# Chapter 1

## Objective of Testing- Reasons for Textile

## Testing:

- Checking the quality and suitability of raw material and selection of material.

- Monitoring of production i.e. process control.

- Assessment of final product, whether the quality is acceptable or not, (how will be the yarn performance in weaving? etc).

- Investigation of faulty materials (analysis of customer complaint, identification of fault in machine etc.).

- Product development and research.

- Specification testing: Specifications are formed and the materials are tested to prove whether they fall within the limits allowed in the specification (e.g. specified by a customer).

# Chapter-2 SAMPLING

A sample is a subset of a population. Sample is a relatively small fraction selected from a population; the sample is supposed to be a true representative of the population.

## Aim of sampling:

To produce an unbiased sample in which the population of the different fibre length in the sample are same as those in the bulk or through sampling systems of each fibre in the bale should have equalchance of being chosen for the sample.

## Sampling methods are governed by:

1. Form of the material (fibreeyarnefabric).

2. Amount of material available.

3. Nature of the test.

4. Type of testing instruments.

5. Information required.

6. Degree of accuracy required.

## Sampling:

It is not possible or desirable to test all the raw material or all thefinal output from a production process because of time and cost constraints.

Many tests are destructive so that there would not be any material left after it had been tested. Because of this, representative samplesof the material are tested.

## TYPES OF SAMPLE:

**Sample are three types. They are:**

### RANDOM SAMPLE:

In this type of sample every individual in the population has an equal chance of being included in it. It is free from bias, therefore truly representative of the population.

### NUMERICAL SAMPLE:

A sample in which the proportion by number of, say, long, medium, and short fibers would be the same in sample as in the population.

### BIASED SAMPLE:

When the selection of an individual is influenced by factors other than chance, a sample ceases to be truly representative of the bulk and a *biasedsample* results.

## Causes of bias in sampling:

### Bias due to physical characteristics:

Longer fibers always have a greater chance of being selected.

### Position relative to the person:

Lab assistant may pick bobbins from top layer of a case of yarn (whether tosave himself the task of digging down into the case or because he has never been told otherwise, we do not know), but the bobbin chosen will be biased due to their position.

## Subconscious bias:

Person selecting cones will pick the best looking ones free fromridges, cubwebbed ends, etc., without thinking about it.

**Population**

All elements, individuals or units that meet the selection criteria for a group to be studied and from which a representative sample is taken for detailed examination. It is the total system that need to be studied.

# Chapter-3

## Yarn Sampling Techniques:

When selecting yarn for testing it is suggested that ten packages are selected at random from the consignment. If the consignment contains more than five cases, five cases are selected at random from it. The test sample then consists of two packages selected at random from each case. If the consignment contains less than five cases, ten packages are selected at random from all the cases with approximately equal numbers from each case. The appropriate number of tests are then carried out on each package.

**Random sampling – yarn in package form:**

Yarn is available in various forms of package such as bobbins, cops, cone and cheese and as hanks. Table of random number is normally used sampling yarn bobbins from comparatively small bulk size. Totally 10 packages may be selected at random.

- If the bulk contains more than five cases, at least five cases are selected at random and then two packages are selected at random from each case.
- If the number of cases is less than five, then ten packages are selected at random approximately, two from each package.

**Fabric Sampling Techniques:**

When taking fabric samples from a roll of fabric certain rules must be observed. Fabric samples are always taken from the warp and weft separately as the properties in each direction generally differ. Figure 3 shows correct sampling method for woven fabric. Fabric samples from warp and weft are taken separately as their properties vary substantially along warp and weft. Identify and mark the warp direction first. Make sure that no two specimens contain

n same warp or weft threads. Mark and cut samples at least 2 inches away from the selvedge. Also, make sure not to take samples from creased, wrinkled or damaged portions of the fabric, if any. In case of knit fabric, samples are taken from different parts of the fabric almost the same way as done for wovens.

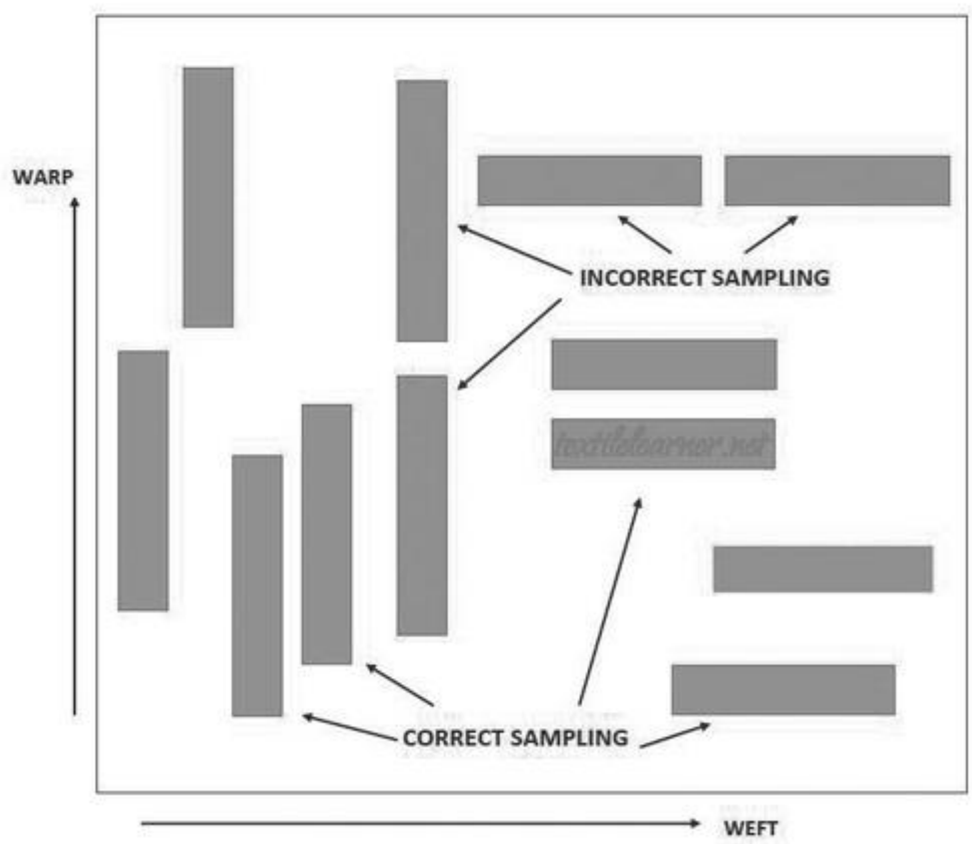



Figure Fabric sampling

## Chapter-4

## MOISTURE & TEXTILES

### Atmospheric Conditions and Relative Humidity:

The dampness of the atmosphere can be calculated in terms of humidity

### Absolute humidity:

The weight of water present in a unit volume of moist air,

### Relative Humidity:

The ratio of the absolute humidity of the air to that of air saturated with water vapour at the same temperature and pressure, expressedas a percentage.

$$RH\% = \frac{\text{Absolute humidity of air}}{\text{Absolute humidity of air saturated with water}} \times 100$$

## Std. Testing Atmosphere:

R. H. % : 65% ± 2%

Temp.: 20° C ± 2° C (cold countries)

27° C ± 2° C (tropical & subtropical countries)

## Measurement of R. H. %:

- *Hygrometer* **–** Wet and Dry bulb hygrometer
- Dry bulb reading – 68° F
- Wet bulb reading – 61°
- FDifference – 7° F
- R. H. % from table 67 %

## Chapter-5

## Moisture and Fibre Properties:

- Dimensions: Swelling in diameter, fabric shrinkage occurs due to fibre swelling
  Advantage of swelling is taken in designing in water proof wrinkled appearance ofsuit (by change in RH%)
  Mechanical properties: Vegetable fibers such as cotton and flax are considered - an increase in strength is noticed when moisture absorbed by the fiber. Other than these fibers strength will be decreased when moisture absorbed by the fiber.
  Other mechanical properties affected by regain include extensibility, crease recovery, flexibility, and ability to be 'set' by finishing processes.
- Electrical properties: The 'before and after' effect of moisture on the electrical resistance of textile material is most striking. Other elctrical properties affected bythe amount of moisture in the material are the dielectric characteristics and the susceptibility to static troubles.
- Thermal effect: Absorption of moisture results generation of heat, i.e. 'heat ofabsorption'
- In winter from a hot room (low RH %) to outside (cold and high RH%) heat generation balancing of heat, otherwise body would suffer.

## Factors Affecting the Regain of Textile Material:

**Time:** A sample takes a certain amount of time to reach equilibrium. This rate of conditioning depends on size and from ofmaterial, the material type.

Relative Humidity: Higher the RH Higher will be Regain.

Temperature: No direct impact, but at high temperature the atmosphere can hold more water.

The previous history of sample: Bleached or scoured cotton will absorb more moisture than untreated material.

## Moisture regain:

Moisture regain is defined as the weight of water in a material as a percentage of the oven-dry weight. Moisture regains, and moisture content is essential in the textile industry.

Let, Oven dry weight of a material = D

Weight of water in this material = W

$$\text{Moisture regain, } R = \frac{W}{D} \times 100 \qquad .......(1)$$

## Moisture content:

Moisture content is defined as the weight of water in a material express as a percentage of the total weight of the material.

$$\text{Moisture content, } C = \frac{W}{W+D} \times 100 \qquad ...............(2)$$

Different textile fibers have distinct moisture regain. For example, cotton has a moisture regain of 7%, and silk has a moisture regain of 11%.

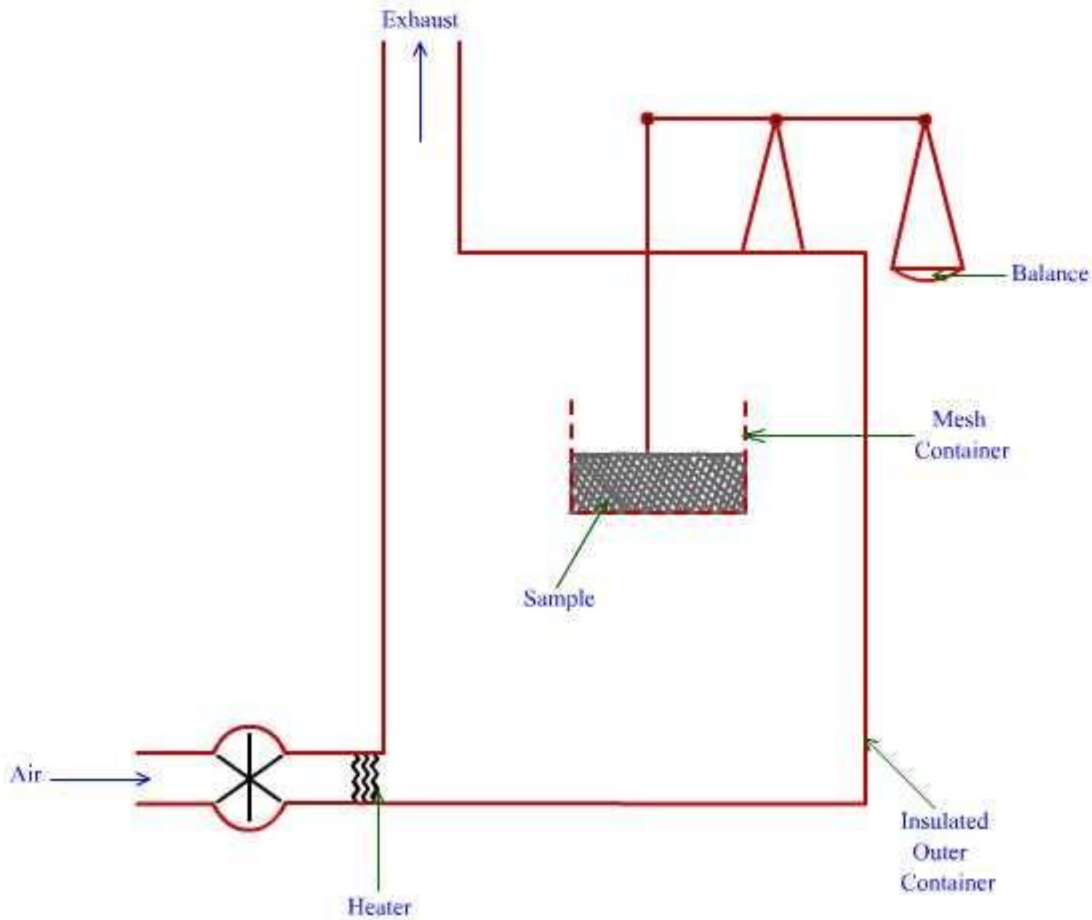
### Measurement of Moisture:

#### By oven dry method (Direct)

- A conditioning oven, as shown in figure, is a large oven which contains the fiber sample in a mesh container. The container is suspended inside the oven from one pan of balance, the mechanism of which is outside the oven.
- This ensures that the weight of the sample can be monitored without disturbing the system.
- A continual flow of air at the correct relative humidity is passed through the ovenwhich is maintained at 105ºC.
- The main advantage of using a conditioning oven for carrying our regain determinations is that all the weighing is carried out inside the oven. The use of the conditioning oven to dry a sample is correct standard procedure; any other method of sample drying has to be checked for acuracy against it.
- The method is based on the assumption that the air drawn into the oven is at the standard atmospheric condition. If this is not the case the correction has to be made

**Percentage correction = 0.5 (1 - 6.48 x $10^4$ x E x R) %**

Where R = relative humidity % e 100, and E = Saturation vapour pressure in pascalsat the temperature of the air enter the oven (taken from a table of values)




## Chapter-6

**Yarn Count Measurement System**

Different system or units are used to measuring the yarn count or yarn number which mostly depends on the material used for preparing the yarn and the area where it was manufactured.

**Yarn count measurement system can be grouped as following categories;**

- Analytical System &
- Instrumental System.

**Analytical System**

Actually this process is consisting with some other systems based on several calculations and this is why it is called Analytical system. The systems are including;

1. Direct System &
2. Indirect System

**1. Direct System**
In this process the count is based on the number of weight units in a length unit. Thus, the size or bulkiness of the yarn is directly proportional to the count number. A coarser yarn will have a higher count number while a finer yarn will have a lower count number. The system is used for very fine and very coarse yarns. This system is mostly used for silk, **jute** etc.

**We can work in this system by following categories;**

- Tex
- Denier

**Tex**
It can be defined as the weight present in 1000 meter of yarn in grams where length of yarn is fixed. It means that, for example, if there is a 1000 meter of yarn and have a weight of 20gm then the yarn count will be 20tex. Because tex refers the weight in gram of unit length.

**Here is the equation for determining the yarn count in Tex;**

$$\text{Tex} = \frac{\text{Weight in grams}}{\text{Length in 1000 meter}}$$

**Denier**
It is defined as the weight of yarn thread in grams presented in per 9000-meter length of that yarn. It is just like about Tex system only has to change the unit length from 1000m to 9000m and then the equation of denier becomes as;

$$\text{Den} = \frac{\text{Sample weight in gm X Unit length (9000m)}}{\text{Sample length in meter}}$$

**2. Indirect System**
In this system the count of yarn expresses the number of length units in one weight unit. Higher the count finer is the yarn. This system is generally used for cotton, worsted, woolen, linen (wet spun), etc. The indirect system covers the majority of the important types of yarns. The count is based on the number of length units in one weight unit

This is also having some sub-system as following;

- Cotton Count
- Metric Count &
- Worsted count.

**Cotton Count**
Actually by the term cotton count can be defined as the number of hanks of 840 yds presented in 1 lb weight of yarn. This is also known as British or English count. It is denoted by Ne

The equation of cotton count measurement is as following;

$$\textbf{Count, Ne} = \frac{\text{Length in hanks of 840 yds}}{\text{Weight in lbs}}$$

$$\text{Or, } \textbf{Ne} = \frac{\text{Sample length in yds X unit weight}}{\text{Sample weight in lbs X unit length}}$$

**Metric Count**
Metric count is express 1000 gm or 1 kg weight of yarn can contain how many numbers of hanks of 1000 meter. It is denoted by Nm.

**<u>The formula of measuring metric count is;</u>**

$$\textbf{Metric Count, Nm} = \frac{\text{Sample length in meter X unit weight}}{\text{Sample weight in kg X unit length}}$$

**Worsted Count**
It is the number of hanks of 560 yds presented in 1 lb weight of yarn is known as worsted count which is widely used for yarn composed by wool.

**<u>Instrumental System</u>**
By this process count of yarn is measured by using different sorts of instrument where any kind of calculation is not needed and we can get directly the yarn count. The machines which are mostly used of count measurement are given bellow;

1. Beesley Balance
2. Wrap Reel Balance
3. Quadrant Balance
4. Stubb Yarn Balance

1. **Beesley Balance:**
   When a cotton yarn is supplied in short length or removed from fabric, the count of yarn can be measured by a special type of balance is called Beesley's balance.

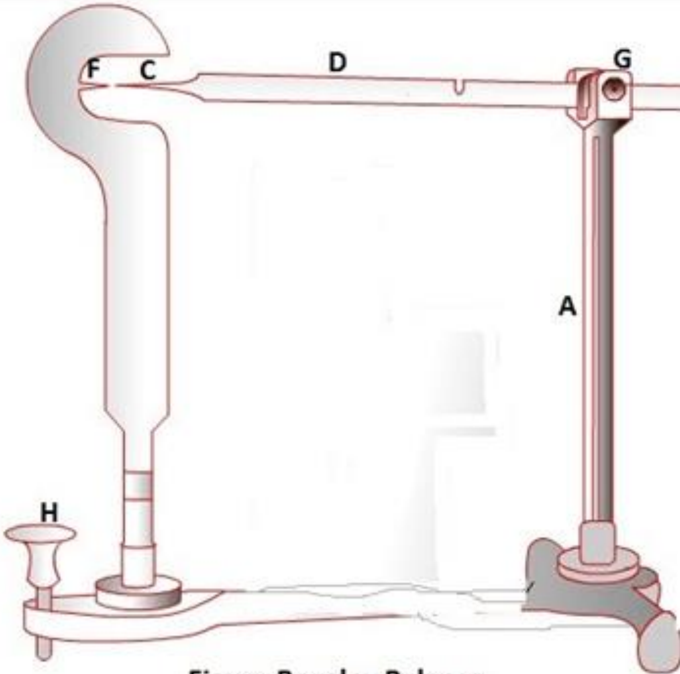



Figure:Beesley Balance

A-Pillar; B-Beam; C-Pointer; D-Notch; E- Sample hook; F-Detam Line; G-Pivot; H-Levelling Screw

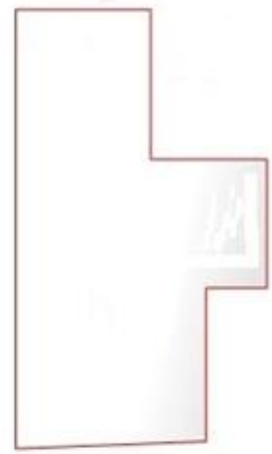


Figure: Templet

**Beesleys Balance:**

Beesleys yarn balance consists of a pillar A which carries a cross beam B, fulcrumed at knife edge at the point G (See figure in above). At one end the cross beam is a hook E upon which the yarn to be tested can be placed. The other end of the beam tappers to a point C. When the beam is in balance, the pointer will coincide with the detum line. The pillar is mounted on the base. The whole instrument is leveled by a leveled screw at one end of the base. The cross has a small notch at the point D to take the counter weight or rider.

Working Procedure:

1. Collect sample by appropriate sampling method.
2. This Sample conditioning at testing atmosphere.
3. Marked the fabric by using template
4. Cut that's fabric by knife according to the marking.
5. The pointer is set directly opposite to the detum line, with no material and counter weight in their proper places, by adjusting the leveling screw. The counter weight for the particular length which is supplied with the instrument is chosen and suspended at the notch D. (For full cotton the large rider is placed in the notch and for ½ cotton small rider is placed)
6. Now yarn is withdrawn from sample and placed sample hook until the pointer comes in level with the detum line.
7. At that stage the threads are taken out and counted which givers directly the cont of yarn teken for testing.
8. There 30 threads in the sample hook at the balanced condition so the count of the yarn is $30^s$

**2. Wrap Reel Balance**
By this standard method of count testing, the count of any type of a yarn can be calculated. In this system yarn is measured by the wrap reel counter.

Yarn count: The **yarn count** is a numerical expression which defines its fineness or coarseness. It also expresses weather the yarn is thick or thin. A definition is given by the textile institute – "Count is a number which indicates the mass per unit length or the length per unit mass of yarn."

$$\text{Cotton Count} = \frac{\text{Length in yard} \times \text{Weight Unit}}{840\ \text{Yard} \times \text{Weight in pound}} \quad \ldots\ldots 0\ 1$$

Wrap reel are two types on the basis of driving method:

1. Hand Drive
2. Power Drive.

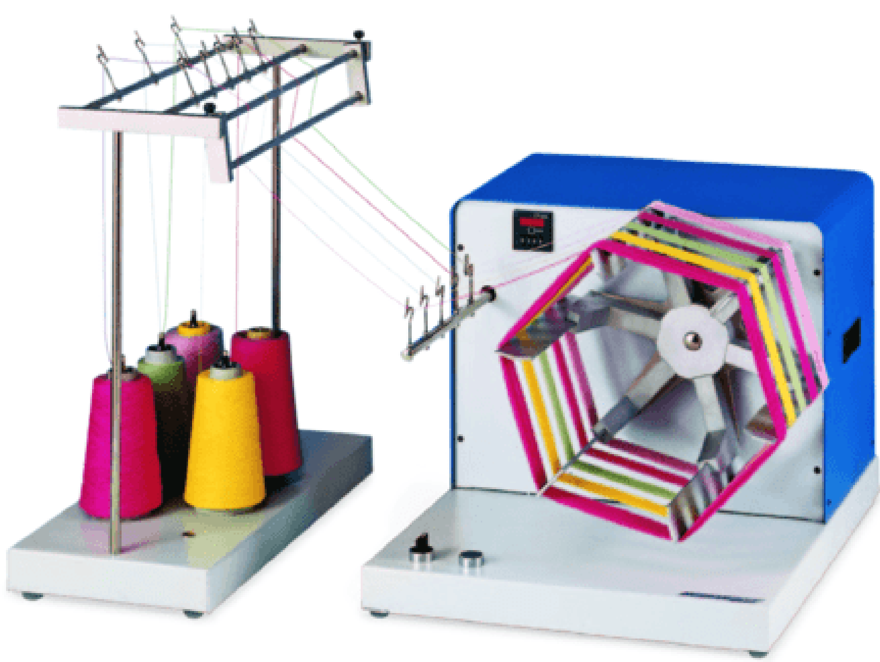


Fig: Motor drive wrap reel

**Analytical Balance:**

An analytical balance (often called a "lab balance") is a class of balance designed to measure small mass in the sub-milligram range. The measuring pan of an analytical balance (0.1 mg or better) is inside a transparent enclosure with doors so that dust does not collect and so any air currents in the room do not affect the balance's operation. This enclosure is often called a draft shield. The use of a mechanically vented balance safety enclosure, which has uniquely designed acrylic airfoils, allows a smooth turbulence-free airflow that prevents balance fluctuation and the measure of mass down to 1 µg without fluctuations or loss of product. Also, the sample must be at room temperature.

Fig: Analytical balance

**Yarn Count Determination Procedure:**

1. Make lea by Wrap reel.
2. Weight the lee by analytic balance.
3. Convert the weight gram to pound.
4. Now the data are put equation (1)
5. Now calculate the count by the equation.
6. Now average count is calculate which is cotton count of this sample.

**Calculation:**

$$\textbf{Count} = \frac{\text{Length in yard} \times \text{Weight Unit}}{840 \text{ Yard} \times \text{Weight in pound}}$$

### 3. Quadrant Balance

Quadrant balance is one type of typical balance. This is direct reading instrument. The count can be directly measure from quadrant balance.

### 4. Stubb Yarn Balance

Stubb yarn balance is also worked on the basis of fixed length & fixed weight as like a Beesley balance and it is used to find the count of fabric sample. Here the number of fixed weight yarn gives the count of yarn.

**Chapter 7-** Twist- Twist is usually expressed as the number of turns per unit length of yarn, for example, turns per inch or turns per meter.

## Twist Directions:

Twist may be performed in the following two directions known as S (clockwise) and Z (anticlockwise) twists These S and Z twist are described below.

**S-twist:**

When a twisted yarn is held vertically and the individual filaments appear as the diagonal in the letter “S,” then it is called an “S–twist.” Similarly, when several yarns are combined and given an S-twist, then the individual yarns appear as the diagonal in the letter “S.”

In another way, a single yarn has ‘S’ twist if, when it is held in the vertical position, the fibers inclined to the axis of the yarn conform in direction of slope to the central portion of the letter S. S and Z twisted yarns are shown in Figure.

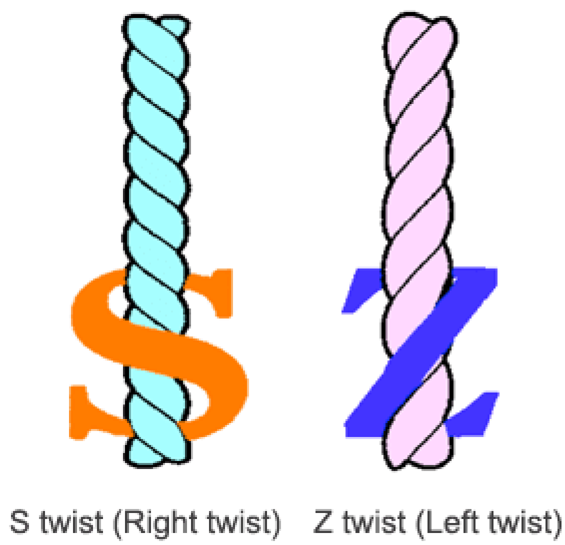


Figure-3: Diagram of S and Z twist

**Z-twist:**

When a twisted yarn is held vertically and the individual filaments appear as the diagonal in the letter “Z,” then it is called a “Z–twist.” Similarly, when several yarns are combined and given a Z-twist then the individual yarns appear as the diagonal in the letter “Z.”

## Effect of Twist on Yarn and Fabric Properties:

The twist level has an effect on the properties of yarn as well as fabric. The following parameters are affected by twist:

1. Hand feel
2. Moisture absorption
3. Wearing properties
4. Aesthetic effects
5. Moisture wicking
6. **Air permeability**
7. Luster

## Twist Measurement Techniques:

**Continuous twist tester:**
The continuous twist tester is designed to increase the number of tests performed per unit time. Yarn passed from a rotating jaw end is wrapped on a rotatable drum. Twist is measured by untwisting and twisting a specific length but, after removal of the twist, it is imparted back onto the yarn. By this method an instrument measures the twist per unit length of yarn.

**Untwist and retwist method:**
The tension-type twist tester is working on the principle of twist contraction. This method is also called untwist-re-twist method. When the level of twist increases, the length of yarn is contracted, and when the twist is removed, the length is increased; if all the twist is removed then the length reaches its maximum value. This method is used on equipment in which one end of the yarn is attached to a counter and the other is attached to a weight-pointer. When the yarn is untwisted, the pointer identifies the slight change in length. When the yarn is untwisting, the length of yarn is increased and the pointer moves from right to left; and when all the twist is removed then the length of yarn is at the maximum and the pointer does not move further from right to left but the rotating jaw continuously rotates in the same direction; further rotation causes length contraction due to **twist insertion**, at that point, before length contraction, the untwisted twist is the yarn twist. The level of twist is indicated by the instrument. This method is suitable for single yarns.

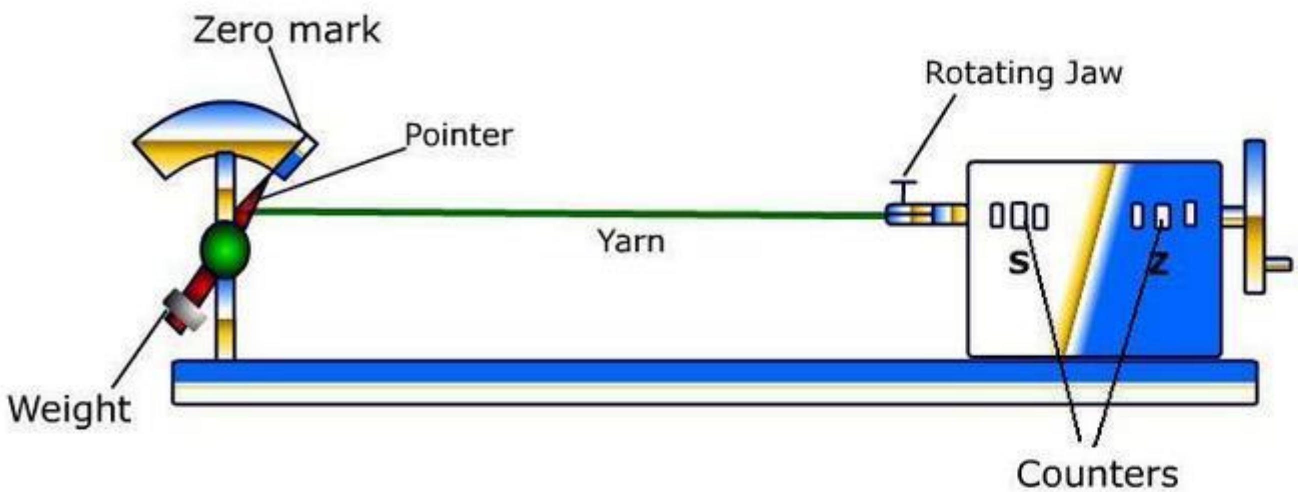



Fig:

**Tension-type twist tester**

The tension-type twist tester as shown above has two jaws (fixed and rotating) for fixing the yarn. The position of the non-rotating jaw is variable according to the gauge length. The pointer connected to the rotating jaw moves over a scale having two graduations.

Working Procedure:
The two discs are disengaged from the worm and are rotated such that the pointer and zero mark coincide with the index mark. The yarn is first gripped in the fixed clamp. After being led through the rotating jaw, the yarn is pulled through until the pointer lies opposite a zero line on a small quadrant scale. The jaw is then closed. At this stage, the specimen is under a small tension and has a nominal length (gauge length).

As the twist is removed the yarn gets extended and the pointer reaches a vertical position. Eventually all the twist is taken out, but the jaw is kept rotating in the same direction until sufficient twist has been inserted to bring the pointer back to the zero mark. When the pointer coincides with the mark, the dial reading is noted and the twists per inch can be calculated using the following formula:

**Twist per inch = dial reading / (gauge length × 2)**

## Chapter 8-

### Fabric Length, Width & Thickness

**Main Test for Textile Testing:** Different Fabric Test

- Dimensional Characteristics- A) Length, B) Width, C) Thickness
- Threads/Inch – EPI, PPI, CPI, WPI
- Count- Warp & Weft
- Weight
- Crimp%,
- Strength
- Shrinkage
- Abrasion & Pilling,
- Handle a) Stiffness, b) Drape, c) Crease Resistance & crease recovery,
- Flame Retardancy,
- Water repellency

### Fabric Length

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

**ISI** suggested the following 3 methods to measure the length of a fabric-

- By using a measuring table
- By using measuring scale
- By using a measuring machine (Trumeter)

**Fabric Length**

By measuring table & scale:

i. From Full length measurement

ii. From Sample length measurement

Conditioning of test samples (Standard Atmospheric Condition):

It is recommended that the fabric should be conditioned in the standard testing atmosphere at 65±2%RH and 20±2ºC(or27±2ºC,for tropical countries) temperature, in a fully relaxed state.

**Trumeter**

- Measuring roller
- Pressure roller
- Fabric passes through between measuring and pressure roller and the length indicate on the counter.

### Fabric Width

Fabric width is the distance from one selvedge to the other, measured perpendicular to the length of the fabric.

**Collection of samples from fabrics:**

Samples should be collected from at least three places from fabric e.g.

- **two samples from the two sides and**

- **one from the middle.**

**Measurement of fabric width**

- In the standard method, (B.S. Hand book) it is recommended that the **fabric should be exposed to a standard atmosphere for at least 24 hours** before **final width measurements** are taken.
- Measurements should take **before and after conditioning**. Then it should be watched that if there is any change in width.
- On a piece of cloth, **10 width measurements** should be made at points distributed at roughly **equal distances throughout the full length** of the fabric piece.
- If full length is not used **a sample length not less than 1 yard** should be used and width measurement should be taken **at least 3 places**.
- Then, in both cases, **mean width** should be calculated.

## Fabric Thickness

Thickness is a parameter of a fabric which controls **handle, creasing, thermal resistance, heaviness or stiffness in use and many other properties of fabric.**

**Principle:**

- The Principle of the measurement of fabric thickness is expressed in B.S. Hand book as follows.
- "Essentially, the determination of the thickness of a compressible material such as a textile fabric consists of the **precise measurement of the distance between two plane parallel plates when they are separated by the cloth**, a known arbitrary pressure between the plates are applied and maintained. It is convenient to regard one of the plates as the pressure foot and the other as the anvil."

**Points to be considered in measuring thickness**

- **The shape and size of pressure foot:** A circular foot of diameter **inch** is usually used. The ratio of foot diameter and cloth thickness should not be less than 5: 1.
- **Shape and size of Anvil:** If a circular anvil is used it should be at least 2 inch greater in diameter than the pressure foot. Where the sample is larger than the anvil, the anvil should be surrounded with a suitable support .e.g. a smooth plane board.
- **Applied pressure:** Recommended pressure is specified e.g. 0.1 lb/inch$^2$ or 10.0 lb /inch$^2$. Suitable weights may be added to pressure foot to obtain these pressures.
- **Velocity of pressure foot:** The pressure foot should be lowered slowly on sample i.e. it needs slow and careful movement.
- **Time:** The thickness is read from the dial of the instrument when the movement of pointer has stopped.
- **Indication of thickness:** A clock type dial is usually built into a thickness tester.

## Fabric weight

- **Gsm (g/m²)**

Gram per square meter is the weight of fabric per unit area. This unit of measurement can also be written as g/m². GSM is the most commonly used unit of measurement worldwide.

- **Gram per yard (g/y)**

Gram per yard is the weight of fabric per unit length (one yard is around 0.91 meter). This unit of measurement is often written as g/y. G/Y is more commonly used in factories.

- **Oz per square yard (oz/yd²)**

Ounce per square yard is the weight of fabric per unit area (one yard is around 0.91 meter). This unit of measurement is often written as oz/yd². Oz/yd² is more commonly used in the UK.

<u>**Crimp**</u>

## Yarn Crimp

When warp and weft interlace in fabric, they follow a curved way. Crimp in a fabric is the measure of this waviness. Crimp of yarn is measured in crimp%.

Crimp% is defined as the mean difference between the straightened thread length and curved thread length while in the cloth and is expressed as percentage.

$$\text{Crimp\%} = \frac{\text{Uncrimped length} - \text{Crimped length} \times 100}{\text{Crimped length}}$$

## Crimp Amplitude

This refers to the extent to which the threads are deflected from the central plane of the cloth.

## Measurement of Crimp- Shirley crimp tester

**Atmosphere:**

- Temperature – 25°C and relative humidity – 67%
- Standard atmosphere: temperature – 20°C and relative humidity – 65%.

**Apparatus:**

1. Crimp tester
2. Fabric sample
3. Scissor
4. Scale

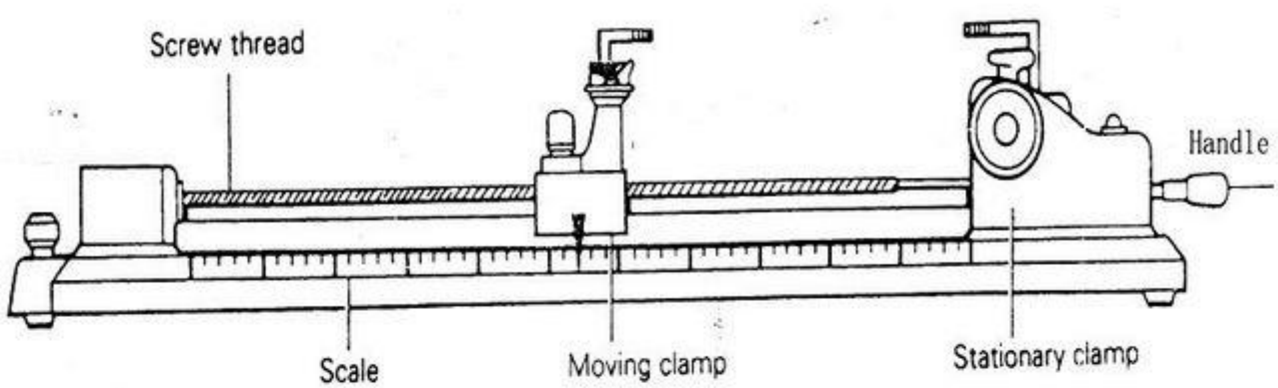



Diagram of crimp tester

**Working Procedure:**

1. At first we have to select the warp or weft way of the fabric. Then we should select the test length of the yarn. Here it is 10″.
2. According to test length we will cut the flap of fabric.
3. Now a single yarn is to remove from the flap of fabric carefully as discussed in theory.

4. One end of the yarn is gripped in the fixed gripper of the machine and the other end is gripped in the other setting the test length.
5. Now the tension for the sample is found out from its count and it is set in the machine.
6. After that we will apply tension along the yarn length with hand by taking away the other end of yarn far from the first end.
7. As soon as the white marl on the tension bar is on the same line of its both sides white mark, we will stop far away the other end.
8. The length of the yarn after applying tension is taken from the scale.
9. Now from this two lengths crimp percentage is calculated from the given formula.
10. In this way at least 10 crimp percentage for warp and 10 for weft is taken and average crimp percentage is calculated from them.

## Chapter -9

### Definition of Pilling

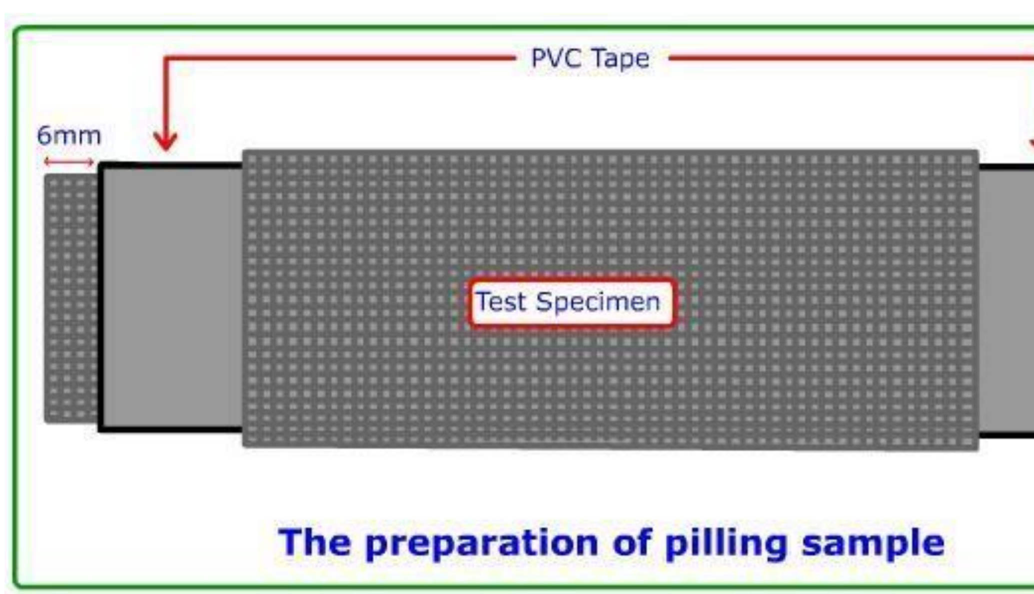
**Pilling is** a fabric surface fault characterized by little 'pills' of entangled fibre clinging to the cloth surface and giving the garment an unsightly appearance**. It is bunches or balls of tangled fibres which are held to the surface of a fabric by one or more fibres.**

### Methods of Measurement:

1. ICI pilling box
2. Random tumbling pilling test
3. Pilling test by Martindale Abrasion Tester

### ICI pilling box:

- A specimen (125 mm x 125 mm) is cut from fabric (2 for warp 2 for weft).
- Stitched face-to-face and turned inside out.
- The fabric tube is then mounted on rubber tubes.
- The loose ends taped with PVC tape.
- All the four samples are then tumbled together in a cork-lined box 9" x 9" x 9" and allowed for required revolution cycle.




The preparation of pilling sample

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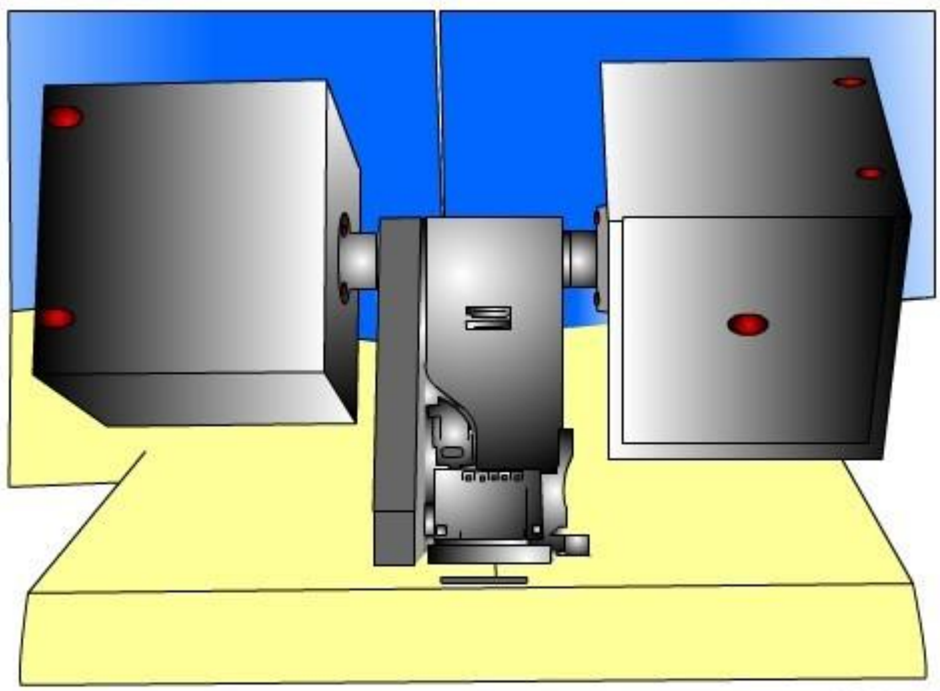



PILLING TESTER

- High “lateral strength” may be advantageous in some applications like technical textiles, floor covering, etc.
- However, the pilling tendency also increases, so in the apparel sector “low lateral strength" is preferable, particularly in knitted goods.
- Polyester fibres are deliberately made brittle for use in knitted products to avoid pilling (anti pilling types).
- Pills do not form where fibres with low lateral strength are used (wool and anti-pill man-made fibres).
- They can be easily scrubbed off.
- But fibres with “high lateral strength” will have higher pilling tendency.
- Pilling resistance and durability are inversely related.

## PILLING GRADES:

Grade 5 No or very weak formation of pills.
Grade 4 Weak formations of pills.
Grade 3 Moderate formations of pills.
Grade 2 Obvious formations of pills.

## Air Permeability of Fabric:

Permeability may be defined as the rate at which gas or liquid passes through a porous medium. Textile fabrics are permeable substances. The fabric needs air, water and vapour permeability so that a person feels comfortable wearing it.

**The level of air permeability varies depending on the following:**

- **Types of yarn**
- **Fabric structure**
- Fiber parameters

## Measurement of Air Permeability:

Air permeability affects the comfort aspect of a garment in terms of air passage through the fabric. High air permeability per unit area of a fabric gives lower protection against winds, especially for outerwear garments, whereas low air permeability causes heavy body perspiration.

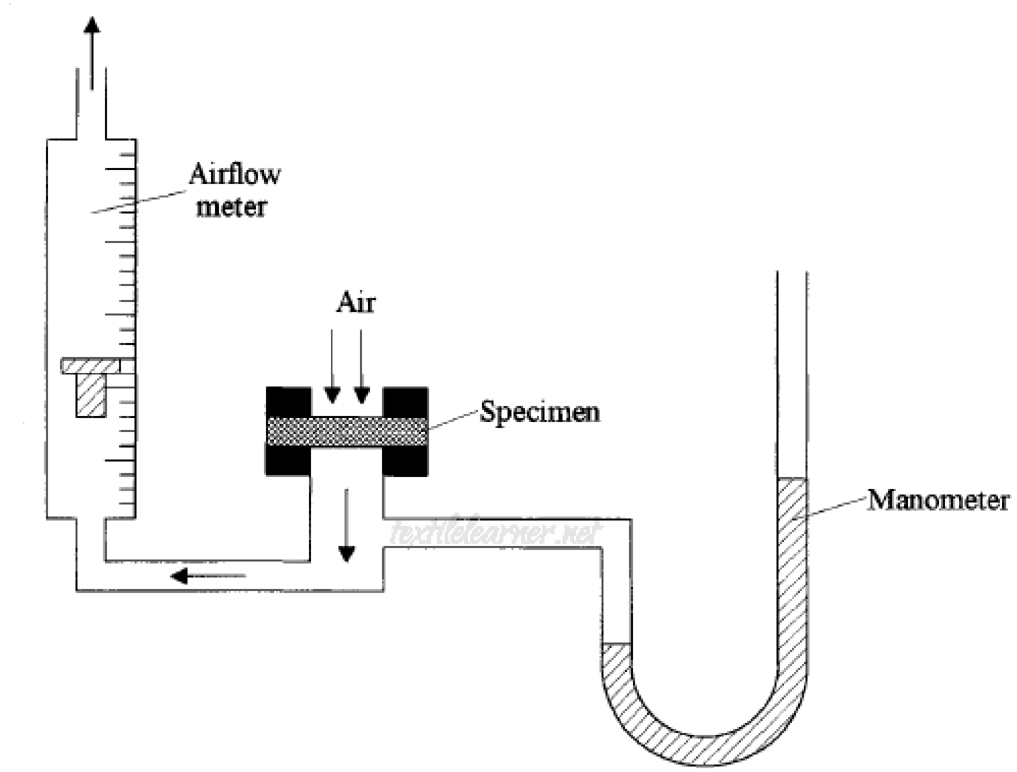



Figure 1: Air permeability test for fabric

In Shirley air permeability tester the sample is clamped between two rubber gaskets, and a guard ring surrounding the test specimen ensures that all the measured airflow passes through the specimen with no leakage. The test area is a circle of 5.07 $cm^2$. Airflow is measured when a pressure differential of 20 mm H20 (0-2 kPa) is applied. Ten measurements of airflow are made on each sample.

## Procedure of air permeability test for fabric:

1. Handle the test specimens carefully to avoid altering the natural state of the material.

2. Place each specimen onto the test head of the test instrument and perform the test as specified in the manufacturer's operating instructions.

3. Place coated test specimens with the coated side down (towards the low-pressure side) to minimize edge leakage.

4. Use a water pressure differential of 125 Pa (12.7 mm or 0.5 in. of water).

5. Read and record the individual test results in SI units as $cm^3/s/cm^2$ and in inch-pound units as $ft^3/min/ft^2$ rounded to three significant digits.

6. For special applications, the total edge leakage underneath and through the test specimen may be measured in a separate test, with the test specimen covered by an airtight cover, and subtracted from the original test result to obtain the effective air permeability.

7. Remove the tested specimen and continue testing until all the specimens have been tested for each laboratory sampling unit.

8. The number of tests may go up to 10 but the minimum required number of tests is 4.

# Chapter- 11

**Fabric wettability-**

The wettability of a solid surface or fabric is defined as **the ability of the surface to hold contact with a liquid**. In other words, it's the surface's ability to be wetted by the liquid.

## Differences Between Waterproof, Water-Resistant and Water-Repellent Fabrics

### Waterproof

The difference between waterproof, water-resistant and water-repellant fabric is primarily the ability to withstand water from seeping in. A waterproof material, like plastic, provides 100% protection from getting wet. However, waterproof **fabrics** that are used to manufacture raincoats, jackets, etc., normally use a membrane material so that it is breathable and one does not get sweaty and clammy from inside.

### Water-Resistant

Water-resistant materials provide some amount of resistance from getting wet, however are not 100% waterproof. Synthetic materials like polyester, satin, pongee and nylon have a natural resistance towards water unlike cotton, which absorbs water readily. They provide the lowest amount of protection from rain and sleet. Often, a water-resistant material is coated with a suitable membrane to make it water-repellant.

### Water-Repellant

Water-repellent materials provide a medium level of protection from water seepage. Water-repellent fabrics are better than water-resistant fabrics and are also known as "hydrophobic" materials. Since water forms beads on the outer cover of the fabric and struggles to penetrate the fabric, it is suitable for making bathing suits, scuba diving suits, etc.

**Determination of water repellency of fabric by Spray tester.**

Spray tester is such an instrument which measures the water repellency of a fabric. In this test a small amount of shower is produced by pouring water through a spray nozzle. The water falls on to the specimen which is mounted over a 6 in. diameter embroidery hoop and fixed at an angle of 45 degrees. To carry out the test, 250 $cm^3$ of water at $70^oF$ are poured steadily into the funnel. The American Association of Textile Chemists and Colorists recommend the use of a chart of photographs against which the actual fabric appearance is compared.


**The ratings are as follows:**

| Rating | Description |
|---|---|
| • 100 | No sticking 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. |

**Apparatus:**

1. Spray tester
2. Water
3. Fabric

Atmosphere:

- Temperature – $25^oC$ and relative humidity – 67%
- Standard atmosphere: temperature – $20^oC$ and relative humidity – 65%.

**Working principle of water repellency test:**

1. The sample fabric is mounted on the embroidery hoop and fixed on the instrument at 45°.
2. Now the beaker is filled with 250 cc water and poured on the funnel.
3. The water is showered through spray nozzle on the fabric.
4. After spraying has finished the sample holder is removed and the surplus water removed by tapping the frame 6 times against a solid object, with the face of the sample facing the solid object.
5. The water repellency is assessed from the spray rating chart.
6. 5 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.
7. The mean of the 5 ratings is taken as the result.

# Chapter -12

## Flammability

It is the ability to burn or ignite any substance by means of fire or any kind of combustion. Various test procedures exist to determine the flammability. In domestic sphere many serious and tragic accidents are the results of clothing catching fire.Flameproof fabrics are absolutely necessary for protective clothing in many industrial processes where chances of inflammable fabrics being ignited are high.

### Some terms and definitions related to flammability

**Flameproof :** A flame proof fabric is one which doesn't propagate flame, i.e. any flame goes out quickly when the igniting flame is with-drawn.
**Flame resistance rating :** The time(in seconds) necessary for the propagation of flame in a vertical strip( 10o inch).
**Flame resistant :** A flame resistant fabric is one whose flame resistance rating is high, i.e. above 150.
**Inherently flame proof material :** A material that has not been subjected to any flameproof processing's yet it has flame-proof quality.
**Durably flame-proof material :** The ability of a flameproof material to retain as flame-proof even after being submitted to washing treatment.
**Temporarily flameproof material :** Material which complies with the requirements of Clause 3 of B.S. 3120, before, but not after, the prescribed washing treatment.

### Factors affecting flame resistance

**1 . Fibre content :** The flame resistance of a fabric is partly dependent on the fibre from which it is made. Cellulosic fibre's like as cotton, flax, viscos rayon give fabrics of low flame resistance. Wool fabrics are difficult to ignite. Nylons and Terylene(polyester), both are thermoplastic fibre's, shrink from the flame and tend no to ignite. Although some stiffening treatments and certain dyes can may result in the ignition of nylon and terylene.

**2 . Yarn types :** Yarn structure does not affect the flame resistance of a fabric.

**3 . Fabric structure :** Flammability is largely independent of fabric structure. It doesn't matter whether it is weaved, knitted, laced, bonded, or felted fabric.

**4 . Fabric weight :** Fabric weight influences flammability of the fabric. For a given fibre the flame resistance rating of fabric has been found to be directly proportional to its weight in ounces(Oz) per Yd2.

## Test Methods

**1 . The visual timing test :** A fabric strip is suspended vertically and then ignited from the bottom edge, then the rate of flame spread is determined .

**2 . The 45 test :** In which the time (t), for the flame to travel 5 inch over fabric sloping at 45 degree angle is measured in seconds. The flame resistance rating , M, is then given by (2.5 x t).

**3 . The hoop test :** In which the rate of flame spread is determined over the fabric mounted on a semicircular frame.

.Three test methods are given: Vertical strip test -

**Method A :**

Basically, this method is the vertical strip test in which the rate of propagation of the flame is measured in terms of the distance in milometers per minute that the base of flame travels up a strip ( 900 mm x 75mm). The time to travel two markers 500 mm apart is observed . The rate of propagation is then given by (500/t x 60 mm/min), where t is in seconds.

**some other information's like after-flame, after-glow, char length are also derived and reported:**

**1 . After-flame :** The time in seconds that elapses between the removal of the std. gas lighting flame and the flame extinction

**2 . After-glow :** the time in seconds between flame extinction and the end of any glowing.

**3 . The charring :** the extent of charring is given by 'char length. This is the difference in mm between the original specimen length and the undamaged length of the specimen.

# Chapter -13

**Fabric Strength testing**

- Fabric Tear Strength Tester – Gives by Elmendorf method fabric strength at Tear in both warp and weft direction.
- Fabric Tensile Strength & Elongation Test Machine
- Bursting strength tester – FOR Knit Fabrics.

Definition of Tensile strength- The tensile strength is **the measure of maximum force fabric can bear or support**, elongate before it breaks, The tensile strength of the fabric is the maximum amount of tensile stress and tension that fabric can take before breaking or failure to resist anymore.

Definition of Tearing strength- Tearing strength is defined as **the force required to start or to continue to tear a fabric, in either weft or warp direction, under specified conditions**. A tear in a fabric or garment generally occurs progressively along a line,

Definition of bursting strength- Bursting strength refers to **the force required to break the fabric**. When force or pressure is vertically applied on fabric it is called bursting. The force needed to rupture the fabric (when applied perpendicularly) is called bursting strength [

## Tensile strength testing:

This is referred to as a strength test where the load is applied along the direction of the test sample.
Tensile strength test of fabric is divided into **two** groups-

1. Strip test and
2. Grab test.

**Strip strength test:**

**i.** Five fabric samples are extended in a direction parallel to the warp and five parallel to the weft.

ii. The specimens are cut to a size of 2.5 inch in width and then removing threads from both edges until the width has been reduced **to 2 inch.**

iii. The test length should **be 8 inch** between the jaws and so enough extra length must be allowed for gripping in the jaws.
iv. Under optimum conditions, the specimen will be mounted **centrally**. Security gripped along the full width to prevent slipping.
v. The load is applied **uniformly** across the full specimen width till the specimen tear out.
vi. If a test specimen breaks **within 0.25 inch** of the line of contact of either of the pairs of jaws at a load less than the average of normal breaks, the result should not be used in calculation.

Grab strength test:

i. At first we take specimen 4”x6”.
i. Then the specimen is marked by a pencil at 1.5“from the edge of the specimen to assist in clamping it so that the same set of threads are clamped in both jaws.
ii. The two jaws are fixed on both side of the specimen from 1” edge. This means that only the central 1 inch of the fabric is stressed.
iii. The gauge length used is 3 inch and the speed is adjusted so that the sample is broken in 20 ± 3s.
iv. One jaw is fixed another jaws moveable.
v. Then the moveable jaws start to move outwards till the specimen is tear out.

## Tearing strength test:

**Tear strength:** Tear strength is the force required either to start or to continue the tear in a fabric under specific condition.
**Tearing force:** Tearing force is the average force required to continue a tear previously started in a fabric.
**Tearing resistance:** Tearing resistance is one of the important properties of a textile fabric. The tear resistance of a fabric indicates its resistance to tearing force.
Three types of tear test:
1. The tongue
2. Trapezoid
3. Elmendorf

**Bursting strength:** This tear strength is basically used for knitted, lace, non-woven fabric, parachute fabrics, filters, sacks and nets etc. It is the uniformly distributed force over a given area applied to the fabric surface which is needed to break.

There are **mainly two** types of bursting strength test-

1. Hydraulic or Diaphragm burst
2. Ball burst

1. Hydraulic Bursting Tester:

**Procedure:**

i. The pressure in a liquid is exerted in all directions and advantage is taken of this phenomenon in the hydraulic bursting tester.
ii. The specimen is clamped by a ring over a thin flexible rubber diaphragm , is clamped over a circular hole in the upper face of a reservoir.
iii. The liquid used may be water or glycerin.
iv. The hydraulic pressure is increased, by valves or screw driven piston and the diaphragm distends taking with it the specimen.
v. At some point the fabric bursts, the pressure being indicated by the gauge .
vi. Since the rubber diaphragm requires a certain pressure to stretch it, corrections may be made either by doing a blank test i.e. noting the pressure required to distend the diaphragm the same amount without the presence of fabric

## Chapter- 14

**Fabric handle** as the name itself implies, is concerned with feel of the material and so depends upon the sense of touch. Different types of material will have different degree of smoothness or roughness when the **fabric handle** is to be judges the sensation for stiffness or hardness or softness, roughness or smoothness are all made use of.

**Factors of fabric handle properties:**

1. **Weight and density**: Weight per unit area (GSM) or unit volume is considered. If the fabric weight is high it will be hard to feel as compared to low weight fabric. Density measures the compactness or relaxation of fabric. It the thread density in the fabric is more it will be more compact to low density.
2. **Surface friction**: It refers to resistance to be slipping either on the finger or on another piece of fabric. For balanced fabric surface friction should be adjustable. Otherwise it will create problem during processing and using. Fabrics vary in surface friction from harsh to slippery.
3. **Flexibility**: It refers case of squeezing of a fabric. Fabrics vary in compressibility from pliable to stiff.
4. **Compress ability**: It refers case of squeezing of a fabric. Fabrics vary in compress ability from soft to hard.

### Stiffness-

Stiffness is a special property of fabric. It is the tendency of fabric to keep standing without any support. It is a key factor in the study of handle and **drape of fabric**. The stiffness of a fabric in bending is very dependent on its thickness, the thicker the fabric, the stiffer it is if all other factors remain the same.

To determine the stiffness of the given fabric sample.

Theory:
A rectangular strip of fabric, 6 in. x 1 in., is mounted on a horizontal platform in such a way that it over change, like a cantilever, and bends downwards as shown in figure.

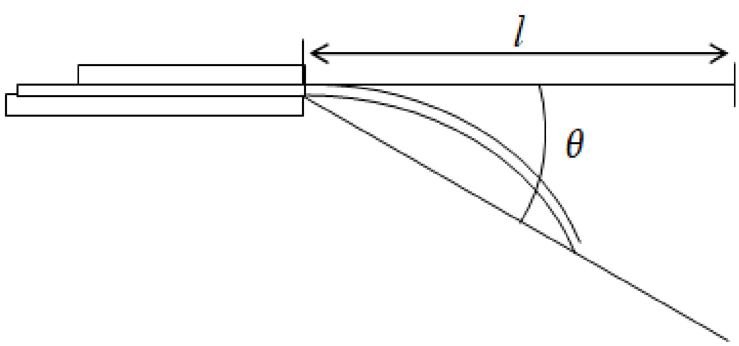



Figure: Fiber stiffness, cantilever principle

From the length l and the angle θ a number of values are determined. Here the length of the fabric that will bend under its own weight to a definite extent is called bending length. It is a measure of stiffness that determines draping quality. The calculation is as follows:

$$c = l f_1(\theta)$$

$$\text{Where, } f_1(\theta) = \left( \frac{\cos \frac{1}{2}\theta}{8 \tan \theta} \right)^{\frac{1}{3}}$$

Three specimens in warp way and three in weft are usually tested and since he relative humidity can affect the results the test should be made in a standard testing atmosphere. The horizontal platform of the instrument is supported by two side pieces made of plastic. These side pieces have engraved on them index lines at the standard angle of deflection of, at which angle f {41(1/2)$^o$} = 0.5. Attached to the instrument is a mirror which enables the operator to view both index lines from a convenient position. The scale of the instrument is graduated in centimeters of bending length and it also serves as the template for cutting the specimens to size.

Apparatus:

1. Stiffness Tester
2. Scissor
3. Scale

Sample:

- Cotton **woven fabric**
- Size: 6 x 1″.

Atmosphere:

1. Temperature – 25$^o$C and relative humidity – 67%
2. Standard atmosphere: temperature – 20$^o$C and relative humidity – 65%.


Fig: Shirley stiffness tester

## Shirley Stiffness Tester Working Principle:

1. To carry out a test the specimen is cut to size 6 in. x 1 in. with the aid of the template.
2. Both the template and specimen are transferred to the platform with the fabric underneath.
3. Now both are slowly pushed forward.
4. The strip of the fabric will commence to droop over the edge of the platform and the movement of the template and the fabric is continued until the tip of the specimen viewed in the mirror cuts both index lines.
5. The bending length can immediately be read off from the scale mark opposite a zero line engraved on the side of the platform.
6. Each specimen is tested four times, at each end and again with the strip turned over.
7. In this way three samples are tested.
8. Finally mean values for the bending length in warp and weft directions can be calculated.

## Fabric Drape and Its Measurement

Drapability

Fabric drapability is a morphological characteristic occurring when fabric is hanging down for its gravity. It is one of the important indicators to measure clothes close fitting. Some fabrics like dresses, curtains, table cloths are required to a good drapability.

Measurement of drape with drapemeter -

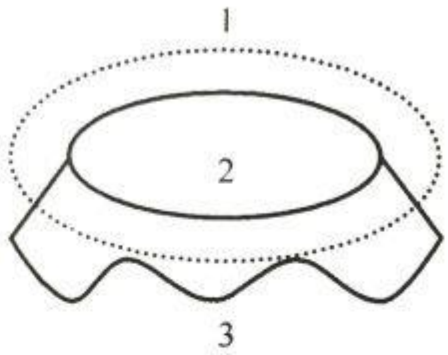



Figure 7 Illustration of Fabric Drape Test

**Test Principle**

The drape sample is projected onto a white sheet, and digital camera is used to obtain sample's drape figure through which we can get some specified quantitative information regarding fabric drapability. The relevant indexes as drape coefficient and drape wave number can be got from computer image processing technology. Generally, fabric drapability is evaluated by drape coefficient "F".

The drape coefficient is **the ratio of the projected area of the fabric sample to its undraped area, in which the area of the supporting disk is deduced**. Drape coefficient = (the area of the shadow – the area of the supporting disk)/(the area of the circular specimen – the area of the supporting disk)

$$F = [(S3-S2) / (S1-S2)] * 100\%$$

Where:

F-Drape Coefficient

S3-the Pojected Area

S2-the Area of Clamping Plate

S1-Sample Area

The bigger the drape coefficient, the stiffer the fabric and the weaker fabric drapability; vice versa. We can get a comprehensive understanding of the fabric drapability through drape wave number and amplitude.

## Chapter- 15

**Serviceability of Fabric** Serviceability is a relative term which is serviceable of performing useful service. Serviceability of a fabric is it's length of life upto it's end of usefulness which occurs when it becomes deficient in one necessary property. Its serviceability ceases when it can longer do so. A time element is included in serviceability. A garment is considered to be serviceable when it is fit for its particular end use. In garment for example, the end of service generally is reached when, due to color fading, shrinkage in laundering or bagging at knees or elbows the garment no longer has a presentable appearance.

After being used for a certain length of time the garment ceases to be serviceable when it can no longer fill its intended purpose in the way that it did when it was new. The particular factors that reduce the service life of a garment are heavily dependent on its end use.

**Factors of Serviceability of a Garment:**
There are many factors or reasons for decreasing service time of any garment or cloth.

1. Changes in fashion.
2. Shrinkage or other dimensional changes of garment which is not allow body fit.
3. Changes in the surface appearance of the fabric.
4. Fading of the colour of the cloth.
5. Failure of the seams of the garment by breaking of the sewing thread or by seam slippage.
6. Frayed appearance of particular part of garments.
7. Tearing of the fabric through being snagged by a sharp object.

**Abrasion-**

Abrasion is just one aspect of wear and is the rubbing away of the component fibers and yarns of the fabric. It is a series of repeated applications of stress; therefore a capacity to absorb punishment is required to the fibers. Inherent fiber properties such as work of rupture may give a high **resistance to abrasion**.

**Abrasion is of three types :**

Plain or flat abrasion - A flat area of material is abraded.

Edge abrasion - Kind of abrasion which occurs at collars and folds.

Flex abrasion - Rubbing is accompanied by flexing and bending.

## Chapter- 16

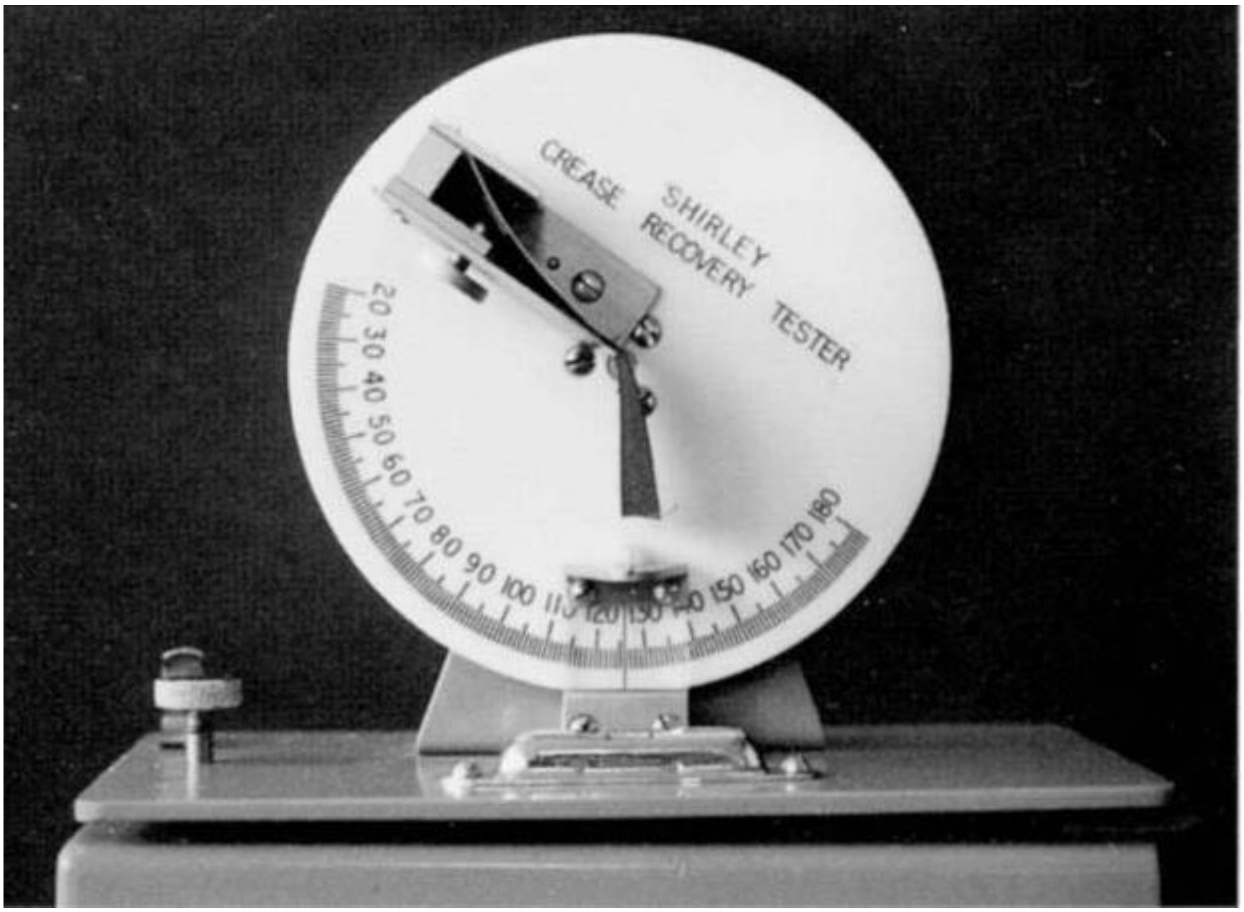
**Crease:**
This is a fabric defect evidenced by **a break line or mark or fold** in a fabric generally caused by a sharp fold. Crease appears when the fabric is distorted in such a manner that part of it is stretched beyond its elastic recovery.

**Crease Resistance :**
The resistance to creasing of textile material during use is known as crease resistance.

**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.

## Shirley Crease recovery tester :
## Construction/machine description :

1. The instrument consists of a circular dial which carries the clamp for holding the specimen.
2. Directly under the center of the dial is a knife edge and an index line for measuring the recovery angle.
3. The scale of the instrument is engraved on the dial.




## Working Procedure :

1. A specimen is cut from the fabrics with a template 2 inch long by 1 inch wide.
2. It is carefully creased by folding in half placing it between two glass plates and adding a 2 kg weight.
3. After 1 min the weight is removed and the specimen transferred to the fabrics clamp on the instrument and allowed to recover from crease.
4. As it recovers, the dial of the instrument is rotated to keep the free edge of the specimen in line with the knife edge.

5. At the end of the time period allowed for recovery, usually 1 min the recovery angle in degrees is read on the engraved scale.
6. Warp and weft way recovery are reported separately to the nearest degree from the mean values of ten tests in each direction

## Considering points while testing :

1. The specimen should be conditioned and tested in a standard testing atmosphere.
2. Random sample should be taken.
3. Selvedge, piece ends, creased or folded regions should be avoided.

## Difference between crease resistance and crease recovery :

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