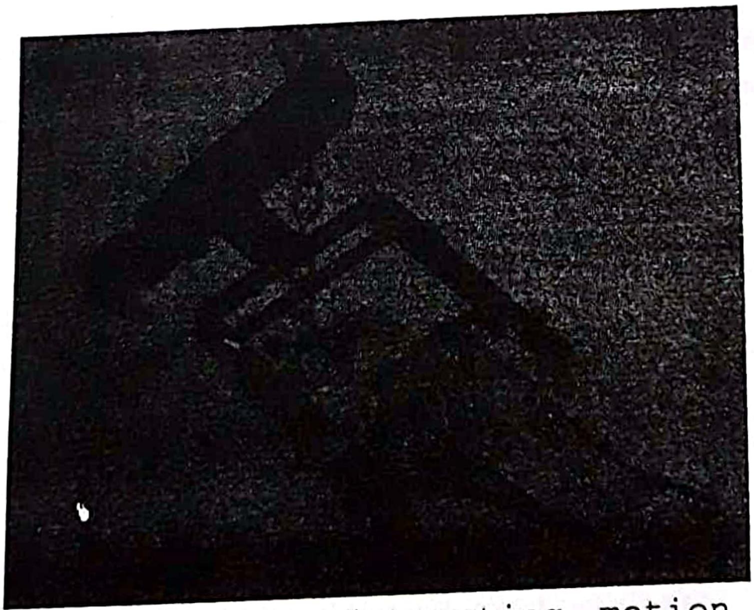


Figure . The B.F.T. abrasion testing machine set up for flex abrasion testing

Three types of test are made and three sets of interchangeable accessories are provided with the instrument.

a. Flex Test:

For flex testing the abradant is a flex plate. The flex plate is a stainless-steel plate about 0.037 inch thick with one edge tapered off and rounded to 0.017″ dia as shown in figure below-



This plate is given a reciprocating motion. Tension is applied to the test specimen by the weight on a bell crank lever acting through a chain link.

The test sample is 5″ long and 1″ wide. The sample is secured at one end over a row of stenter pins on the carriage and led round the radiused edge of the flex plate and the free end is then secured over the stenter pins.

A load of 4 lb is added to the spigot S and a 2 lb weight to the bell crank lever, thus a 2:1 velocity ratio causes the tension in the specimen to be 4 lb.

When the machine is switched on the reciprocating of the carriage causes the fabric to be repeatedly pulled back and forth round the edge of the flex plate and continuous flexing is achieved. Eventually the fabric breaks and a switch is operated, automatically stopping the machine. The number of cycles is read from the counter and recorded. The mean of five tests is taken- warp way, weft way, or in both direction if necessary.

Since the number of cycles obtained is quite high, the mean value is divided by 1000 for easy handling of the result.
Flex Result, P = Mean value of 5 tests / 1000

b. Ball Toughness:

In this test a cover plate with a hardened tool-steel strip is clipped on to the top of the carriage C. The test strip is mounted over this steel plate and secured by stenter pins on either side of the carriage. The abradant is (3/16)″ ball bearing in a special holder which is pushed home into the upper head H.

A load of 1.5 lb is added to the spigot. The sample will be 6″ × 1″ in size. If the warp ball toughness is to be tested, tne long side of the specimen will be parallel to the weft, so that the ball runs across the warp threads.

With the moto running, the carriage reciprocates beneath the ball and in time the ball penetrates the fabric and then contacts the hardened strip. When this happens a small current flow, small enough to avoid any chance of sparking and turn switches the machine off.

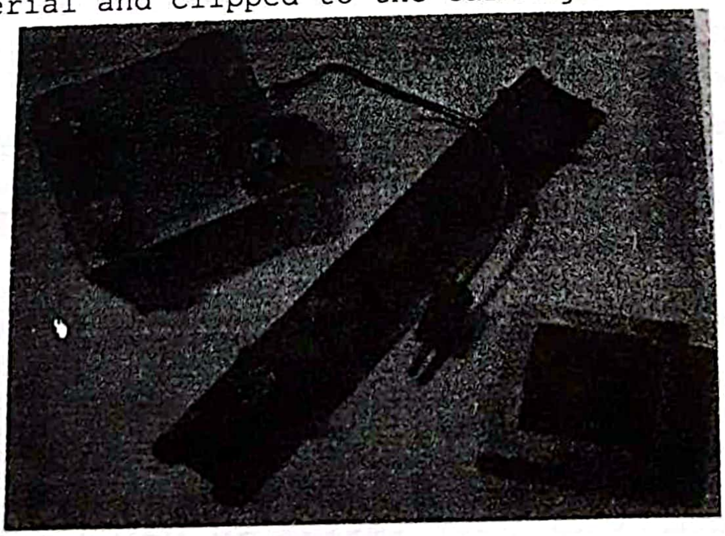
Five tests are carried out for warp & weft and mean values are recorded. The number of cycles is normalized by a factor 10^{-2} and the ball toughness B is calculated as

Ball toughness, B = Mean of 5 tests / 100

The ball penetration tests depend to certain extent on the fabric structure but is mostly related to the toughness or brittleness of the individual fibres. A treatment which increases fibre brittleness reduces the B value considerably. Lubrication has a comparatively small effect on B. Increase of lubrication leads to decrease the B value a little.

c. Flat Abrasion

The abradant used in the flat abrasion test is a stainless-steel gauze in a special holder which is fixed to the upper head by springs. An extra counterpoise weight is clipped to the rear end of the upper link of the parallel motion in order to balance the mass of the gauze holder. The test specimen is stretched over a resilient pad of conducting material and clipped to the carriage.



A 2 lb load is added to the spigot S. After a certain amount of rubbing the steel gauze contacts the pad, a current flow, and the machine is switched off automatically.

The normalizing factor for the flat abrasion test is 10^{-3}.

So, Flat Resistance, F = Mean of five values / 1000

Interpretation of Test Results:

Method I

The ball and flex abrasion results are presented as a harmonic mean and is termed as Duty factor, D.

$$D = \frac{2}{\left(\frac{1}{B}+\frac{1}{P}\right)}$$

It was found that poor fabrics had low duty factors and good fabrics, higher duty factors. For example, a poor overall fabric when tested gives a value B = 2.6 and P =3.5 Then the duty factor, D is calculated 3.00

For another fabric which supposed to be a good fabric, the B = 24.7 and P = 46.4 giving a duty factor of 32. By using this duty factor the fabric can be rated under different classes as below-

Sl. No.	Fabric Type	Satisfactory wear	Outstanding wear
1	Light duty group e.g Dress fabircs	1-4	4-7
2	Heavy duty group e.g Mensuitings, Slacks	6-10	10-20
3	Shirtings	5-8	8-15
4	Overalls	7-12	12-25

Tab: Levels of practical duty factor on Rayon staple fabric with a crease resistance finish.

Method II

The figure of Merit, M. The figure of Merit is the harmonic mean of the ball, flex and flat abrasion.

$$M = \frac{3}{(\frac{1}{B}+\frac{1}{P}+\frac{1}{F})}$$

For any fabric low values of all 3 tests will reduce the figure of merit. If a fabric has a weak link, M will be reduced. For example, if B=100, P=100 and F=100, M also will be equal to 100. But in a fabric, if B=100, P=100 and F=2, then M will suddenly drop to 5.7. Therefore, the fabric designer has to find out the reason for the material's low flat abrasion value. In many commercial end uses, no weak links are permissible, e.g. in shirting's, treasuring's and suiting. Generally, heavy work cloths require higher standards than cloths for leisure wear.

Martindale Abrasion Resistance Tester

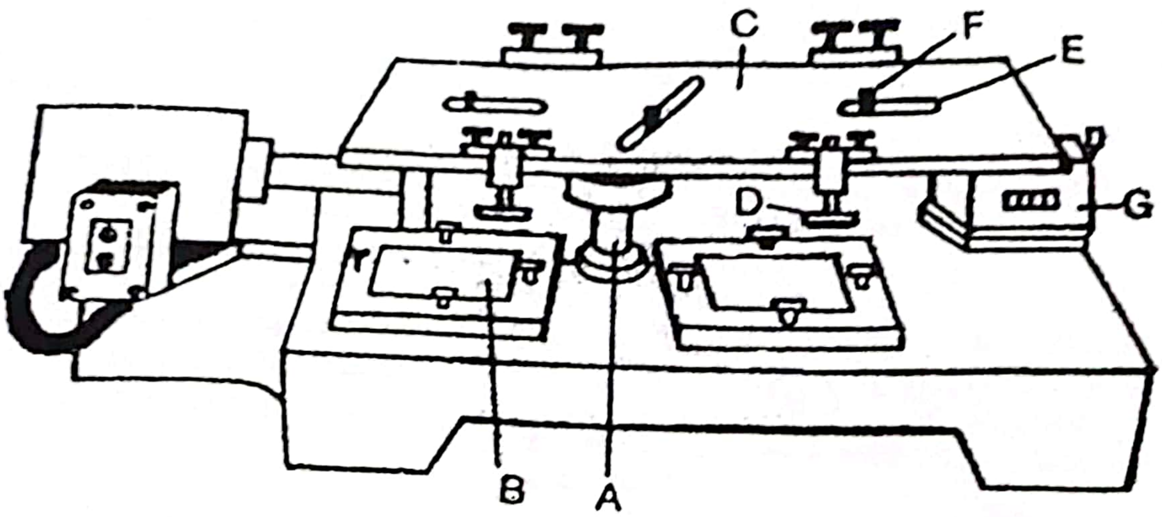
The Martindale abrasion tester is a useful instrument for determining the resistance to abrasion of all clothes of cotton, synthetic, and blended materials. The design of the instrument makes the use of the principles of two simple harmonic motions working at right angles. The instrument can be used for getting circular or linear motion. Therefore, the adaptability of instrument for different conditions is possible.

The machine is used for both oven and knitted fabrics and with little modification, the instrument can also be used to test the pilling resistance and also resistance to edge abrasion. There is a provision in the instrument for varying the condition such as

1. Pressure of abrasion
2. The type of abrading material such as cloth to cloth and cloth to emery or any hard surface

The provision of this change is quite useful for making service test on fabrics, especially where the fabric is to be used for purposes other than dress material. Example furniture covers.

Description:
The machine consists of a top plate supported by three pillars. On the top of each pillar is a ball Caster. These ball casters allow the plates to slide easily in the horizontal plane, determined by 3-point support. The driving arrangement for the plate consists of mechanical device of worm and worm wheel, driving three circular cam discs.



A- Pillar **C- Top Plate** **E- Slot**

B- Abradant **D- Sample Holder** **F-Peg** **G-Pre setting counter**

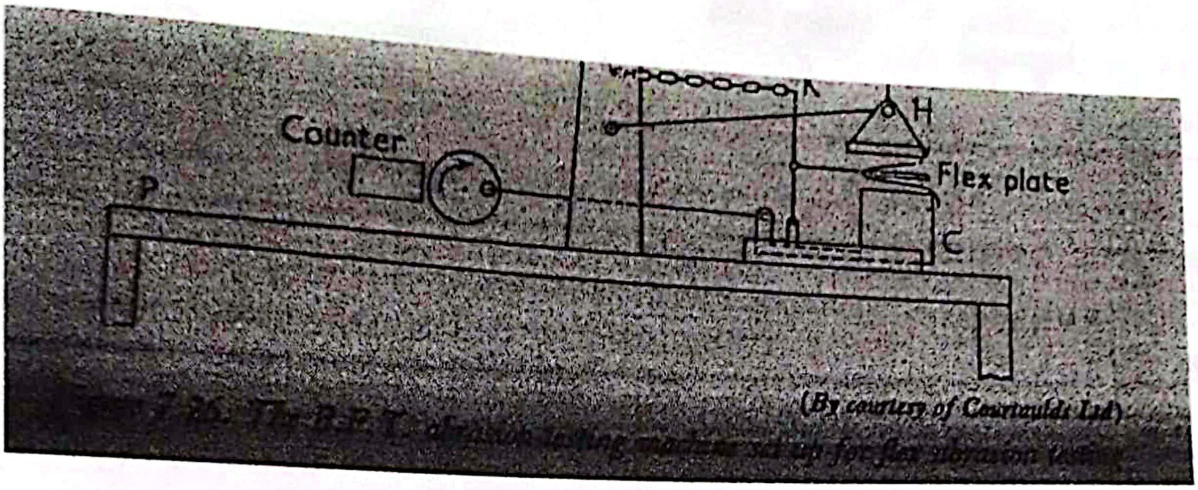
Fig: The Martindale Abrasion Tester

As the cam disc carrying the pins rotate, they rotate the plate. Hence the result of these two motions will be two simple harmonic motions at right angles. The top plate also consists of four holes to carry the circular sample holders and they can be clamped to the top plate. Four specimens of 38 mm diameter are cut and fixed on the sample holders. The sample holders are able to move vertically in the clamp bushes. The sample holders touch the table surface and it will be flat and will move in the same plane in which the top plate slides.

Because of the movement of cloth is rubbed against the cloth surface in harmonic pattern. At what stage it will be circular and then changes to a curve of an ellipse until the line becomes a straight line along the diagonal of the circle. This type of motion has the advantage that the specimen will be robbed in all persons i.e., both in verb and weft with and this is superior to flex abrasion.

End point

And point is determined either by visual examination i.e., the appearance of holes for a known cycle or loss in wet in the sample for known cycles or revolutions. The latter one is better and preferred. The loss in weight is plotted against the number of cycles and the graph is analyzed.



P = Platform S = Spigot
C = Carriage
Counter
H = Head

1. **Flex Test: (Flex Abrasion)**

   5" * 1"
   Place Between C & H
   2 lb on bell crank lever
   4 lb on Spigot, S
   For this 2:1, tension in the specimen in 4 lb

   Flex Result , P = Mean value of 5 tests / 1000

2. **Ball Toughness:**

   6" * 1"
   1.5 lb load on spigot

   Ball Toughness, B = Mean value of 5 tests / 100

3. **Flat Abrasion**

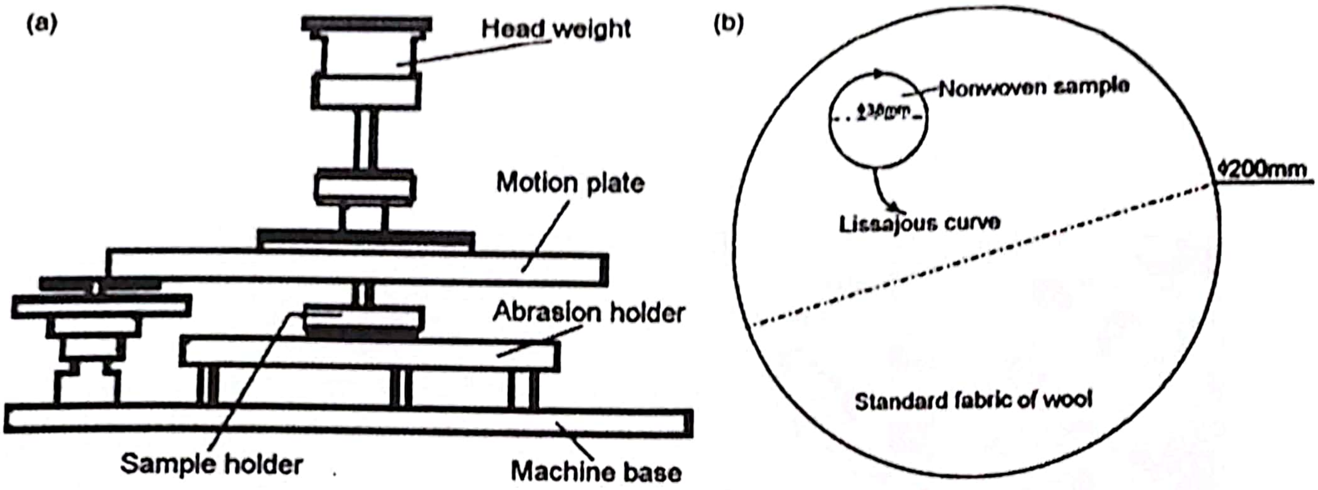
   2 lb on S

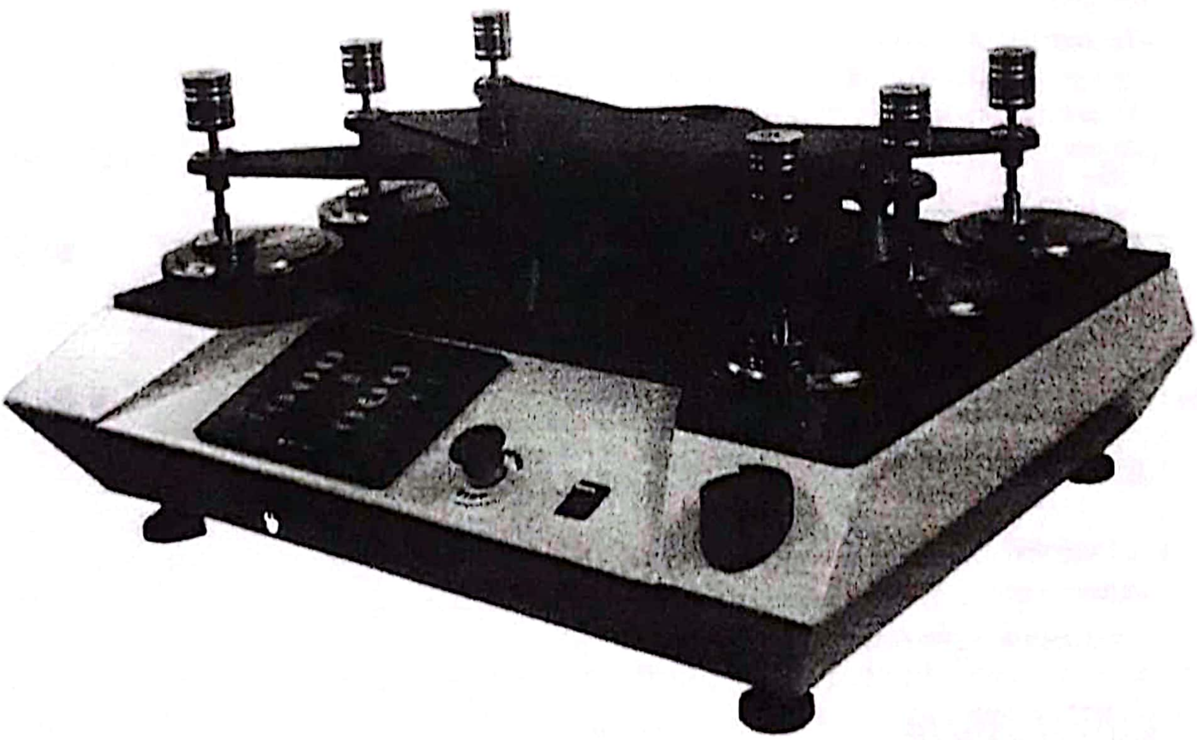
   Flat Resistance, F = Mean value of 5 tests /1000

Calibration:

Interpretation of Result:
Method 1:

$$\text{Duty Factor, } D = \frac{2}{\frac{1}{B} + \frac{1}{P}}$$


(a)
Head weight
Motion plate
Abrasion holder
Sample holder
Machine base
(b)
Nonwoven sample
Lissajous curve
Φ200mm
Standard fabric of wool



Pilling

Pilling: Pilling is a fabric surface fault characterized by little 'pills' of entangled fibre clinging to the cloth surface and giving the garment an unsightly appearance. The pills are formed during wear and washing by the entanglement of loose fibres where protrude from the fabric surface. Pilling can be considered to be the first sign of wear by light abrasion in a fabric, made from staple fibre yarns.

Pills: Pillar are small knots or balls of mixture of large number of small fibres accumulated at the surface of the fabric and entangled by the mild frictional action during processing or wearing. They are soft but firmly held on the surface of the material.

Mechanism of Pilling: Pilling happens due to wearing of the surface. The surface of the fabric when abraded, the constituent fibres from the yarn surface get liberated and become loose, and further abrasion bring out entanglement on its surface.
These loose fibres or entangles fibres form hard pills on the fabric surface giving an unsightly appearance. The appearance of pills is more prominent in the synthetic material and also materials blended with synthetic fibres.

Pilling Test

A number of Pilling test methods and instruments have been developed in various laboratories. After rubbing under controlled conditions, the pilling of the sample may be assessed **numerically** by counting the number of pills formed; alternatively, the **appearance** of the test specimen may be compared with standard sample and given some form of rating. There are at least three types of tester which are popular to conduct the pilling test. They are-

1. Martindale Abrasion Tester
2. I.C.I. Pill Box Tester.
3. (The Du Pont) Random Pilling Tester

1. Martindale Abrasion Tester:

The Martindale Abrasion Tester can be used for Pilling test as well. The normal sample holders are replaced with lightweight square holders which are keyed so that they may have vertical movement but cannot turn on their axes. An adjustment has to be made to convert abrasion into pilling in the tester. After a certain number of rubs the samples are examined and the number of pills counted. This may be repeated, say, in stages of 500 cycles up to 3,000 or 5,000 and the rate of development of pills noted.

2. I.C.I. Pill box tester

The Method of Test: A piece of fabric measuring 5″×5″ is sewn so as to be a firm fit when placed round a rubber tube(6″ long, 1¼″ outside dia, and 1/8″ thick). The cut ends of the fabric are covered by cellophane tape and four tubes are placed in a box (9″×9″×9″) lined with cork 1/8″ thick, which is then rotated at 60 rev/min for 5 hours.

For garments normally subjected to repeated washing as well as to wear, washing may be desirable prior to preparing the tubes of fabric. Hence, it is the practice to apply a standard hand wash in 0.5% soap at 45°C for 15 min to Terylene/Cotton and Terylene/Viscose shirt and dress fabrics.

After tumbling, the extent of pilling is assessed visually by comparison with the arbitrary standards 1, 2, & 3. Under test conditions fabrics of Standard 1 become hairy but do not pill, fabrics of Standard 2 become hairy and pill slightly, while fabric of Standard 3 become hairy and pill more severely. (Figure next page)

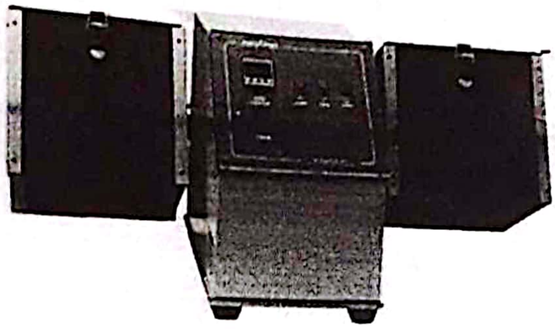
Another Ratting is (1) No pilling, (2) Slight but tolerable pilling (3) Moderate pilling of borderline acceptability (4) Unacceptable pilling (5) Extremely high pilling. Ratting varies depending on Testing Standards.

Interpretation of the result should be governed by the following principles:

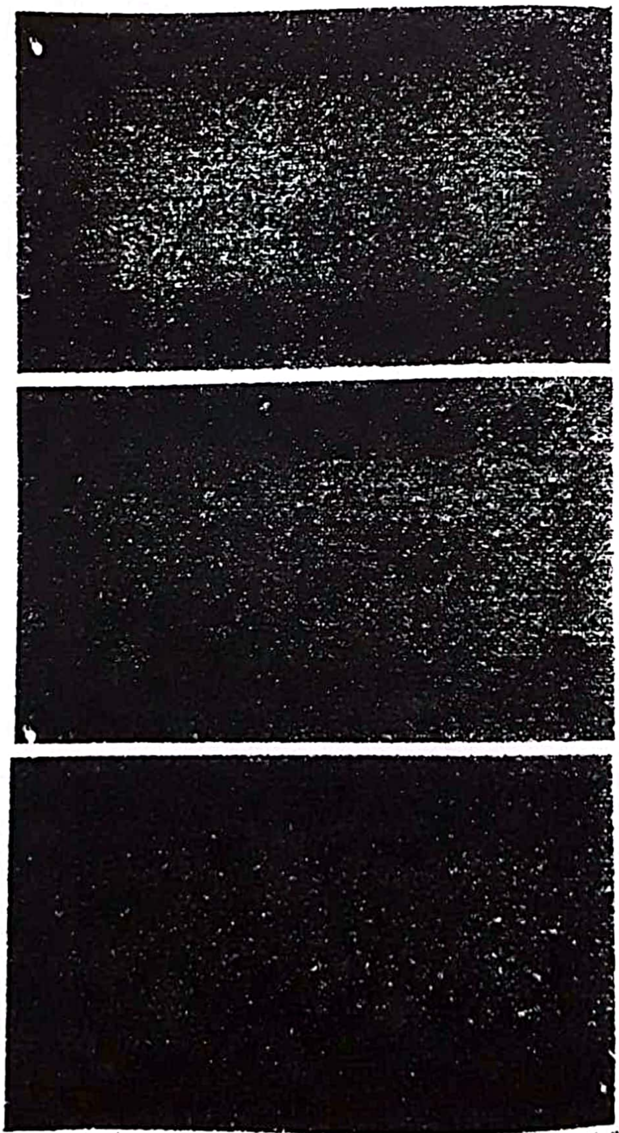
1. The extent of pilling, exemplified by appearance standard, will not be produced by every person but only by those who are particularly hard on their clothes.

2. Experience has shown that when pilling does occur is it usually limited to the most susceptible parts of a garments; e.g. collars, cuffs, pocket edges, front skirt panels. When, however, pilling is severe under the conditions of test, it is probable that the body of the garment will become an affected area, and that the number of persons who will produce the effects is also likely to increase.

3. From a pilling point of view, shirts, blouses, lingerie, and dresses are considered to be critical end-use. These garments will be frequently laundered between wearing, while medium and heavy weight garments will not normally be washed or cleaned with similar frequency. In this latter group, trousers and suits are considered to be more critical than skirts, costumes, and rainwater.



(I.C.I. Pill box Tester)



(a)

(b)

(c)

(By courtesy of I.C.I. Ltd)

ure 7.33. Pilling standards: (a) Standard 1; (b) Standard 2; (c) Standard 3 (½ original size)

3. The du Pont Random Pilling Tester:

A six-unit tester is used, each unit consisting of a cylindrical chamber 6″ long by 5¾″ inside diameter, horizontally mounted, containing a two-bladed impeller which rotates at 1,200 rev/min. The inside of the chamber is lined with neoprene, about 1/8″ thick, which can be changed when necessary. Into each unit three 5″×5″ fabric samples are loaded together with a small amount of cotton lint, the latter being used because the pills which are formed bear a closer resemblance to pills formed during wear than those formed when the lint is absent.

After 1 hour whisking and tumbling the test fabrics are examined visually and compared with standard samples. Five ratings are used.

Factors Responsible for Pilling:(Study with effects)

1. Fibre Characteristics

- (a) Morphological Structure
- (b) Chemical Structure
- (c) Fibre Structure
- (d) Fibre Length
- (e) Fibre Fineness
- (f) Strength
- (g) Extensibility

2. Yarn Characteristics

- (a) Blend Composition
- (b) Count
- (c) Twist
- (d) Plying
- (e) Regularity (evenness) of yarn
- (f) Hairiness
- (g) Short fibres

3. Fabric Characteristics

- (a) Weave
- (b) Knitting
- (c) Intersection
- (d) Ends and Picks

4. Frictional or Abrasive Forces

Pill Formation During Wet Processing:

Pilling is caused on the fabric surface, where it comes in contact with an object in motion or by rubbing. In wet processing of textiles, these conditions exist in different stages such as drying, dyeing, printing, finishing etc.

Drying is one process which may cause pilling of the fabric. During drying, the water from the surface of the fabric evaporates and water from the core of the yarn comes onto the surface along with loose fibres to maintain equilibrium. Hence **improper drying temperature** my accelerate pilling.

Pilling may also be caused during drying due to abrasion between the layers of the fabric or due to **frictional contact with the rollers in motion**. Too much swelling together with high temperature may intensify pilling.

Calendaring is another process where some more pilling can take place due to abrasion with the rollers in motion. **Too much tension** can intensify such fault. The wearing forces on garments, too much tightness or too rough uses, may accelerate pilling.

Effects of Pilling:

Pilling rarely affects the actual durability of a fabric but it affects adversely in processing as well as to the physical properties of the fabric like appearance, handle etc

In dyeing, the pills are likely to absorb more dye resulting in deep shade in contrast to the ground and consequently cloth appears skittery. Further if it develops on the dyed garments during use, it will be lighter in shade resulting in skittery appearance of the materials.

In printing, the sharpness of the outlines of the printed design in the fabric will be spoiled in the presence of pills. Further if it develops on the printed fabric during wear, the printed pattern will not only be blurred but the beauty of the print will be lost.

In finishing, the presence of pills hamper to a great extent in the production of a clean and clear finish. They spoil the appearance of garment.

It also affects adversely the handle of the fabric and consequently deteriorates the comfort of the fabric.

The effect of such changes is dependent on the degree of pilling as well as on the severity of the process adopted. Thus pilling renders the materials unsuitable for domestic use.

Remedies:

1. Steps to be taken prior and during spinning and weaving:

(a) Fibres with cross section other than circular, dumb-bell, and artificially serrated cross section are the best.

(b) Longer stape length, coarser fibres, higer extensibility, greater crimp etc restrict the slippage of the fibres and hence control the tendency to pill.

(c) The common suitable blends of polyester and cellulosic fibres in order of decreasing pilling, are 80/20, 67/33, 50/50.

(d) Higher proportion of short fibres is problem so combing is essential to avoid this defect.

(e) Coarser denier, hard twist, lower hairiness of the yarn are desirable to control pilling. Ply yarn is better and ply yarn with hard doubling twist is the best.

(f) The tendency to pilling is greater, if protruding fibres are present in the yarn. By increasing the number of interlacements in wearing or knitting the loose fibres can be bound tightly at greater length and pilling can be reduced. Higher number of ends and picks minimize this fault.

2. Steps to be taken after weaving or knitting:

(a) Shearing and cropping
(b) Singeing
(c) Heat setting
(d) Surface carbonizing

3. Chemical Treatment:

(a) Binding agents: Resin or any such type of binding agents help is controlling pilling to a great extent. The binding agents hold the loose or protruding fibres on the surface of fabric firmly. There is very little possibility of these fibres to be removed and getting entangled on rubbing to from pills.

(b) Hydrophilic agents: Hydrophobicity or hydrophilicity plays an important rule in pill formation. Thus treatment with a special polymer composition of acrylic type froms a hydrophilic non-tacky film of good cohesion which helps in eliminating undesirable pilling to a great extent.

[Any antipilling treatment should not reduce handle properties greatly]

FLAMMABILITY

Flammability is the ability of a substance to burn or ignite, causing fire or combustion. The degree of difficulty required to cause the combustion of a substance is quantified through fire testing.

- Flammability
- Flammable
- Flame proof
- Flame Proof Types
- Factors Affecting Flame resistance
- Available Methods of Test
- Standard for the Flammability
- Flammability Testing
- Flame Resistance Finish

FLAMMABLE

A flammable fabric is one which propagates flame, i.e. it continues to burn after the igniting flame has been removed.

Flame Resistance Rating (M): A figure derived from the flammability testing of fabrics and is of the same order as the time in seconds necessary for the propagation of flame 100 inch in a vertical strip.

- Flammability
- Flammable
- Flame proof
- Flame Proof Types
- Factors Affecting Flame resistance
- Available Methods of Test
- Standard for the Flammability
- Flammability Testing
- Flame Resistance Finish

FLAME PROOF

A flame-proof fabric is one which does not propagate flame, i.e. any flame goes out quickly when the igniting flame is withdrawn.

Flame-Resistance: A flame resistant fabric is one whose flame resistance rating is high.

- Flammability
- Flammable
- Flame proof
- Flame Proof Types
- Factors Affecting Flame resistance
- Available Methods of Test
- Standard for the Flammability
- Flammability Testing
- Flame Resistance Finish

FLAME PROOF TYPES

Inherently Flame-proof Material: Material which, although not submitted to a flame-proofing process, in flame proof.

Durably Flame-proof Material: A flame-proof material which, after being submitted to a washing treatment, remains flame proof.

Temporarily Flame-proof Material: Material which complies with the standard requirement, before, but not after, the prescribed washing treatment.

- Flammability
- Flammable
- Flame proof
- Flame Proof Types
- Factors Affecting Flame resistance
- Available Methods of Test
- Standard for the Flammability
- Flammability Testing
- Flame Resistance Finish

FACTORS AFFECTING FLAME RESISTANCE

- Fibre content
- Types of Yarn
- Fabric Structure
- Fabric weight

- Flammability
- Flammable
- Flame proof
- Flame Proof Types
- Factors Affecting Flame resistance
- Available Methods of Test
- Standard for the Flammability
- Flammability Testing
- Flame Resistance Finish

AVAILABLE METHODS OF TEST

- The Visual Timing Test (Here the rate of flame spread is determined over fabric suspended vertically)
- The 45° Test(The time, t for the flame to travel 5 inch over fabric sloping at an angle of 45 degree is measured in seconds. The flame resistance rating, M, is then given by 2.5 * t)
- The Hoop Test(The rate of flame spread is determined over the fabric mounted on a semicircular frame)

- Flammability
- Flammable
- Flame proof
- Flame Proof Types
- Factors Affecting Flame resistance
- Available Methods of Test
- Standard for the Flammability
- Flammability Testing
- Flame Resistance Finish

STANDARD FOR THE FLAMMABILITY OF CLOTHING TEXTILES

16 CFR PART 1610

Consumer Product Safety Commission is amending its flammability standard for general wearing apparel, the Standard for the Flammability of Clothing Textiles, 16 CFR part 1610. The Standard, originally issued in 1953, has become outdated in several respects. The revisions better reflect current consumer practices and technologies and clarify several aspects of the Standard.

- Flammability
- Flammable
- Flame proof
- Flame Proof Types
- Factors Affecting Flame resistance
- Available Methods of Test
- Standard for the Flammability
- Flammability Testing
- Flame Resistance Finish

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Exemption of Testing:

Plain Surface
Raised Surface

Note: Acrylic, Modacrylic, Nylon, Olefin, Polyester, Wool

2.6 oz/sq.yards

- ☐Flammability
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Procedure of Testing:

Refurbishing: 5 Specimen
Original: 5 Specimen

Preliminary Test: Direction finding
Specimen: 6" * 2"
Brushing:
45 degree
Sensor
1sec, 16 mm flame length

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Interpretation of Result:

For Plain Surface
&
For Raised Surface

Class 1: Normal Flammability:

Class 2: Intermediate Flammability:

Class 3: Rapid and Intense Burning

- ☐Flammability
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Interpretation of Result:

Plain Surface:

DNI= Did Not Ignite
IBE = Ignite But Extinguish
Burn Time

- ☐Flammability
- ☐Flammable
- ☐Flame proof
- ☐Flame Proof Types
- ☐Factors Affecting Flame resistance

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Interpretation of Result:

Class	Plain surface textile fabric	Raised surface textile fabric
1	Burn time is ≥ 3.5 seconds.	• Burn time is > 7.0 seconds; or • Burn time is 0-7 seconds with no base burns (SFBB). Exhibits rapid surface flash only.
2	N/A	Burn time is 4-7 seconds (inclusive) with base burn (SFBB).
3	Burn time is < 3.5 seconds. NOT ACCEPTABLE	Burn time is < 4.0 seconds with base burn (SFBB). NOT ACCEPTABLE.

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- ☐Flame proof
- ☐Flame Proof Types
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Interpretation of Result:

Raised Surface:
SFuc
SFpw
SFpoi
- - sec.
- - SF only
- - SFBB
- - SFBBpoi
- - SFBBpoi*

- ☐Flammability
- ☐Flammable
- ☐Flame proof
- ☐Flame Proof Types
- ☐Factors Affecting Flame resistance

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FLAME PROOFING AND FLAM-RESISTANT FINISHES

But should be considered following

1. Be permanent and not disappear at the first laundering or cleaning
2. Be non-toxic
3. Be non-irritant to the skin
4. Leave the handle and other desirable fabric properties unaffected.

Objective Evaluation of Fabric Hand (Handle Properties)

Subjective sensory perceptions of sheet-type fibrous products (such as woven and knitted fabrics, nonwovens, paper products, leathers, and other such products) in contact with the human skin during use have long been recognized as being among the most important quality attributes for such products. It has, however, been very difficult to evaluate such perceptions, which often play a decisive role in the extent of customer satisfaction with such products, objectively by using instrumentation.

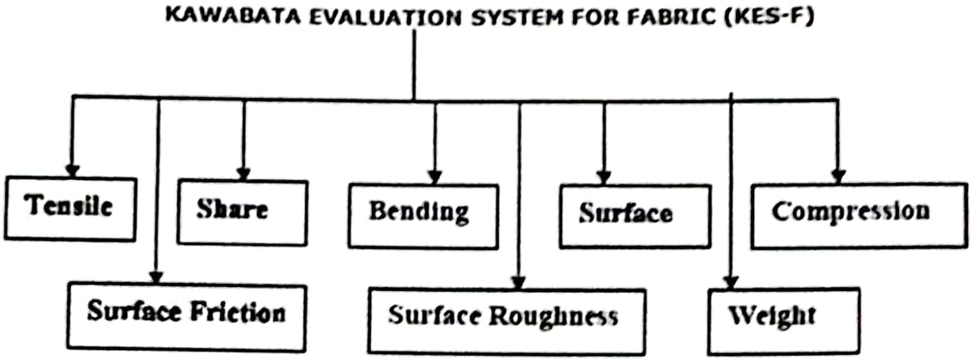
These sensory perceptions are often expressed in terms of the concept of the "hand" of a fabric. Fabric hand is defined in the textile industry as the quality of a fabric assessed by the reaction obtained from the sense of touch. People's overall tactile sensory responses towards fabrics, defined as the fabric hand, comprise the combined effects of physical, physiological, psychological, and social factors.

The following two methods (KES and FAST) and systems are used to obtain objective evaluations of fabric characteristics in attempts to quantify subjective human sensory perceptions:

Kawabata Evaluation System (KES):

This system was developed at Kyoto University in Japan. KES is a series of instruments used to measure those textile material properties that enable predictions of the aesthetic qualities perceived by human touch. KES instruments quantify garment material tactile qualities through objective measurement of the mechanical properties related to comfort perception. KES provides a unique capability, not only to predict human response, but also to provide an understanding of how the variables of fiber, yarn, fabric construction and finish contribute to perceptions of comfort.

It is used to quantify the subjective human perceptions of aspects of the "hand feel" of a fabric. It is used to measure tensile and shear properties on a Tensile and Shear Tester, pure bending properties on a Pure Bending Tester, compression properties on a Compression Tester, and surface friction and roughness on a Surface Tester. The image pasted below, summarizing the system. These measured mechanical properties are then related to various subjective fabric hand feel descriptors; such as stiffness, softness, fullness, smoothness, and Total Hand. There is quite good correlation between the subjective perceptions and the measured properties.



KAWABATA EVALUATION SYSTEM OF FABRIC (KESF):

1. **KES-FB1 ® Tensile and shearing**
2. **KES-FB2 ® Bending**
3. **KES-FB3 ® Compression**
4. **KES-FB4 ® Surface friction and variation**

Compression: KES FB3 Compression Tester

Compressional properties of a 2 cm^2 area are measured with the KES-FB3 Compression Tester at an appropriate force for material type being tested.

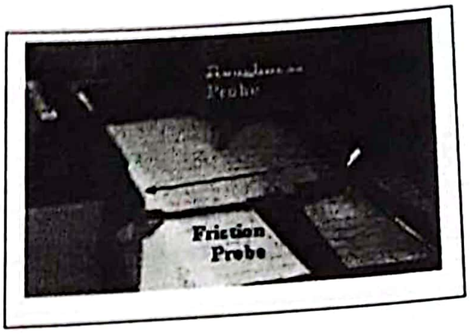
- **EMC** – compressibility, percent comparison of initial thickness measurement to that at maximum applied force. A higher value indicates greater compressibility.
- **RC** - compressional resilience, percent recovery or regain in thickness, when the force is removed. Higher value indicates a greater recovery from being compressed.
- **Thickness** - millimeters; measured at 0.5 gf / cm^2.

Bending: KES-FB2 Bending Tester

KES-FB2 Bending Tester measures the force required to bend the test fabric approximately 150°.

- **B** - bending rigidity per unit fabric width, gf.cm^2 / cm. Higher B value indicates greater stiffness / resistance to bending motions.

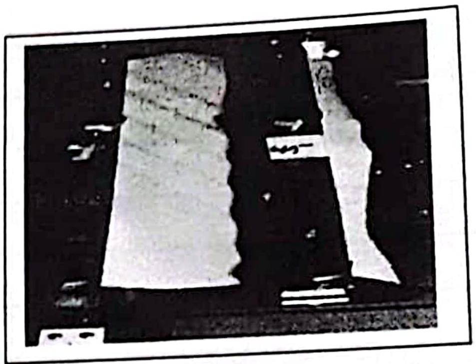
Surface: KES-FB4 Surface Tester



The surface properties of friction (resistance / drag) and surface contour (roughness) are determined using the KES-FB4 Surface Tester.

- **MIU** – coefficient of friction, 0 to 1 with higher value corresponding to greater friction or resistance and drag.
- **SMD** – geometric roughness, micron; higher values correspond to geometrically rougher surface.

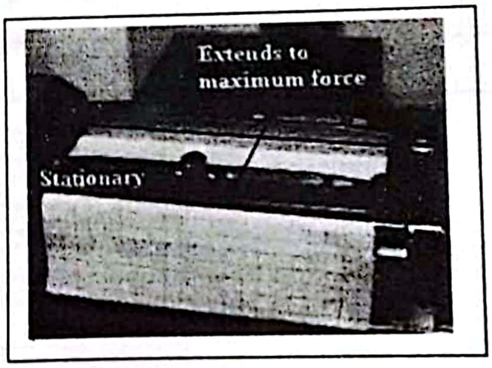
Shearing: KES-FB1 Shear Tester



In shear testing, the KES-FB1 Tensile-Shear Tester applies opposing, parallel forces to the fabric, until a maximum offset angle of is reached. A pretension load is applied to the specimen.

- **G** – shear stiffness, gf/cm.degree, is the ease with which yarns move, resulting in soft / pliable to stiff / rigid structures. Lower values indicate less resistance to the shearing motion; corresponds with better drape.

Tensile: KES-FB1 Tensile Tester



KES-FB1 Tensile Test, measures the stress / strain parameters at a maximum load for the type of material being tested.

- **EMT** – extensibility or stretch, percent strain at maximum applied force: completely elastic (100%) to inelastic (0%); higher value indicates greater stretch.
- **RT** – tensile resilience, percent recovery from stretch when the applied force is removed. Higher values indicate greater recovery from having been stretched.

Summery:

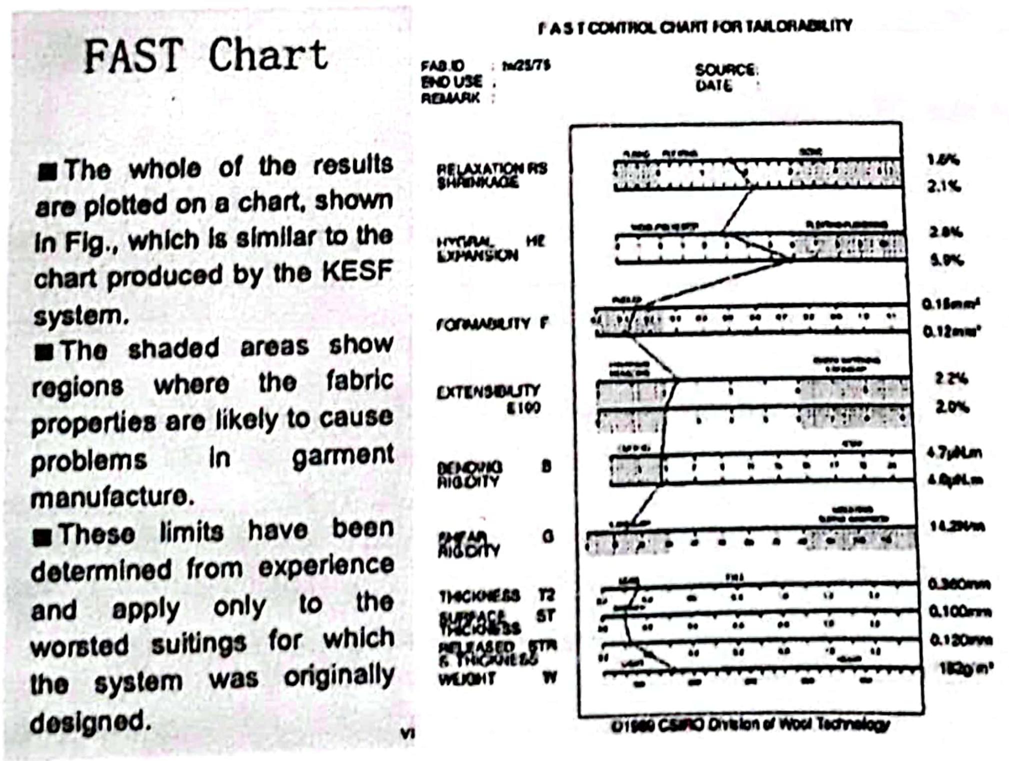
Tensile	LT	Linearity of load extension curve
	WT	Tensile energy
	RT	Tensile resilience
Shear	G	Shear rigidity
	2HG	Hysteresis of shear force at 0.5°
	2HG5	Hysteresis of shear force at 5°
Bending	B	Bending rigidity
	2HB	Hysteresis of bending moment
Later compression	LC	Linearity of compression thickness curve
	WC	Compressional energy
	RC	Compressional resilience
Surface characteristics	MIU	Coefficient of friction
	MMD	Mean deviation of MIU
	SMD	Geometrical roughness
Fabric construction	W	Fabric weight per unit area
	To	Fabric thickness

Fabric Assurance by Simple Testing (FAST)

This system was developed at the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia. It was initially designed specially to predict the properties of wool and wool blended fabrics that affect their tailoring performance and the appearance of the tailored garments in wear. It is used both to predict such properties of fabrics and to provide information which can be related to the fabric handle.

Unlike the KES system which was developed much earlier, the FAST system only measures the resistance of a fabric to deformation, and not the recovery of the fabric from deformation. However, the FAST system is claimed to be much cheaper, simpler, and more robust than the KES system, and hence to be perhaps better suited for use in an industrial environment. It consists of three instruments (compression meter, bending meter, and extension meter, which provide test results that can be recorded instantaneously and automatically) and a test method (dimensional stability test, for which the results are recorded manually).

The results are plotted on a control chart to provide a Fabric Fingerprint which indicates whether the tested fabric will be suitable for the intended end use. The image pasted below, depicting how the results are summarized with this system.



FAST consists of three instruments and a test method:

FAST - 1: Compression meter

FAST - 2: Bending meter

FAST - 3: Extension meter

FAST - 4: Dimensional stability test

The FAST 1, 2 and 3 could be interlinked and results are recorded automatically and FAST-4 data are recorded manually

FAST - 1: Compression meter:

- This instrument measures fabric thickness at various loads and surface thickness
- The fabric thickness at two different pressures enables the accurate measurement of surface layer thickness
- Thickness is measured at a pressure of 2 gf/cm^2
- Surface thickness is the difference in thickness of a fabric measured at pressures of 2 gf/cm^2 and 100 gf/cm^2.
- This gives information about the hairiness or surface bulk of the fabric (closely related to surface treatment like brushing, singeing)
- Released surface thickness is the measure of the surface thickness after the fabric has exposed to steam or water

FAST - 2: Bending meter:

- This measures the fabric bending length according to BS 3356-1961.
- The bending length is converted into bending rigidity, which is directly related to fabric stiffness - an important component of fabric handle
- The operator error in aligning the sample is eliminated with the use of an optical sensor
- The main problems associate with bending rigidity occurs in fabrics that have low values. These fabrics due to the ease with which they bend, would be difficult to handle and sew.
- Fabric extensibility is combined with bending rigidity to give formability - a parameter related to the incidence of seam pucker

FAST - 3: Extension meter:

This instrument measures fabric extension at various loads and bias extension.

- Extension is displayed as a percentage with a 0.1% resolution.
- Extensibility is measured at three loads 5 gf/cm (E5), 20 gf/cm (E20) and 100 gf/cm (E100).

- The difference between E5 and E20 is used to calculate *Formability*
- E100 is used in control chart (Fabric Fingerprint) as the measure of fabric extensibility. If the value is below approximately 2% then the fabric will be difficult to extend during seam overfeed.

Bias extension is converted to shear rigidity - which is directly related to fabric *looseness* - another important component of fabric hand.

Shear rigidity below 30N/m, the fabric deforms so easily that it may give problems in handling, laying up and sewing.

Conversely if it is above 80N/m then the fabric can be difficult to overfeed, mould, etc.

FAST - 4: Dimensional stability test:

- This measures relaxation shrinkage hygral expansion
- The test is completed in less than an hour as compared to the conventional one-day test
- A forced convection oven, a template and a ruler are the only equipment required to do the test.

Summery:

Test	Measures	Predicts Problem In
FAST-1	Thickness Compression	Pressing (Finish Stability)
FAST-2	Bending	Cutting Automated Handling
FAST-3	Extensibility	Laying-Up Pattern Matching Overfed Seams Moulding
	Shear Rigidity	Laying-Up Moulding Sleeve Insertion
FAST-2 and FAST-3	Formability	Seam Pucker
FAST-4	Relaxation Shrinkage	Sizing Seam Pucker Pleating
	Hygral Expansion	Appearance Loss Pleating

Use of FAST:

FAST can tell one how well a fabric will perform.

Abnormal FAST Fabric Fingerprints point to potential problem areas

Fabric Fingerprints can be used for-

- ✓ Fabric specifications
- ✓ Developing new fabrics
- ✓ Comparing fabric finishing routs
- ✓ Assessing stability of finished fabrics
- ✓ Predicting tailoring performance
- ✓ Final garment appearance

Broad areas of Use of FAST:

I) Fabric Finishing (Using FAST-1): Change in fabric surface characteristics after finishing process can be measured.

II) Tailorability:

a) Formability and seam pucker (Using FAST-2 and FAST-3):

- ✓ Sewing operations, especially those involved in overfeeding, imposes strains on the fabric.
- ✓ Stiff fabrics resist buckling
- ✓ Extensible fabric accommodates overfeed

b) Laying up and cutting (Using FAST-3): Very extensible fabrics, which move around while being cut, cause problems with sizing, pattern matching and sewing stage.

c) Sewing of long seams (Using FAST-3): Very extensible fabrics are difficult to match over a long seam length.

d) Steaming and pressing (Using FAST-4): Pressing operation rely on amount of fabric shrinkage. Garment appearance is affected by fabric shrinkage.

e) After care (Using FAST-4): Care must be taken when dealing with the fabrics which exhibits excessive shrinkage

f) Garment appearance (Using FAST-4): During conditions of high relative humidity, the onset of pucker can be attributed in part to increasing fabric dimension, i.e. hygral expansion.