# Preface

Testing of any product is necessary to evaluate the quality of the product for its intended end use or to apply adequate process controls, if it is an intermediate product. The standard atmosphere for testing, influence of moisture on properties of textiles, sampling methods as well as conditioning of sample before testing, testing procedures and the interpretation of results are important factors to be taken into consideration for a repeatable and reproducible evaluation results.

It is, therefore, crucial to understand the importance and necessity of textile testing andin this context various testing methods and procedures are standardized by organizations such as BIS, ISO, AATCC, ASTM, BSI, DIN, ANSI, and so on. Bureau of Indian Standards (BIS) has been designated as the National Standards Body of India and the Indian standards published by BIS have the status of 'National standards' with statutory recognition. It is to be noted that Indian Standards published by BIS contain best practices from experts from all stakeholder groups in the country.The regulatory role of standards can be seen in various Quality Control Orders issued by the Government of India.

This Handbookelaborates the physical testing of textiles in the form of yarn, the emphasis throughout being on Indian standards. The objectives of this Handbook are to : give the user, details on all published national standards on methods of test for textiles; help the various users to establish a suitable quality assurance system in the organization; serve as a guide for the ordinary consumer to know the characteristics of textiles which are important with reference to its end use; and assist the textile technology students, educational and research institutions in the selection of the appropriate methods of test for various in depth studies/research.

Every effort has been made to make the various sections self-contained but in certain cases relevant provisions have been extracted and reproduced. In all such cases, for detailed guidance, reference should be made to individual standards. On one hand, the Handbook is expected to be a self-contained reference document whereas on the other, it is desirable to keep it less voluminous. The present version of the Handbook is the judicious choice with respect to the two aspects referred.

# CONTENTS

# CHAPTER I

# REGULATORY ROLE OF STANDARDS

# CHAPTER I

## 1 REGULATORY ROLE OF STANDARDS

### 1.1 Why Standards

A standard is a document that describes the best way of doing something. It could be about making a product, testing a product, managing a process, delivering a service or supplying materials. Standards are used to establish a best practice approach for achieving a desired outcome. The agreed methodology can then subsequently be used as part of ensuring consistent results, for example, in manufacturing and testing a product, managing a process or delivering a service.

The benefit of Indian standards is that they contain a built-in legitimacy. They are based on collaboration – between the respective stakeholders – and are founded on consensus. As such, they provide essential guidance for government, industry, and consumers alike, and help societies move their development trajectory towards more sustainable and inclusive growth. Standards help spread knowledge. Although sometimes difficult to measure, knowledge transfer is an essential component for economic growth.

At the national level, standards are an increasingly important part of international trade to ensure that trade is facilitated and unnecessary barriers to trade are avoided. A coherent approach to the use of standards in regulation assists governments as they strive to become more effective in serving their society, economy and environment.

### 1.2 How do standards promote economic growth?

All economies need growth that is sustainable and inclusive. However, trade is not an end itself. The quality of economic growth, including the increase in benefits for all of society and minimizing negative impacts on the environment, is also essential. Standards can play an important role because they often provide readily available best practices, and tools, for addressing aspects needed to underpin the quality of growth. They can also simultaneously contribute to the achievement of the Sustainable Developmental Goals SDGs.

If people with a legitimate interest in, and detailed knowledge of, the particular product and processes participate in developing the technical requirements, they are likely to identify the least-cost options for achieving public goals, resulting in increased competitiveness and the least wasteful use of resources.

Compliance with such standards should not be seen as an add-on-cost, but as a worthwhile investment in providing a satisfactory and sustainable product, service or process. Standardization encourages the involvement of business, governments, consumers, academia, civil society and other stakeholders, i.e. anyone who may be affected by it, in developing the technical specifications that may subsequently be used to give effect to the objectives of a regulation or legislation.

### 1.3 Technical Regulations

Technical Regulations (TRs) are an important group of regulations relevant to standardization practice. The WTO defines a TR as a "document which lays down product characteristics or their related processes and production methods, including the applicable administrative provisions, with which compliance is mandatory". Like other regulations, TRs are prepared through a legislative process that is normally defined in a country's constitution or laws. A TR normally includes administrative provisions such as the accountability for the regulation and definition of the competent authority, guidance for the competent authority for interpretation of the regulation, the conformity assessment procedures to be used (i.e. inspection, testing, certification and validation) to demonstrate compliance with the regulation, enforcement mechanisms to be used, and sanctions to be applied in cases of non-compliance.

Standards used in public policies and regulations provide benefits to the public and private sector and citizens through:

- better designed policies and regulations based on agreed requirements and norms;
- reduced costs and administrative burdens of associated regulatory requirements;
- increased trust and involvement of the private sector and consumers in regulatory processes; and
- enhanced confidence of trading partners and investors

These standards are made mandatory either directly, under the legislation that established the NSB, or by a relevant ministry. The WTO TBT Agreement does, however, recognize that the use or full use of an International Standard may not be practicable. Fundamental climatic or geographical factors, economic or technological problems, are considered as legitimate reasons for not using International Standards. Every effort should also be made to reduce deviations to a minimum and such deviations should also be identified.

Standards and TRs play a key role in helping societies and consumers in safeguarding public health Public sector policymakers are required to pursue a wide range of objectives. These may be related to safeguarding public health, protecting the environment or even addressing national security issues.

## 1.4 Standards, Technical Regulations and WTO TBT Agreement

The World Trade Organization – Technical Barrier to Trade (WTO TBT) Agreement is an international treaty that defines the relation between voluntary standards and Technical Regulations. The preamble of the WTO Agreement on TBT states that "no country should be prevented from taking measures necessary to ensure the quality of its exports, or for the protection of human, animal or plant life or health, of the environment, or for the prevention of deceptive practices, at the levels it considers appropriate subject to the requirement that they are not applied in a manner which would constitute a means of arbitrary or unjustifiable discrimination between countries where the same conditions prevail or a disguised restriction on international trade, and are otherwise in accordance with the provisions of this Agreement."

The relation and the increased use of voluntary standards is to a large extent based on the requirements defined in the agreement and similar or the same requirements can also be found in many bilateral and regional trade agreements. Article 2.4 in the WTO TBT Agreement states "Where technical regulations are required and relevant

International Standards exist or their completion is imminent, Members shall use them, or the relevant parts of them, as a basis for their technical regulations except when such International Standards or relevant parts would be an ineffective or inappropriate means for the fulfilment of the legitimate objectives pursued, for instance because of fundamental climatic or geographical factors or fundamental technological problems." The overall objective of the same is to establish transparency between members through the use of International Standards as a common reference when establishing mandatory requirements on products. Using the same reference is a way to harmonize the effects of the national legislation to facilitate trade.

# CHAPTER II

# SAMPLING AND CONDITIONING

# CHAPTER II

## 2 SAMPLING AND CONDITIONING

### 2.1 Sampling of Cotton Yarn

The number of tests for determination of various characteristics is based on statistical analysis of the extensive amount of data collected from various organizations to ascertain the inherent variability. As a ready reckoner, the Indian standards published on sampling of yarns may be referred to for deciding the number of samples to be tested.

**IS 3920 : 1985 Methods for sampling of cotton yarn for determination of physical characteristics (*first revision*)** prescribes the methods of sampling for cotton yarn for determination of physical characteristics, namely, count, lea breaking load, twist, evenness (Uster percent) and appearance grade. It specifies the number of tests that should be made for each characteristic. It also lays down the criteria for ascertaining the conformity of the yarn to the specified requirements of the characteristics.

This standard gives the requirement, in terms of nominal value for lot average together with tolerances (or minimum value for lot average) and a maximum limit for coefficient of variation. The criteria for conformity and suitable sample size for determination of the coefficient of variation have also been specified. An extensive amount of data was been collected from a large number of textile mills to assess the inherent variability of the various characteristics and recommend the number of tests to determine the characteristics with specified degree of accuracy.

### 2.2 Sampling of Man-Made Fibre Filament Yarns

**IS 7703 (Part 4) : 1981 Methods for test for continuous filament polyester and polyamide flat yarn: Part 4 sampling**, prescribes the methods for sampling of continuous filament polyester and polyamide flat yarn for determination of various physical characteristics, namely, linear density, tenacity, elongation at break, evenness, broken filament and oil content. It gives the number of tests for determination of various characteristics with specified degree of accuracy. It also lays down the criteria for ascertaining the conformity of yarn to the specified requirements.

### 2.3 Conditioning of Yarns

Most of the textiles being hygroscopic in nature, the relative humidity and temperature of the atmosphere affect their physical and mechanical properties appreciably. In order that reliable comparisons was to be made among different materials and products and among different laboratories, it is necessary to standardize the humidity and temperature conditions and the procedure by which the textile material may be brought to the moisture equilibrium before testing. The conditioning temperature of 20 °C ± 2 °C as specified in International Standards is not suitable for tropical countries like India where the atmospheric temperature is normally much higher than 20 °C. It is almost impossible to maintain this temperature, especially during summer when the atmospheric temperature rises even up to 50 °C. The temperature of 27 °C ± 2 °C for conditioning of the test specimens for tropical countries like India has been referred in IS 6359.

**IS 6359 : 2023 Method for conditioning of textiles (*first revision*)**prescribes a procedure for conditioning of all textile materials. This standard also prescribes a procedure for pre-conditioning of textiles which would be necessary if specified in the standard test method or specification for the material under test before conditioning.

# CHAPTER III

# LINEAR DENSITY (COUNT) OF YARN

# CHAPTER III

## 3 LINEAR DENSITY (COUNT) OF YARN

### 3.1 Count of Cotton Yarn

**IS 1315 : 1977 Method for determination of linear density of yarns spun on cotton system (*first revision*)** prescribes methods for determination of linear densityof yarn spun on cotton system in cotton count and tex. This method isapplicable to single, plied and cabled yarns,

**Cotton Count** — The linear density of cotton yarn expressed asnumber of 768.1 m hanks per 453.6 g (840 yd hanks/lb).

**Tex** — The primary unit in a system of units for expressing theuniversal count of yarn; the mass in grams per kilometre ofyarn.

#### *3.1.1 Cotton Count System*

*Special Yarn Count of Balance* — Prepare a skein of 109.73 m (120 yd)on the wrap reel or take the specified length of yarn,and place or hang it on the balance and read off the linear density ofyarn from the scale provided.

*Pan Balance* — Reel out skeins of 109.73 m (120 yd) on the wrapreel and then determine their mass in grams individually on the balance correct to 1 mg. Calculate linear density of cotton yarn inthe cotton count system up to one decimal place by the following formula:

$$Ne = \frac{453.6}{7 \times m} = \frac{64.8}{m}$$

Where,

$Ne$ = cotton yarn count; and

$m$ = mass of skein of 109.73 m (or 120 yd), in grams.

#### *3.1.2 Tex System*

Prepare a skein of 100 m on the wrapreel or take the specified length of yarn, and place orhang it on the balance and read off the linear density of yarn from thescale provided on the special yarn count balance.

Alternatively, reel out skeins of 100 m on the wrap reel and determine their mass in grams, individually on thebalance correct to 1 mg. Calculate the linear density of yarn in tex system upto one decimal place by the following formula:

$$t = \frac{m}{100} \times 1\,000 = 10\,m$$

where,

$t$ = count of yarn in tex; and

$m$ = mass of skein of 100 m, in grams.

## 3.2 Count of Jute Yarn

The method for determination of count of jute yarn is different from that of cotton yarn. Count of jute yarn is determined by the methods prescribed in **IS 570 : 1964 Methods for determination of universal count of jute yarn (*revised*)**.

### *3.2.1 Procedure*

*First Method*

Take one of the conditioned skeins constituting the test specimens and weigh it correct to the nearest 0.1g. Calculate its universal count in the manner prescribed in **3.2.2**.

*Second Method*

Take a skein of yarn constituting the test specimens and dry it to constant weight at 105°C to 110°C in the drying oven. Determine its constant weight. Stop the draught through the oven during weighing. Take the weight to be constant when the difference between the two consecutive weighings at an interval of 20 minutes is less than 0.1percent of the first weight.

> NOTE - In order to avoid risk in oil evaporation, the draught in the drying oven shall not be continued throughout the drying period but shall be in operation only intermittently.

Calculate the conditioned weight of the skein by the formula given below:

$$\text{Conditioned weight of the skein} = \frac{A\,(100 + R)}{100}$$

where, $A$ = oven-dry weight, in g, of the specimen, and
$R$ = moisture regain value of 17 percent.

**3.2.2** Calculate the universal count of the test specimen using the formula given below:

$$\text{Universal count, in tex} = \frac{W}{L} \times 1000$$

where $W$= weight, in g, of the test specimen and
$L$= length, in m, of the test specimen.

## 3.3 Count of Woolen and Worsted yarn

Count of woolen and worsted yarn is determined by the methods prescribed in **IS 681 : 2015 Textiles – Methods for determination of universal count of woolen and worsted yarn (*first revision*)**

### *3.3.1 Procedure*

*Preliminary Extraction of the Test Specimen*

Take a specimen and extract it with dichloromethane. Dry the specimen in air.

#### *3.3.1.1 Determination of Count*

*First Method*

Condition the test specimen. Weigh it correct to 0.01 g and note its weight. Calculate its universal count in the manner prescribed in **3.3.2**.

*Second Method*

Transfer the test specimen to the drying oven and dry it to constant weight. Determine the oven-dry weight of the test specimen.

NOTE — Constant weight may be assumed to have been attained by the specimen when two successive weighing at intervals of 20 min differ by less than 0.05 percent.

**3.2.2** Calculate the conditioned weight of the test specimen by the formula given below:

$$\text{Conditioned weight oftest specimen} = \frac{A \times (100 + R)}{100}$$

where

$A$ = oven-dry weight of the, and

$R$ = moisture regain value of 18¼ percent for unchlorinated woolen and worsted yarns and 16 percent for chlorinated woolen and worsted yarns.

## 3.4 Count Man-Made Fibre Filament Yarns

**IS 7703 (Part 1) : 1990 Methods of test for man-made fibres continuous filament flat yarn – Part 1 Linear density (*first revision*)** prescribes the method for determination of linear density of man-made fibres continuous filament flat yarn.

#### *3.4.1 Principle*

The linear density is determined from the mass of a specified length of yarn and expressed in denier or tex. The specimen is first conditioned free from tension and length is measured under standard pretension. The specimen is then oven-dried to constant mass and weighed. The commercial moisture regain is then added to the oven-dry mass and the resultant mass is used in calculating the linear density of the specimen.

#### *3.4.2 Procedure*

Take at least six test specimens, two from each package, one drawn from the inside and one drawn from the outside of the package, except when the yarn is on pirns. When the yarn is on pirns, take at least ten test specimens each reeled off the middle portion of each pirn. Place each test specimen in the ventilated drying oven maintained at 105 ± 3°C and fed with air from standard atmosphere. Continue drying until constant mass is obtained.

NOTE - The mass shall be taken as constant when the difference between any two successive weighings made at intervals of 20 minutes does not exceed 0.1 percent.

Record the oven-dry mass of each test specimen correct to 1 mg.

### *3.4.3 Calculation*

Calculate the linear density for each test specimen by one of the following formulae:

a) Tex = (100+R) × $\frac{10\ M}{L}$

b) Denier = (100+R) × $\frac{90\ M}{L}$

where

*R* = percentage commercial moisture regain of the fibre used in the yarn being tested (*see* Note),

*M* = oven-dry mass of the test specimen in grams, and

*L* = length of specimen in metres.

NOTE — Unless otherwise agreed to between the buyer and the seller commercial moisture regain values for various man-made fibres as given below may be used:

| Sl No. | Material | Commercial Moisture Regain, percent |
|---|---|---|
| i) | Polyester | 0.4 |
| ii) | Polyamide | 4.5 |
| iii) | Rayon | 11.0 |
| iv) | Cupro | 11.0 |
| v) | Acetate | 6.5 |
| vi) | Acrylic | 1.5 |
| vii) | Vinyon (polyvinylchloride) | Zero |
| viii) | Olefins | Zero |
| ix) | Triacetate (primary) | 3.5 |
| x) | Textile glass | Zero |
| xi) | Modacrylic<br>Class 1<br>Class 2<br>Class 3 | <br>0.4<br>2.0<br>3.0 |

## 3.5 Crimp and Linear Density

**3.5.1** Warp and weft yarns interlace in fabric during the weaving stage. They follow a wavy or corrugated path. Crimp percentage is a measurement of this waviness in yarns. Due to this crimp formation in the yarn, the method for determining the linear density of the yarn from a fabric differs from that of yarn from a package. **IS 3442 : 2023 Textiles method for determination of crimp and linear density of yarn removed from fabric (*second revision*)** prescribes a method for the determination of crimp and linear density (direct or indirect count) of yarn removed from any textile fabric in which yarns are intact and can be removed in measurable lengths. In case the fabric contains plied or cabled yarn, the method is applicable for the determination of its resultant linear density.

**3.5.2** The linear density of yarn determined by this method may not, however, be expected to agree with the linear density of grey yarn used for weaving the fabric because of the changes brought about in the yarn linear density by the processing treatments as well as the treatments prescribed in this standard for removal of the added matter.

**3.5.3** This standard is applicable to yarns that stretch less than 5 percent when tension on yarn is increased from 0.25 g/tex to 0.75 g/tex. By mutual agreement, it may be adapted to yarns that stretch more than 5 percent by use of pre-tension lower than the specified method for elastomers or use of tension higher than that specified in this method to remove crimp out of textured yarns.

***3.5.4 Principle***

Yarns are removed from a strip of fabric of known length, straightened by a tension that is applied according to the nature and linear density of the yarn and measured in the straightened state. The difference between the straightened length of the yarn and the distance between its ends while in the fabric is expressed as a percentage of the latter.

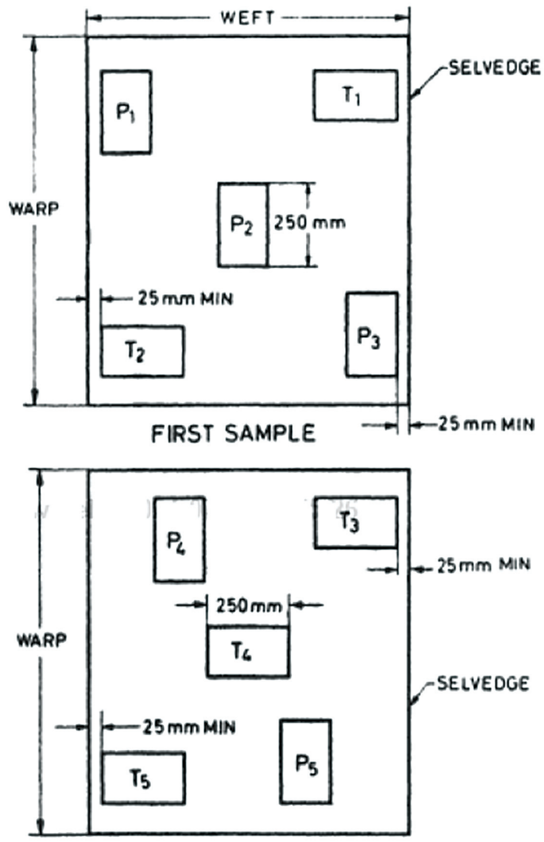
***3.5.5 Apparatus***

A device capable of measuring the straightened length of yarn in a horizontal or vertical direction provided with two yarn clamps/grips, each of which closes at its rear end first and when closed, has parallel gripping surfaces. The distance between the grips is adjustable and through one of which a known tension can be applied. Each clamp shall consist of two jaws, preferably metallic, having parallel gripping surfaces.

NOTE — Any available crimp tester may be used for this purpose.

***3.5.6 Preparation of Test Specimens***

From the various portions of the fabric comprising the test sample , cut out strips of five warp way test specimens P1, P2, P3, P4 and P5 and five weft way test specimens T1, T2, T3, T4 and T5, taking care that the same group of warp and weft yarns is not repeated. Each specimen shall be 250 mm long and of sufficient width to yield at least 25 warp or weft yarns/threads per strip.




*Second Sample*

**Fig. 1 Layout of Test Specimens**

### *3.5.7 Procedure*

*Warp Yarn*

For determining the approximate universal count of the warp yarn in tex, which is necessary for calculating the tension to be applied during the test, take one of the warp way test specimens. Draw twoparallel marks 200 mm apart at right angles to the direction of warp. Remove 10 warp yarns and cut them along the marks with a sharp razor blade and template. Determine the mass of all the yarns in milligrams and calculate the approximate universal count of the yarn in tex by the following formula:

$$t = \frac{m}{2}$$

Where

$t$ = approximate universal count in tex of the warp yarn; and

$m$ = mass in milligrams of 10 warp yarns.

Take the test specimen P1 and draw two parallel marks 200 mm (l) apart at right angles to the direction of the warp. Ravel a warp yarn out of the test specimen P1 to a length of about 50 mm. Hold the yarn as close to the end as possible and fasten its loose end in the tension clamp so that one of the marks on the yarn coincides with the inner edge of the tension clamp. Pull the yarn out of the test specimen sideways, taking care not to stretch the yarn or release the other end of the yarn to avoid the removal of any twist. Hold the yarn as close to the end as possible to avoid any untwisting.

Draw the yarn through the other clamp and fix the yarn such that the second mark on the yarn coincides with the inner edge of the clamp. Measure the length of the yarn between the two marks in millimetres under tension with a ± 10 percent range. (It should be noted that the tex of yarn for this purpose is only approximate). In a similar manner, determine the length between the marks of 9 other warp yarns. From the data thus obtained, calculate the average straightened length between the marks (l1) of 10 warp yarns.

Calculate the crimp percent in the yarn by the following formula:

$$\text{Crimp percent} = \frac{l_1 - l}{l} \times 100$$

where

$l_1$ = average length in millimetres of the yarns when straightened, and

$l$ = length in millimetres of the yarns while in cloth.

NOTE — The crimp percent may be determined by using crimp tester, following the procedure as prescribed in the instrument manual

Cut the test specimen along the marks with a sharp razor blade and template. Remove the sufficient number of warp yarns (*see* Note) out of the specimen so that the total length of the yarns removed is about 10 m, and place them in a suitable container.

NOTE — It may be necessary to trim off the protruding weft yarns frequently to avoid fraying of the warp yarns.

Calculate the total length (*L*) of the yarns collected in the container in millimetres taking the average length between the marks ($l_1$) determined, as the length of each yarn.

Make the yarns into bundles or loops and remove the finishing material. Determine the mass (*M*) of the yarns in milligrams after conditioning.

From the data thus obtained, determine the universal count T of the yarn in tex by the following formula:

$$T = \frac{M}{L} \times 1000$$

where

$M$ = total mass in milligrams of the yarns; and

$L$ = total length in millimetres of the yarns.

Determine the crimp and linear density of the warp yarn in the remaining four test specimens, P2, P3, P4, and P5 in a similar manner. Find the average of the 5 values in each case, round off these values to one decimal place and report the values thus obtained as the crimp percent and count of the warp yarn.

NOTES

**1** If it is desired to express the result in any of the traditional count systems, use one of the following formulae as applicable:

a) Count in the direct system = $\frac{M}{L} \times 1000 \times C_1$

where

*M* and *L* have the same meaning and

$C_1$ = a constant corresponding to the count in the direct system in which the result is desired (*see* Table 1).

b) Count in the indirect system = $\frac{L}{M \times 1000} \times C_2$

where

*M* and *L* have the same meaning; and

$C_2$ = a constant corresponding to the count in the indirect system in which the result is desired.

**2** For factors and tables for conversion of yarn linear density from one system to other, reference to IS 3689 may be made.

**Table 1 Constants for Direct Count Systems**

| Sl No. | Yarn Count System | Unit of Mass used | Unit of Length Used | Unit of Yarn Count | Constant $C_1$ |
|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) |
| i) | Denier | 1 gram | 9000 metres | g/9 000m | 9 |
| ii) | Jute | 1 pound | 14400 yards (spindle Unit) | 1b/14 400 yd | 0.029 03 |

**Table 2 Constants for Indirect Count Systems**

| Sl No. | Yarn Count System | Unit of Length used | Unit of Mass Used | Unit of Yarn Count | Constant $C_1$ |
|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) |
| i) | Cotton (English) | 840 yards (hank) | 1 pound | 840 yd/1b | 590.5 |
| ii) | Linen (wet spun) | 300 yards (lea) | 1 pound | 300 yd/1b | 1 654 |
| iii) | Spun silk | 840 yards | 1 pound | 840 yd/1b | 590.5 |
| iv) | Woollen (Dewsbury) | 1 Yard | 1 ounce | yd/oz | 31 000 |
| v) | Woollen (Yorkshire) | 256 Yards (skein) | 1 pound | 256 yd/1b | 1 938 |
| vi) | Worsted | 560 Yards (hank) | 1 pound | 560 yd/1b | 885.8 |

*Weft Yarn*

Determine the crimp and linear density of the weft yarn by taking the test specimens T1, T2, T3, T4 and T5 and following the procedure similar to the one prescribed above.

In case the determination of the crimp of the yarn in the fabric is not required and only the linear density is to be determined, the straightened length and mass of the yarn after desizing may be used for calculating the count.

## 3.6 Conversion Tables

A variety of count systems is being used in the different sectors of the textile industry. With the increasing complexity to be found in industrial and commercial fields, there is an ever-growing need for standardization of count systems. than one kind. Further, with the growing use of yarns containing more of fibre and of fabrics containing yarns made from different fibres, it has become increasingly evident that the adoption of a single yarn count system would avoid confusion and save time. **IS 3689 : 1966 Conversion factors and conversion tables for yarn counts** provides the solution to this problem and defines the various count systems and provides factors and formulae for inter-conversion of yarn counts. Tables for inter-conversion of values in traditional count systems and Tex System are also included in this standard.

# CHAPTER IV

# TWIST IN YARN

# CHAPTER IV

## 4 TWIST IN YARN

### 4.1 Direct Counting Method

**IS 832 (Part 1) : 2021/ISO 2061:2015 Textiles - Determination of twist in yarns Part 1 Direct counting method** specifies a method for the determination of the direction of twist in yarns, the amount of twist, in terms of turns per unit length, and the change in length on untwisting, by the direct counting method. This standard is applicable to

a) single yarns (spun and filament),
b) plied yarns, and
c) cabled yarns.

Separate procedures are given for each type of yarn. The method is designed primarily for yarns in packages, but, with special precautions, the procedures can be used for yarns taken from fabrics. It is not suitable for the determination of twist in a monofilament.

NOTE See also ISO 1890, which was prepared especially for the needs of glass textile technology, and ISO 7211-4.

This standard also covers the determination of twist in plied and cabled yarns as follows:

a) in plied yarns: the final twist of the plied yarns and the original twist of the single yarn before plying;
b) in cabled yarns:
   — the final cabling twist of the yarn;
   — the original twist of the plied yarn after plying, but prior to the last stage of processing;
   — the twist of the single yarn before plying.

If desired, the twist of single and plied yarn components, as they lie in the final structure, can be determined by the special procedure given later.

This standard is not applicable, except by agreement, to yarns which stretch more than0,5 % when the tension increases from 0.5 cN to 1.0 cN per unit linear density of the yarn expressed in tex. Such yarns can be tested under special conditions of tension which are accepted by all parties interested in the test results. This standard is also not suitable for products of open-end spinning and intermingled (interlaced) multifilament yarns. This standard is not applicable to yarns which are too large to permit their being placed in the clamps of the testing apparatus without crushing or distortion severe enough to affect the test results.

### 4.2 Principle

The twist in a known length of yarn is removed by rotating one end of the specimen with respect to the other until the components of the yarn being tested are parallel. The exact number of turns required to remove the twist is reported in terms of turns per unit length of yarn.

### 4.3 Length of Test Specimen

*Single spun yarns*

The initial length of the specimen shall be as great as possible, but shall be somewhat less than the average length of the staple fibre used to spin the yarn. The initial lengths of specimens listed in **Table 1**are commonly used.

**Table 1 — Specimen lengths**

| **Type of yarn material** | **Specimen initial length** mm |
|---|---|
| Cotton | 10 and 25 |
| Worsted | 25 and 50 |
| Woolen | 25 and 50 |
| Bast fibre | 100 and 250 |

***Single multifilament, plied, and cabled yarns***

Take an initial length of 250 mm ± 0.5 mm if the nominal twist is >1 250 turns/m and an initial length of 500 mm ± 0.5 mm if the nominal twist is <1 250 turns/m.

### 4.4 Selection

Test specimens shall be taken, at the lowest tension practicable, from the end of the package if this is the normal method of use; otherwise, take the yarn from the side of the package. Discard the few metres of yarn at the beginning and end of the package in order to avoid damaged sections. If it is desired to reel laboratory sample skeins, the yarn specimens shall be taken and shall be representative of the original package.

If two or more test specimens are taken from an individual yarn package, they shall be taken at random intervals of at least 1 m in order to minimize the effects of cyclic variation introduced during the manufacture. If more than two specimens are taken from an individual package, take groups of specimens, not more than five to a group, at intervals of several metres.

### 4.5 Number of test specimens

Take the number of specimens required in the material specification, when applicable. In the absence of material specification, take a number of specimens designed to give the precision specified below, depending on the information available on the variation of twist results in the material being tested.

If information on variation is available, take a number of specimens, n, calculated by the formula given in **Table 2**, to secure the precision specified at a probability of 95 %.

**Table 2 — Formula for number of specimens, n, using information on variation**

| Type of yarn | Range of twist | Precision | Formula for $n$[a]) |
|---|---|---|---|
| Single multifilament | Less than 40 turns/m | ±4.0 turns/m | $0.240\sigma^{2}$ [b]) |
| Single multifilament | 40 turns/m to 100 turns/m | ±5.0 turns/m | $0.154\sigma^{2}$ [b]) |
| All other yarns | - | ±5.0 % | $0.154\nu^{2}$ [c]) |
| a) Where n is the number of tests.<br>b) Where σ is the standard deviation of individual results, determined from extensive past records on similar materials.<br>c) Where ν is the coefficient of variation of individual test results, determined from extensive past records on similar materials. | | | |

If no information on variation is available or in the case of a dispute, determine the number of specimens as follows.

a) Take the number of specimens, n, specified in Table 3, which also indicates the variation assumed to calculate n.

b) Calculate the coefficient of variation, í, or the twist results by normal statistical methods. If the variation is such that the precision with 95 % confidence is greater than 5 %, increase the number of tests. The number of tests required can be calculated as follows:

$$n=\left[\frac{1,96v}{5}\right]^2$$

where

*n is* the number of tests;

ν is the coefficient of variation of individual test results, determined from extensive past records on similar materials.

**Table 3 — Number of specimens, n, in the absence of information on variation**

| Type of yarn | Range of twist | *n* | Assumed variation[a] |
|---|---|---|---|
| Single, spun | All | 50 | ν = 18 % |
| Single, multifilament | Less than 40 turns/m | 20 | σ = 8,0 turns/m |
| Single, multifilament | 40 turns/m to 100 turns/m | 20 | σ = 10,0 turns/m |
| Single, multifilament | More than 100 turns/m | 20 | ν = 10 % |
| Plied and cabled yarns | All | 20 | ν = 10 % |
| [a] Where ν and σ are as defined in **Table 2**, footnotes [b] and [c]. | | | |

## 4.6 Procedure

**4.6.1** *Determination of the direction of twist*

Hold one end of the yarn in such a position that a short length (at least 100 mm) is suspended in a vertical position. Examine the vertical section of the yarn and determine if the slope of the yarn elements (fibres, filaments, or component yarns) conforms to the slope of the central portion of the letters “S” or “Z”. Designate the direction of twist as “S” or “Z” as observed.

**4.6.2** ***Determination of the amount of twist***

***4.6.2.1 Single, spun yarn***

Set the movable clamp of the twist counter at the distance specified for the nominal staple length of the fibres in the spun yarn being tested, ±0,5 mm. Remove any lateral play in the clamps which might significantly affect the gauge length of the specimen. Verify the gauge length by measuring the clamp separation with an accurate gauge or caliper. Set the revolution counter to zero. Taking care not to disturb the twist, mount the specimen in the clamps under a pretension equivalent to (0.5 ± 0.1) cN/tex.

If yarns which extend 0.5 % or more under the specified pretension are to be tested, they shall be subjected to a pretension which produces an extension not greater than 0.1 %. The pretension used in these exceptional cases shall be reported and shall be agreed to by all persons interested in the test results.

Remove the twist by turning the rotatable clamp until it is possible to pass a needle from the face of the non-rotatable clamp to the face of the rotatable clamp between the untwisted fibres. Use a means of magnification, if necessary, to make sure that all the twist has been removed.

Note the direction of twist as indicated on the revolution counter. Be sure it agrees with the direction determined by inspection of the specimen. Record the initial length, the direction of twist, and the number of turns in the specimen. Repeat the operation until the required number of specimens has been tested.

***4.6.2.2 Single, multifilament yarns***

Set the clamps of the twist counter at a distance of 250 mm (or, by agreement, 500 mm) ± 0,5 mm. Remove any lateral play in the clamps that might significantly affect the gauge length of the specimen. Verify the gauge length of the specimen by measuring the clamp separation with an accurate gauge or caliper. Set the revolution counter to zero. Proceed as directed for single, spun yarns.

When information on change in length on untwisting is desired, release the mechanism fixing the movable clamp and determine the length of the original specimen after untwisting and under the original tension. Note the change in length and specify increase or decrease in length. Repeat the operation until the required number of specimens, n, has been tested.

***4.6.2.3 Plied yarns***

Determine the plied twist by the procedures given for single, multifilament yarns. After removing the twist from the plied yarn, cut loose and remove all but one of the component yarns to obtain an individual end of the single yarn. It is assumed that all components of the original yarn have the same direction and amount of twist. If this is not known to be so, it shall be verified. If any difference in kind exists, each component yarn shall be tested and reported separately. If the component yarns are spun yarns, additional specimens will be required, and it is desirable to save the cut-away strands without loss of twist to provide the specimens.

If the single yarn component has been spun from staple fibres, determine the twist in the single yarn, but if the single yarn component is multifilament, determine the twist. When information on change in length on untwisting is desired, release the mechanism fixing the movable clamp and determine the length of the original components after untwisting and under the original tension. Note the change in length and specify increase or decrease in length. Repeat the operation until the required number of specimens, n, has been tested.

#### *4.6.2.4 Cabled yarns*

Determine the cable twist as directed for single, multifilament yarns to obtain the total number of turns of hawser or cable twist in the test specimens. After removing the cable twist, cut loose and discard all but one of the component yarns to obtain an individual strand of plied yarn. Note the length under the original tension and determine the plied twist as directed for multifilament yarns to obtain the total number of turns of the plied yarn component.

Cut loose and remove all but one of the component yarns to obtain an individual single yarn. If the single yarn has been spun from staple fibres, determine the single yarn, but if the single yarn is multifilament, determine the single yarn twist. When information on change in length on untwisting is desired, release the mechanism fixing the movable clamp and determine the length of the original specimen after untwisting and under the original tension. Note the change in length and specify increase or decrease in length. Repeat the operation until the required number of specimens, n, has been tested.

If it is desired to determine the final twist in the plied and single yarn components, all strands shall be cut free from the original specimen, except for the component to be tested. The strands remaining in the clamps can be tested as directed for spun or single filament yarns.

## 4.7 Calculation of results

#### *4.7.1 Average twist per specimen*

Calculate the average twist per test specimen, in turns per metre, using the formula:

$$t_x = \frac{1000x}{l} \quad (2)$$

where

$t_x$ is the average twist, in turns per meter;

$l$ is the length of the test specimen before untwisting;

$x$ is the total number of turns observed in the test specimen.

#### 4.7.2 Average twist per sample

Calculate the average twist per sample, in turns per metre, using the formula:

$$\bar{t_x} = \frac{\Sigma t_x}{n} \quad (3)$$

where

$\bar{t}_x$ is the average twist per sample;

$\Sigma t_x$ is the sum of the average twist in all test specimens;

$n$ is the number of test specimens.

#### 4.7.3 Variation of observations

If the coefficient of variation and 95 % confidence interval of the twist are desired, they shall be calculated by standard statistical methods.

#### 4.7.4 Change in length on untwisting

If the change in initial length is desired, it shall be calculated according to the following formula and reported as extension or contraction, as appropriate.

$$\triangle l = \frac{l_u - l_t}{l_t} \times 100 \quad (4)$$

Where

$\Delta l$ is the percentage extension if $\Delta l$ is a positive value;

$\Delta l$ is the percentage contraction if $\Delta l$ is a negative value;

$l_t$ is the length of the twisted specimen;

$l_u$ i s the length of the untwisted specimen.

Values calculated for yarn spun from short fibres are considered very unreliable to be reported.

#### 4.7.5 Twist factor (α)

If desired, the twist factor can be calculated, as follows:

$$\alpha = t\left(\frac{p_t}{1000}\right)^{1/2} \quad (5)$$

where

$\alpha$ is the twist factor;

$t$ is the twist, in turns per metre;

$\rho_t$ is the linear density, expressed in text.

The twist factor can also be calculated from the metric count, as follows:

$$\alpha = \left(\frac{1}{p_t}\right)^{1/2} \quad (6)$$

where

$\alpha$ is the twist factor;

$t$ is the twist, in turns per metre;

$\rho_t$ is the linear density, expressed in the metric system.

## 4.2 Untwist Re-twist Method

**IS 832 (Part 2) : 2011/ISO 17202 : 2002 Textiles – Determination of twist in yarns Part 2 Untwist/ retwist method for single spun yarns (*second revision*)** specifies the method for the determination of the direction of twist in single yarns and the amount of twist, in terms of turns per unit length, by the indirect untwist/retwist method.

This standard is applicable to single spun yarns and is not applicable to:

a) open-end spun yarns;

b) false twist and self twist yarns;

c) air-jet yarns;

d) yarns that stretch more than 0.5 % when the tension increases from 0.5 cN/tex to 1.0 cN/tex.

e) yarns that are too large to permit their being placed in the clamps of testing apparatus without crushing or distortion severe enough to affect the test results.

The method is designed primarily for yarns in packages, but by the application of special precautions the procedures can be used for yarns taken from fabrics.

### *4.2.1 Principle*

The untwist/retwist method is an indirect method for determining twist. It involves untwisting a specimen and then retwisting it in the opposite direction until it has regained its initial length. It is assumed that the number of turns inserted during retwisting is equal to the initial twist of the specimen and that consequently, half the number of turns recorded on the counter represents the twist of the specimen.

The untwist/retwist method is very sensitive to the pretension used, therefore two methods are proposed: the generally-used method A and a double method B which is less sensitive to inaccuracies in pretension and therefore gives more reliable accurate results. Method B is, however, more time-consuming than method A and it is therefore recommended mainly for automatic twist testers.

*Method A — Single method*

Specimens are tested according to the principle described in **4.2.1**.

*Method B — Double method*

An initial specimen is tested as described in **4.2.1**. A second specimen is tested by untwisting to a quarter of the turns obtained on the initial specimen, then retwisting back to the initial length to correct for errors caused by pretensioning.

### *4.2.2 Comparison of methods*

The untwist/retwist method, whether A or B, is used for acceptance testing for economic reasons because it requires less testing time and fewer specimens than the reference direct-counting method. The accuracy of the untwist-retwist method, especially of method B, is good, that is, the results are comparable to those of the direct method, provided appropriate pretension and extension control limits have been utilized.

If there is disagreement arising from differences in values reported by the purchaser and the seller when the untwist/retwist method is used for acceptance testing, then the statistical bias, if any, between the laboratory of the purchaser and that of the seller should be determined; each comparison shall be based on test specimens randomly drawn from one sample of material of the type being evaluated.

The "setting" of twist in some fibres causes excessive contraction when the yarn is retwisted in the reverse direction. Therefore, the number of turns required to bring the specimen back to its original length may be less than the number of turns removed in untwisting. This effect may be partially offset by the use of higher pre-tensioning load; but this increases the danger of stretching the yarn. Little information is available on the correct tensions to use, either for yarns made from different fibres or with different amounts of twist.

The untwist/retwist method can be useful where the objective is to measure variations from an average value. Another possible application is where a large amount of twist testing is required on yarns of similar type and twist. In this case, preliminary tests comparing the results of the untwist/retwist method with the results of the reference direct method could be used to determine the correct pre-tension.

#### *4.2.3 Test Specimens*

The initial length of the specimen shall be 500 mm ± 1 mm. The test specimens shall be taken at the lowest tension practicable, in the manner in which the yarn would normally be taken from the package during subsequent processing (i.e. by unrolling from the side of the package). The few metres of yarn at the beginning and, if relevant, at the end of package shall be discarded in order to avoid damaged sections.

If two or more test specimens are taken from an individual yarn package, they shall be taken at random intervals of at least 1 m in order to minimize the effects of cyclic variation introduced during manufacture. If more than two specimens are taken from an individual package, take groups of specimens, not more than five to a group, at intervals of several metres.

For woven fabrics, take warp specimens from separate ends, since each represents a separate package. Because the fabrics may have been woven on any of a variety of looms which are either random quilling (traditional), sequential quilling or shuttleless, take weft specimens at random through the whole laboratory sample to obtain data as representative as possible. If a strip 2 m long is used as a source of specimens, this procedure will usually provide specimens from several different bobbins of weft yarns.

For weft-knit fabrics known to be multi-feed, take specimens from successive courses in one portion of the laboratory sample. For weft-knit fabrics known to be single-feed or for which the type of feed is not known, take specimens at random from the whole sample. In warp-knit fabrics, it is, in most cases, impossible to unravel specimens with the necessary length. Therefore, the untwist/retwist method is usually not applicable.

#### *4.2.4 Number of test specimens*

Take the number of specimens required in the material specification, when applicable. In the absence of material specification, take a number of specimens such that the user may expect at the 95 % probability level that the test results are not more than

5 % of the average above or below the true average of the lot. Determine the number of specimens for each lot sample as follows.

a) Reliable estimate of v: when there is a reliable estimate of v based upon extensive past records for similar materials tested in the user's laboratory as directed in the method, calculate the required number of specimens using equation (1):

$$n = (t^2 \times v^2)/A^2 = 0{,}154v^2$$

where

$n$ is the number of specimens (rounded upward to a whole number when n is less than 50 or to a multiple of five when n is 50 or more);

$t$ = 1,96, the value of Student's $t$ for infinite degrees of freedom, two-sided limits, and a 95 % probability level ($t^2$ = 3,842);

$v$ is the reliable estimate of the coefficient of variation of individual observations on similar materials in the user's laboratory under conditions of single-operator precision;

$A$ = 5 % of the average, the value of the permissible variation, and 0,154 is calculated by $t^2/A^2$.

b) No reliable estimate of $v$: when there is no reliable estimate of $v$ for the user's laboratory, equation (1) shall not be used directly. Instead, specify a fixed number of 16 specimens. This number of specimens is calculated using $v$ = 10,5 % of the average which is a somewhat larger value of $v$ than is usually found in practice. When a reliable estimate of $v$ for the user's laboratory becomes available, equation (1) will usually require fewer than 16 specimens.

#### *4.2.5 Procedure*

*Determination of direction of twist*

Hold one end of the yarn in such a position that a short length (at least 100 mm) is suspended in a vertical position. Examine the vertical section of the yarn and determine if the slope of the yarn elements (fibres) conforms to the slope of the central portion of the letters "S" or "Z". Designate the direction of twist as "S" or "Z" as observed, in accordance with ISO 2.

*Determination of amount of twist*

**Method A — Single method**

— set the specimen length at 500 mm ± 1 mm;

— remove and discard a length of 2 m to 3 m of yarn;

— taking care not to disturb the twist, fasten the specimen in the grip of the moving part; insert the specimen in the rotating grip under the prescribed pretension, adjust its length by moving the pointer to zero, then tighten the grip;

— untwist the yarn at a speed of 1 000 turns/min ± 200 turns/min, then retwist it in the opposite direction until the pointer returns to zero;

— note the counter reading which represents the twist expressed in turn/m;

— remove about 1 m of yarn between two successive specimens.

**Method B — Double method**

— follow the complete procedure described in 10.3.1 but do not reset the counter to zero;

— take a second specimen and mount it in the grips as described above;

— untwist the yarn at a speed of 1 000 turns/min ± 200 turns/min but only until reaching a quarter of the twist (nominal, or as determined by preliminary tests), then twist back until the pointer returns to zero;

— note the counter reading which represents the twist expressed in turns/m;

— repeat the above two-specimen procedure until the required number of tests has been performed;

— remove about 1 m of yarn between successive specimens.

### *4.2.6 Calculations*

The specimen length is 500 mm, therefore, the counter reading corresponds directly to the value of the twist expressed in turns per metre.

Calculate the average twist per sample, in turns/m, using the formula:

$$\bar{t_x} = \frac{\Sigma t_x}{n}$$

where

$\bar{t}_x$ is average twist of the sample;

$\Sigma\bar{t}_x$ is the sum of the twist in all test specimens;

$n$ is the number of test specimens.

*Variation of observations*

If the coefficient of variation and 95 % confidence interval of the twist are desired, they shall be calculated by standard statistical methods.

*Twist factor* ($\alpha$)

If desired, the twist factor can be calculated, as follows:

$$\alpha = t\left(\frac{T}{1000}\right)^{1/2}$$

where

$\alpha$ is the twist factor;

$t$ is the twist, in turns per metre;

$T$ is the linear density, expressed in tex.

# CHAPTER V

# YARN STRENGTH PARAMETERS

# CHAPTER IV

## 5 YARN STRENGTH PARAMETERS

### 5.1 Breaking Load and Elongation of Single Strand

**5.1.1** Breaking load is a measure of strength of the yarn and elongation is an indication of the ability of the yarn to absorb energy. If it is too low weaving becomes difficult or impossible but low elongation yarns have better dimensional stability.

**IS 1670 : 1991 Textiles – Yarn – Determination of breaking load and elongation at break of single strand (*second revision*)** prescribes method for determination of breaking load and elongation atbreak of yarn using constant-rate-of-traverse, constant-rate-of-loading and constant-rate-of extension machines. Since for any fibre type breaking load is approximately proportional to the linear density, strands of different sizes are compared by converting the observed breaking load to breaking tenacity (centinewtons or millinewtons per tex)

The method prescribed in this standard is applicable to monofilaments and multi filamentsother than tyre cords and industrial yarns, ands pun yarns (single, plied or cabled) made from all kinds of textile fibres or their blends with the exception of yarns that stretch more than 5.0 percent when tension is increased from 0.5to 1.0 g (5 to 10 mN) per unit linear density of the yarn in tex.

This standard is designed primarily for yarn in package form but can be used for single strands removed/extracted from a woven/knitted fabric. This standard does not cover textured yarns and fancy yarns. The test method described offers two options with respect to moisture content of the specimens at the time of testing.

*Option1*— Conditioning to moisture equilibrium in the standard atmosphere for testing textiles.

*Option 2* —Testing in wet condition. Tests on wet specimens are usually made only on yarns which show a less strength when wetor when exposed to high humidity, for example, yarns made from animal fibres and man-made fibres based on regenerated and modified cellulose. Wet tests are made on flax yarns to detect adulteration by failure to gain strength.

This method also offers three options for the physical confirmation of the specimen.

*OptionA* — Straight.

*Option B* — Knotted.

*Option C*— Looped.

NOTES

**1** The reduction in strength due to the presence of a knot or loop is considered a measure of brittleness of yarn. If a textile yarn is looped or knotted its tensile strength may reduce. This can arise when a yarn is bent to a small radius of curvature (as in sewing or knitting) or knotted (as in the manufacture of nets). In order to assess the importance of these effects, loop strength and knot strength are described.

2 The knot strength test as described in this standard is not intended to assess the efficiency of any given type of knot for joining together two separate lengths of yarns.

3 Elongation in a knot or loop test is not known to have any significance and is not usually recorded.

4 Unless otherwise indicated, 'single-strand strength' is assumed to refer to a straight, conditioned specimen (Option 1A).

### *5.1.2 Principle*

The specimen is gripped between two clamps of the tensile testing machine and continually increasing load is applied longitudinally by moving one of the clamp; until the specimen ruptures. Values of the breaking load an delongation at break of the test specimen are red directly or from a chart attached.

### *5.1.3 Conditioning of Test Specimens*

*Option 1: Conditioned Specimens*

Prior to test, the specimens shall be conditioned to moisture equilibrium in the standard atmosphere of 65 ± 2 percent relative humidity and 27 ± 2°C temperature.

When the test specimens have been exposed to standard atmosphere for at least as much time as given below in such a way as to express as fast as possible, all portions of the specimens to the atmosphere, they shall be deemed to have reached moisture equilibrium:

| Equilibrium Moisture Regain Value of the Yarn at Standard Atmosphere | Time |
|---|---|
| Percent | hour |
| Less than 4 | 6 |
| From 4 to 10 | 12 to 24 |
| Above 10 | 24 to 48 |

The test shall be carried out in standard atmosphere.

*Option 2: Wet Specimens*

Reel a short skein from each of the packages forming the test sample. Clamp a group of specimens by both ends to prevent loss of twist and submerge them in distilled or demineralized water at room temperature until they are thoroughly soaked and sink under their own weight. The time of immersion must be sufficient to wet out the specimens thoroughly. The time period will be at least 2 minutes for regenerated cellulose yarn and at least 10 minutes for acetate. For yarns that do not readily wet with water, such as those treated with water repellent or water-resistant materials, add a0.1 percent solution of a nonionic wetting agent to the water-bath. Do not use any agent that will affect the physical properties of the yarn appreciably. If a wetting agent has been used, the specimen must be thoroughly rinsed in distilled or demineralised water before conducting the test. When using Option 2B, tie the knots very loosely before wetting in order to savetime and to avoid handling while transferring the specimens from container to the testing machine.

***5.1.4 Apparatus***

A single-strand tensile testing machine working on one of the following principles:

a) Constant-rate-of-traverse (CRT),
b) Constant-rate-of loading (CRL), and
c) Constant-rate-of-extension (CRE).

It may be noted that, in most cases the results obtained on one type of machine will differ from those obtained on another type and the three types of testing machines will not necessarily give the same results for any given yarn.

Breaking load decreases slightly as the time-to-break Increases. The rate of change is approximately of the order of 5 to 10 percent decrease in the breaking load for a ten-fold increase in the time to break. It is assumed that by testing with a specified time-to-break, any difference between the results is reduced to a minimum.

The specimens shall break within 20 ± 3seconds in the case of constant-rate-of loading and constant-rate-of-extension machines. In the case of constant-rate-of-traverse machines, the rate of traverse shall be 300 ± 15 mm/min and the load range of the machine shall be such that the observed value lies between 10 and90 percent of the full scale load. The permissible error in the machine at any point in this range shall not exceed ± 1 percent of the load.

A variable-speed drive, change gears or interchangeable weights are required to obtain a constant time-to-break of 20 ± 3 seconds. If the rate of operation is adjusted in steps, the steps should not be greater than 1.25: 1.00.

The machines shall be provided with the following arrangements:

a) Two clamps to grip the specimen, provided with a mechanical or pneumatic device so constructed that through its means it is possible to secure a specimen firmly between the jaws of the clamps so that it does not slip during the test. Also, the edge of the surface of each jaw as well as the jaw lining shall be such that it would not cut or damage the specimen during testing. When specimens cannot be satisfactorily held with unlined flat-faced jaws, then lined jaws or, if necessary, capstan, drum, bollard clamps or snubbing type jaws may be used. With some yarns these devices may be necessary in order to reduce the clamping pressure required to prevent slippage; otherwise the clamping pressure will have to be so great that jaw breaks would be frequent.

NOTES

**1** Flat-faced clamps are usually used with fine yarns and the snubbing type clamps with high strength yarns or coarse yarns and when specimens slip in the clamps or the number of breaks at or close to the jaws exceeds statistical expectation. To check slippage make a mark on the specimen as close as possible to the back of each clamp, operate the machine to break the specimens and observed whether the marks have been pulled towards or between the jaw faces of either clamp.

**2** For sewing threads or similar yarns, clamps described as follows may be used: For yarns of linear density up to 320 tex, use an inverted screw type clamp (Fig. 1) or pulleys with lot king vices (Fig. 2) or pins. For yarns of linear density of 320 tex or higher, clamps of vice type(Fig. 3) may be used. With these clamps, specimen length is not determined precisely and consequently measurements of extension are not accurate and therefore the results should not be compared with those obtained with unlined flat jaws.

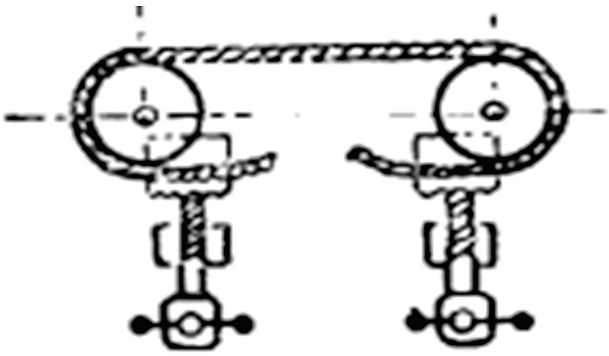


*FIG. 1 INVERTED SCREW TYPE CLAMPS*

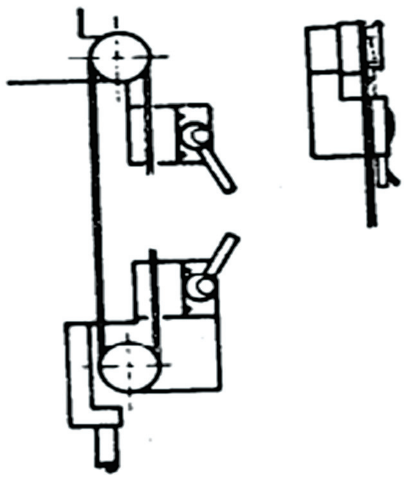


*FIG. 2 PULLEYS WITH LOCKING VICES*

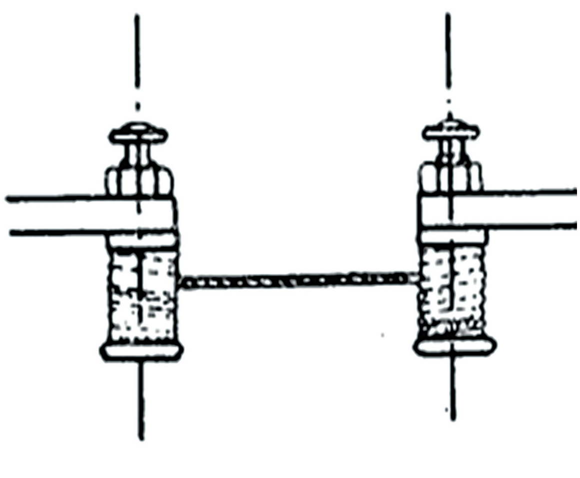


*FIG. 3 CLAMPS OF VICE TYPE*

b) Means for applying specified pre-tension to the specimen when clamped (the tension device may be a dead-weight, a spring, or an air-actuated mechanism). The pre-tension. shall be as follows:

1) For conditioned specimens — 0.50 ± 0.05 cN /tex, and

2) For wet specimens – 0.25 ± 0.03 cN/tex.

NOTE — This tension should not stretch the specimen more than 0.5 percent, otherwise a mutually acceptable lower tension should be applied.

c) Means for adjusting the distance between the clamps.

d) A scale or dial or autograph recording chart graduated so as to give load in cN or N and elongation in millimetres. The error of the indicated or recorded jaw separation shall not exceed 1 mm.

NOTE — Prior to test, care should be taken to ensure that the instrument is calibrated.

Automatic testing (self-loading and recording) machine may be used provided thatit can be operated under specified conditions.

### *5.1.5 Procedure*

Set the clamps of the testing machine so that the distance between the nips of the clamps along the specimen axis (including any portion in contact with snubbing surfaces) is 500 ± 2 mm. With the help of preliminary specimens, set the machine so that the specimen breaks within 20 +3 seconds but if the machine is constant-rate-of-traverse type, set it at a rate of traverse of 300 ± 15 mm/min. Take the yarn, discard a first few metres of it, and secure its one end in the jaws of one clamp in such a way that the twist does not change. Place the other end in the other clamp, apply the required pre-tension from this free end tore move any slack or kink without appreciable stretching and secure it in the jaws of the clamp.

NOTES

**1** By mutual agreement, the nominal gauge length of 200 ± 1 mm may be used though under these conditions, results for breaking load are likely to be slightly higher than those obtained with a gauge length of 500 mm.

**2** Traditionally the jute trade uses a test length of 610 ± 2 mm for testing of jute yarns.

**3** Traditionally the silk trade uses a test length of 100 ± 2 mm for testing of silk yarns.

**4** In case yarn removed from fabrics is to be tested, a test length of 200-+2 mm shall be used.

**5** Because of the difficulty of securing the same tension in all the filaments and slippage of the specimen in the clamps, erratic results are frequently obtained with zero twist multifilament yarns unless a small amount of twist is inserted before testing. A twist of 120 ± 10 tpm is usually satisfactory. Twist a specimen about 225 mm longer than the gauge length to be tested.

Test the adequately conditioned specimens as described below:

*Option 1: Conditioned*

Test in the standard atmosphere for testing textiles.

*Option 2: Wet*

Test the thoroughly soaked specimens in the normal machine set up or immersed in a tank fitted to the machine. Mount the specimens using a pre-tension of 0.25 ± 0.03 cN/tex. Transfer the wet specimens directly from the water-bath to the testing machine and break the specimens at once, and in any case, within 2 minutes after removing them-from the water-bath.

*Option A: Single-Strand Breaking bad*

Mount the specimen using apre-tension of 0.50 ± 0.05 cN/tex. Operate the machine, carry the test to rupture and record the breaking load and elongation at break. If the specimen slips or breaks in the jaws or breaks within 5 mm from the edge of the jaws, the result shall be discarded and another test specimen taken in lieu thereof.

NOTES

**1** In case of jute yarns where elongation tests are carried out separately, 10 tests for elongation may be sufficient.

**2** Even if a test value is isolated on account of break near the jaw, the value shall be noted but not taken into account in calculations. If such breaks exceed 10 percent of the number of specimens tested, suitable corrective action on the machine should be taken.

**3** Yarns made from blends or combinations of fibres may show elongation beyond the point of maximum load, particularly if one of the components is an elastomeric fibre. When the low elongation components of a yarn are broken, the load falls on the remaining fibres, which continue to elongate until they are broken. Breaking elongation is defined as that corresponding to the maximum load. If elongation continues after the maximum load has been passed, then elongation at rupture may be determined separately.

*Option B: Knot Breaking Load*

Place one end of the specimen in one clamp of the machine, tie a single over hand knot near the middle of the specimen. For aS-twisted yarn (*see* note), a S-knot shall be uses (*see* Fig.4 and 5). Place the other end in the second clamp and tighten the clamp.

NOTE — For plied and cabled yarns, the twist direction refers to the final twist.

Start the machine and observe and record the breaking load. Repeat the procedure until the required number of specimens have been broken.

*Option C: Loop Breaking Load*

Each specimen shall consist of two interlinked looped lengths of yarn taken from one package or end. Secure both ends of one piece in one clamp of the testing machine so that the length of the loop is about one half the gauge length.

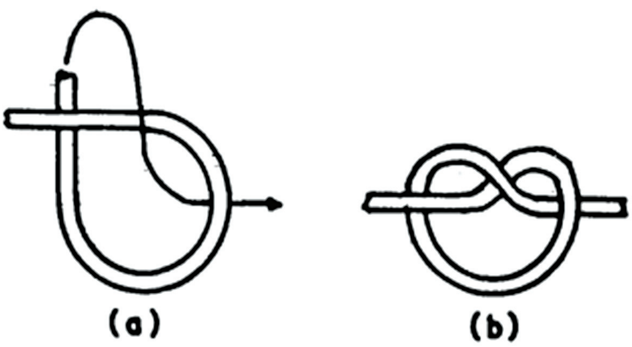



FIG. 4 Z-KNOT IN Z-TWIST YARN

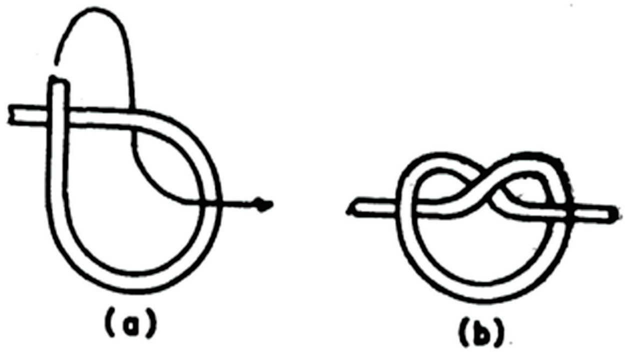



FIG. 5 S-KNOT m S-TWIST YARN

Pass one end of the second piece through the loop formed by the first, place both ends of the second piece in the other clamp of the machine and close the clamp. Start the machine and observe and record the breaking load. Repeat the procedure until the number of specimens have been broken.

### *5.1.6 Calculations*

*Breaking Load*

Calculate the mean breaking load in newtons from all the observed values expressing it to three significant figures. Also calculate the coefficient of variation.

*Elongation (or Extension) at Break (Option A only)*

Calculate the mean elongation at break in percent from all the observed values expressing it to two significant figures. Also calculate the coefficient of variation.

*Tenacity*

Calculate the tenacity by the following formula:

Tenacity in cN/tex or mN/tex

$$= \frac{\text{(Mean breaking load in centinewtons or millinewtons)}}{\text{Mean linear density in tex}}$$

NOTE — The linear density of yarn or cord shall be determined from the same package.

## 5.2 Yarn Strength

**5.2.1 IS 1671 : 1977 Method for determination of yarn strength parameters of yarns spun on cotton system (*first revision*)**prescribes methods for determination of yarn strength parameters of yarns spun on cotton system using cotton count and tex system. In cotton count system, determination of lea breaking load and count strength product (CSP) have been prescribed and in the metric system, determination of skein breaking load, yarn strength index (YSI)and skein breaking tenacity (SBT) have been prescribed.

**5.2.2 Testing Machine** — a skein breaking load testing machine working on constant-rate-of-traverse (CRT) principle. Its rate of traverse shall be 300 ± 15 mm/min and the load range of the machine shall be such that the observed values would lie between 10 and 90 percent of the full scale load. The permissible error in the machine at any point in this range shall not exceed ± 1 percent.

The machine shall be provided with the following arrangements:

a) Two pulleys or hooks for holding the skein with sufficient space to allow the even distribution of threads without much overlapping.

b) Means for adjusting distance between the pulleys or hooks.

c) A scale or dial or autograph recording chart graduated so as to give load in kilograms.

***5.2.3 Procedure***

Prepare skeins of 109.73 m (120 yd), 100 m or 50 m as required. Prepare at least 30 test specimens and condition them.

Bring pulleys or the hooks of the testing machine to the zero position. Take the conditioned skein of yarn and fix it on the pulleys or hooks. Carefully separate the yarn on the pulleys or hooks to avoid the individual strands overlapping each other. Start the machine and carry the test to rupture. Record the skein breaking load in kilograms as indicated on the scale, dial or recording chart.

Determine the mass in grams of the broken skein and calculate the linear density of yarn in cotton count or tex system (as the case may be). Determine the skein breaking load and linear density of yarn of theremaining specimens following the procedure as laid down in.

***5.2.4 Calculations***

Calculate the average breaking load and average linear density of all the observations taken. Calculate the coefficient of variation (CV) of all the breaking load values taken.

***Cotton Count System***

*Count Strength Product (CSP)* — Calculate the count strength product or count strength product corrected to nominal count, correct to awhole number, from the following formulae:

a) $\text{CSP} = L_1 \times N_e$

b) $\text{CSP (Corrected)} = L_{1c} \times N_e^1$

where

$L_1$ = average breaking load, in pounds (kg × 2.2), of the lea;

$N_e$ = average cotton count;

$L_{1c}$ = average breaking load, in pounds (kg × 2.2), corrected to nominal count; and

$N_e^1$= nominal cotton count.

***Tex System***

*Skein Breaking Tenacity (SBT)* —Calculate the tenacity or tenacity of yarn corrected to nominal linear density, correct to one decimal place, by the following formulae:

a) SBT in grams per tex = $\frac{L_2 \times 1000}{t \times 2 \times 50} = \frac{L_2 \times 10}{t}$

b) SBT (Corrected) = $\frac{L_{2C} \times 10}{t^1}$

Where

$L_2$= average breaking load of 50 m skein, in kg;

$t$ = average linear density of yarn, in tex;

$L_{2C}$ = average breaking load of 50 m skein, in kg, corrected to nominal linear density; and

$t^1$ = nominal linear density, in tex.

*Yarn Strength Index* (*YSI*) — Calculate the yarn strength index or yarn strength index corrected to nominal linear density, correct to awhole number by the following formulae:

a) YSI = $\frac{L_3 \times 1\,000}{t}$

b) YSI (Corrected) = $\frac{L_{3C} \times 1000}{t'}$

where

$L_3$ = average breaking load of 100 m skein, in kg;

$t$ = average linear density of yarn, in tex;

$L_{3c}$ = average breaking load of 100 m skein, in kg, corrected to nominal linear density, and

$t1$ = nominal linear density, in tex.

NOTE — It has been found that for a given yarn, the Yarn Strength Index and Count Strength Product are numerically the same for all practical purposes. However, to calculate the yarn strength index of a skein from the count strength product of a lea (or vice versa), the specified, observed or calculated breaking load value of the skein shall be converted into breaking load value of a lea (or vice versa).

## 5.3 Dry & Wet Tenacity and Elongation Man-Made Fibre Filament Yarns

**5.3.1** Tenacity is a term used in textiles to describe the strength of a fiber. It refers to the ability of a fiber to resist breaking or stretching when it is subjected to tension or stress. In other words, it measures the amount of force that is required to break a fiber or filament. Tenacity differs in dry and wet conditions. IS 7703 (Part 2) : 1990Methods of test for man-made fibres continuous filament flat yarn – Part 2 Dry and wet tenacity and elongation (*first revision*) prescribes methods for the determination of dry and wet tenacity and elongation of man-made fibres continuous filament flat yarns.

### *5.3.2 Principle*

Conditioned specimen or the wet specimen is Gripped between the two clamps of the tensile testing machine and a continual increasing load is applied longitudinally by moving one of the clamps until the specimen breaks. Values of elongation corresponding to a predetermined load, maximum breaking strength and elongation at break of the test specimen are noted. Tenacity is calculated by dividing the breaking strength in newton by the linear density in tex and multiplying by 100 and the elongation (percent) by dividing the elongation by the gauge length.

### *5.3.3 Apparatus – Tensile Machine*

A single strand tensile strength testing machine working on one of the following principles shall be used:

a) Constant rate of traverse (CRT)

b) Constant rate of load (CRL), or

c) Constant rate of extension (CRE)

The specimens shall break within 20 s ± 3 sin case of constant rate of load and constant rate of extension machines. In case of constant rate of traverse machine the rate of traverse shall be 300 mm/min ± 15 mm/min, and the load range of the machine shall be such that the observed values would be between 10 percent and 90 percent of the full-scale load. The permissible error in the machine at any point in this range shall not exceed ± 1percent. The machines shall be provided with the following arrangements:

a) Two clamps to grip the specimen, each provided with the following provisions:

   i) Each clamp of the machine shall be of curved type in which the yarn is gripped between the plain-faced jaws and this makes an half turn round a cylindrical extension of one of the jaws before passing on to the other similar clamp. The cylindrical friction surface shall be between 10 to 20 mm in diameter. An outline of the above type of clamp is shown in Fig. 1. The length of specimen between points *A* and *A'* is the test length.

   ii) Each clamps shall be provided with a mechanical or pneumatic device so constructed that through its means a specimen can be secured firmly between the jaws of the clamps so that it does not slip during the test. Also the edge of the surface of each jaw shall be such test it would not cut or damage the specimen during testing.

b) Means for adjusting the distance between the clamps;

c) Means for applying pre-tension of 0.5 cN/tex ± 0.1 cN/tex to the specimen when clamped (tension device may be a dead weight, a spring or an air-actuated mechanism).

d) A scale and dial or autographic chart recorder graduated so as to give load and elongation at predetermined load and at break.

### *5.3.4 Test on Conditioned Specimens for Dry Tenacity and Elongation.*

Set the clamps of the testing machine so that the distance between the clamps is 250 ± 2 mm or 500 ± 2 mm or as agreed to between the buyer and the seller. With the help of preliminary specimens, set the machine so that the specimen breaks within 20 ± 2 seconds in the case of constant rate of loading or constant rate of extension type machine. In the case of constant rate-of-traverse type machine, set the rate of traverse at 300 ± 15 mm/min. Take the yarn from the conditioned sample and discard a first few metres of yarn. Fix one end in the jaws of one clamp in such a way that the twist does not change. Apply the required pre-tension from the free end and secure it in the jaws of the other clamp.

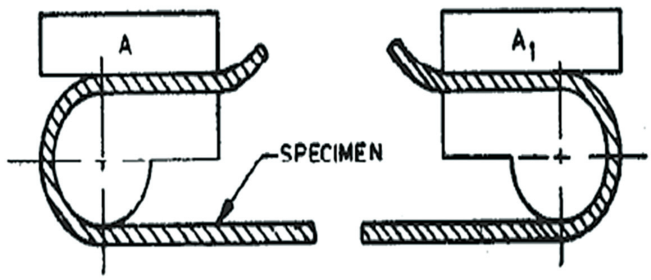



*Fig. 1 Schematic Diagram Of Gripping Clamps*

Operate the machine and carry the test to rupture and record the breaking strength, elongation at predetermined or maximum load as required and elongation at break from the load elongation curve of the autographic chart recorder provided.

> NOTE — Even if a test value is isolated on account of a break near the jaw, the value shall be noted but not taken into account in calculations. If such breaks exceed 10 percent of the number of specimens tested, suitable corrective action should be taken on the machine.

Open both the clamps and remove the broken specimen. Test another test specimen in a similar manner discarding at random several metres of yarn between two successive tests. Perform minimum 10 tests or as agreed to between the buyer and the seller.

### *5.3.5 Test on wet Specimens for wet tenacity and elongation*

Take the required number of test specimenseither 20 or as agreed to between the buyer and theseller and immerse them in distilled water (*see* IS1070) for at least 2 minutes in case of regenerated cellulose rayon and 10 minutes for acetate rayon.

NOTES

**1** The period of immersion should be sufficient to wet out the specimens thoroughly. Longer periods of immersion would not register further loss of strength if wetting is sufficient. Specimens treated with water-repellent or water-resistant finishes may have to be immersed for prolonged period. For yarns which do not wet out readily with water, a penetrating agent such as neutral soap or a non-ionic wetting agent may be added to the water bath, the amount of the agent used being such as not to exceed that required to obtain maximum rate of wetting out and as not to affect the normal physical properties of the yarn.

2 If the number of specimens cling together in the water bath, they should be separated by gently raising and lowering them in water so as to permit a single strand to be drawn out without strain.

### *5.3.6 Calculations*

*Tenacity*

Calculate the mean dry or wet breaking strength in newtons from all the observed values and calculate the tenacity as follows:

$$\text{Tenacityin cN/tex} = \frac{\textit{Mean breaking strength in newton x 100}}{\textit{Mean linear density in tex}}$$

NOTE — The linear density of yarn shall be determined from the same package.

*Elongation*

Calculate the mean elongation at predetermined load as required and also at break in percent from all the observed values.

# CHAPTER VII

# YARN UNEVENNESS

# CHAPTER VII

## 6 YARN UNEVENNESS

**6.1.1** Unevenness is a measure of variation in weight per unit length of the yarn or the variation in thickness of the yarn. yarn evenness is one important characteristic that is used to quantify the quality of the final product. High-quality yarn requires an arrangement of fibers in which the number of fibers in each transverse section (longitudinal variation) is approximately the same.

**6.1.2 IS 16576 : 2022/ISO 16549:2021 Textiles - Unevenness of textile strands - Capacitance method (*first revision*)** describes a method, using capacitance measuring equipment, for determining the unevenness of linear density along the length of textile strands. The method is applicable to tops, slivers, rovings, spun yarns and continuous filament yarns, made from either natural or man-made fibres, in the range of 4 tex (g/km) to 80 ktex (kg/km) for staple-fibre strands and 1 tex(g/km) to 600 tex (g/km) for continuous-filament yarns. It is not applicable to fancy yarns or to strands composed fully or partly of conductive materials such as metals; the latter requires an optical sensor, and to raw silk filaments which are tested according to a specific standard. The method describes the preparation of a variance-length curve, as well as the determination of periodicities of linear density. It also covers the counting of imperfections in the yarn, namely of neps and of thick and thin places.

***6.1.3 Principle***

A specimen is passed between two plates of a capacitor causing changes in capacitance which are proportional to the changes of mass of the specimen. The instrument evaluates these changes and reports them as coefficient-of-variation unevenness, $CV_u$, or mean-deviation unevenness, $U_u$.

The fibre dielectric constant is also a factor determining the capacitance change. As long as the dielectric constant is unchanging (non-blended strands or perfectly uniform blending), the dielectric constant has no influence on the unevenness reading, which depends solely on the variation of mass. If the dielectric constant differs for the types of fibres in a blend and if, at the same time, the blend is irregular, then the reading of unevenness is increased above its true value. The interpretation of results therefore requires caution.

Irregularities in the distribution of additives such as sizes, in moisture content and in fibre blending can increase the measured unevenness above its true value. Several studies have been conducted over the years comparing the true unevenness of a specimen, determined by cutting and weighing, with the reading from an unevenness tester. Good agreement was obtained, so the readings from the tester can be taken as being the true unevenness value. The value of unevenness has meaning only if both $L_w$ and $L_b$ are known and they should, inprinciple, always be reported, preferably as $CV_u$ ($L_b$, $L_w$).

*Example* $CV_u$ (10 mm, 1 000 m).

In practice, these two values are usually left unstated and are assumed to be those of the most commonly used unevenness tester, namely:

— $L_b$: 8 mm for yarns, 12 mm for rovings, 20 mm for slivers and tops;

— $L_w$: total length of the test specimen (50 m for tops and slivers, 100 m for rovings, 400 m for yarns).

There are two possible expressions for unevenness, $CV_u$ and $U_u$. The $U_u$ is now obsolete and its use, while permitted, is discouraged. $CV_u$ is the preferred expression.

If mass is distributed near to "normal" ("Gaussian"), then the ratio of $CV_u/U_u$is approximately 1,25.This conversion factor should be used cautiously because, in case of departures from normality, the ratio can be considerably different. The conversion factor may be used to convert a table of quality levels from $U_u$ to $CV_u$.

When $CV_u$ is plotted against $L_b$, a "variance-length curve" is obtained which gives additional information on the material's unevenness. When the plot is made on log-log paper, then the curve is almost a straight line and its slope gives information on the relationship between short-term and long term unevenness.

Unevenness testers usually contain a spectrogram unit, which analyses the data and provides information on periodic variations of linear density. This information is useful in finding faults in the processing. The analysis uses an algorithm based on the Fourier transformation.

Unevenness testers usually contain a counter for yarn imperfections, namely neps, and thick andthin places. The level beyond which the imperfections are counted can be adjusted. Additional information on alternative methods is given at the end.

Unevenness is a fundamental feature of yarn construction. It influences the efficiency of processing as well as fabric appearance. Lower unevenness generally results in a better-looking fabric, but the relation is not simple, and interpretation requires special care.

### *6.1.4 Apparatus*

Different types of apparatus are in use for measuring strands made of staple fibres and filament yarns. The apparatus consists of the following elements:

a) measuring device, featuring:

- a condenser assembly suitable for strands of varying linear density;
- yarn guiding and pre tensioning devices;
- an adjustable-speed motor to advance the strand;

b) signal processing unit, which:

- computes and indicates the values of $CV_u$ or $U_u$ and may also calculate the variance-length curve and present a graph of the periodic variations of linear density;
- also counts the number of imperfections in most instruments. The unit shall be able to operate atthe threshold level of +50 %, above which thick places are counted, and the level of -50 %, below which thin places are counted;

— reports a reading for neps which shall be a product of the length, expressed in millimetres, of the nep and the percent excess over the average linear density of the yarn (for example, 4 mm·50 %).Levels of +200 % and +280 %, above which neps are counted, shall be available;

— other levels (for the three imperfection types) are also usually available;

c) printer (optional), which provides a plot of the linear density of the strand;

d) twisting device for testing untwisted or low-twist filament yarns.

This device produces false twist in an untwisted or low-twist filament yarn, so that the yarn presents a nearly round cross-section as it passes through the condenser. The direction of the imparted false twist must be the same as that of any twist present in the yarn. The twisting device need not be used for the testing of mono filaments. If the yarn passes through the condenser assembly in a flat mode, there is the danger of adding variation depending on the way the flat yarn is presented. Also, the application of too high twist can lead to a higher variation. Twist should be chosen such way that the variation of mass shows the lowest possible value.

To calibrate, use the procedure built into the instrument if possible. Alternatively, use a standard (usually tape) of known unevenness provided by the instrument manufacturer and follow the manufacturer's instructions. Finally, if the manufacturer's standard is not available, an in-house material lof known and preferably low unevenness may be used.

### 6.1.5 Procedure

*Setting of the apparatus*

If the tester allows a choice between a "normal" and an "inert" test, perform the "normal" test and then the "inert" if desired to establish the variance-length curve. The "normal" choice for some testers will result in the performance of both the "normal" and the "inert" tests automatically, so the setting can be to "normal".

*Setting of the diagram scale*

The following diagram scale settings are recommended for most cases:

— tops and slivers: ±25 %;

— rovings: ±50 %;

— glass-fibrerovings: ±100 %;

— staple-fibre yarns: ±100 %;

— filament yarns: ±10 % or 12,5 %.

*Condenser assembly*

In case the apparatus is equipped with an arrangement of several condensers, the measuring ranges of the neighbouring slots overlap to some extent, so that certain specimens can be tested in two slots, and the results may differ. Follow the instrument manufacturer's recommendation as to selection of slot for strands of a particular linear density.

In case the apparatus is equipped with only one special-shaped condenser for single yarn-testing, the condenser is automatically positioned, depending on the linear density of the yarn to be tested.

*Selection of running speed*

The following speeds are recommended. Other speeds may be used by agreement and shall then be stated in the test report. For most cases:

- tops and slivers: 25 m/min;
- rovings: 50 m/min;
- yarns: 400 m/min.

*Guiding facilities*

Before starting the test, adjust the guiding and tensioning devices to provide a pretension which doesnot extend or otherwise distort the material. The specimen must pass through the condenser withoutfluttering which would produce an error of measurement.

*Twisting device*

Thread low-twist or untwisted filament yarns through the twisting device. Plot representing the linear density along the strand Switch on the drive of the plotter, if used. Only a short length of the plot is needed.

*Preliminary run*

Old instruments may not stabilize their electronic measuring system automatically. In such cases, a preliminary run is recommended of approximately 20 % of the prescribed length.

*Test run*

Set the feed in motion and observe that the passage through the condenser is smooth and undisturbed. Run the test until the indicated $CV_u$ or $U_u$ value is stable, or for a specified time or length of strand, as mutually agreed.

### *6.1.6 Calculations and Expression of Results*

If several packages were tested with one reading for each package, calculate the average $CV_u$ or $U_u$ value and, if required, the coefficient of variation of the individual values and the 95 % confidence limits. Round all results to the nearest 0.1 %.

If desired, determine the variance-length curve. If the instrument does not give the $CV_u$ for long lengths, determine an additional $CV_u$ for long-term unevenness by cutting and weighing, usually 100-msegments of yarn.

Express the incidence of imperfections as the number per kilometre. Express the incidence of thick places as the number for which the linear density exceeds the average linear density of the yarn by at least 50 %. Counts at threshold levels other than +50 %, if used, shall also be reported.

Express the incidence of thin places as the number for which the linear density is less than 50 %of the average linear density of the yarn. Counts at threshold levels other than -50 %, if used, shall also be reported.

Express the incidence of neps as the number which exceeds a reading of +200 %.Counts at a threshold reading of other than +200 %, if used, shall also be reported.

> NOTE - A reading of +200 % is normally used for ring yarns and +280 % for open-end yarns.

***6.1.7 Other methods for the determination of unevenness***

There are three methods for evaluating unevenness:

a) visual assessment;

b) measuring devices which determine the variation of the mass of the material or other characteristics proportional to mass. Capacitance-type testers are covered in the body of this document.

c) measuring devices which determine the variation of the diameter of the material or other characteristics proportional to diameter.

***6.2 Unevenness in Man-Made Fibre Filament Yarns***

**6.2.1 IS 7703 (Part 5) : 1987 Methods of test for continuous filament polyester and polyamide flat yarn – Part 5 Unevenness percentage** prescribes a method of test for determination of short-term variations in mass per unit length (unevenness percentage) of continuous filament polyester and polyamide flat yarn.

**6.2.2** This method covers the indirect measurement of unevenness of the flat yarn by means of continuous runs on a suitable Uster unevenness testing instrument. The direct procedure for measuring unevenness by cutting and weighing short lengths of a flat yarn is not covered by this standard. Low twist filament yarns should be tested after the yarn is pre twisted while testing.

***6.2.3 Principle and Limitations***

A yarn is passed through the sensing device of an Uster unevenness tester at constant speed and a momentary value proportional to the linear density of the yarn is recorded. The Uster instruments are equipped with an integrator that calculates the unevenness automatically and the value is read while the yarn is passing through the instrument after 400 m of yarn have been tested.

The variation of one specific property, linear density, is termed unevenness. The method is concerned with measuring the unevenness of flat yarn. Unevenness is always expressed as between successive lengths and over a total length. When the length between which unevenness is measured ($L_{-b}$) is very short (8 mm of yarn), then reference is often made to short-term unevenness.

Unevenness can be measured by direct method or indirect methods. The direct method consists of cutting and weighing yarn segment of length $L_b$ and is the reference method of determining unevenness. Unevenness testing instruments, as covered in this standard, use the indirect method where unevenness is determined by the measurement of yarn properties closely related to and dependent on linear density. The accuracy of the indirect method and of an instrument utilizing it can be judged by a comparison of the value of unevenness it gives with one obtained by the direct method of cutting and weighing.

The Uster unevenness testing instruments measure those properties of the yarn which change the capacitance when the yarn passes between the plates of a capacity or. A number of mathematical concepts are used to express the unevenness of yarn. They are all based on the coefficient of variation or its square. There is, therefore, some advantage in using an unevenness testing instrument that gives the coefficient of variation and thereby fits into the general mathematical scheme.

**6.2.4 Capacitance-Type Unevenness Testing Instrument**— A suitable Uster unevenness tester using automatic integrator or any other suitable instrument which can satisfy the requirements The instrument shall have the following accessories provided.

*Package Holders, Guides, Tension Devices and Take-up Mechanism*— Which allow for or assist in, uniform delivery of the yarn at the specified speed without undue acceleration or deceleration and at a reasonably constant tension.

*Recorder*— To give a permanent chart record of the test details and to depict the unevenness. It is a means to record all unevenness.

Pre-twisting with constant tension material feeding facilities for low-twist filament yarns to impart false-twist into low-twist filament yarn, while it passes between the sensing elements at a uniform tension, may be necessary.

***6.2.5 Procedure***

Calibrate the unevenness testing instrument as prescribed by the instrument manufacturer,

NOTE — Do not separate the length of yarn to be tested from the packages prior to testing.

Mount the package on a suitable holder, Thread the free end of the yarn through the sensing elements of the tester and through the take-up mechanism. If a low twist yarn is to be tested, pass it through a device imparting false twist.

Set the take-up mechanism to yarn speed of 100 m/min or to speed of travel as agreed to between the buyer and the seller. If a recorder is used, set the yarn to chart speed 10 cm/min with test time limited to four minutes. Adjust the controls of the tester to record on the central part of the recorder chart or on the central part of the instrument meter or both.

Turn on the integrator. Test a total yarn length of at least 400 m in one uninterrupted run, unless otherwise agreed .upon by the purchaser and the seller. Record the meter unevenness value. Follow the unevenness tester instruction manual for operational procedures not outlined in this method.

### *6.2.6 Calculations*

The CV percentage and U percentage can be estimated from the chart by converting the line of the record into a frequency distribution. U percentage can also be estimated by the use of a planimeter. Normally, however, CV percentage or U percentage will be read from the integrator.

If more than one value of CV percentage or U percentage is obtained for individual packages, then calculate arithmetic mean of values of unevenness for each package.

Calculate the average of CV percentage or U percentage for all packages. If required, calculate the coefficient of variation or the standard deviation (or both) of the CV percentage or U percentage values obtained for each package.

# CHAPTER VII

# SHRINKAGE IN YARN

# CHAPTER VII

## 7 SHRINKAGE IN YARN

### 7.1 Hot Air Shrinkage

**7.1.1** Manmade thermoplastic filament yarns can be shortened by various influencing factors during processing and use. Usually heating, wetting, or wet-heating process that leads to shrinkage. Depending upon raw material, a filaments reacts more strongly to heat, moisture or moist heat. The dimensional stability of manmade thermoplastic filament yarns is decided by the residual shrinkage present in the yarn. The residual shrinkage is measured by either boiling water method or hot air method. Shrinkage is an important property because it determines the fabric behavior during end use. **IS 17088 : 2019 Textiles - Synthetic filament yarns - Determination of shrinkage in dry-hot air (After treatment)** covers the general method of skein preparation, method of test for determining shrinkage in hot air.

***7.1.2 Testing Procedure***

***7.1.2.1 Skein Method A (Manual Measurement)***

Measuring the Initial Length of the Test Specimens - Hang one conditioned skein from the hook at the top of the length-measuring stand, with the knot placed at the hook. Carefully add sufficient weight on the bottom of the skein, to produce the tension calculated. This tension shall be reached slowly to prevent any over tensioning. Maintain the tension for (30 ± 3) s and measure the straightened length ($L_0$) to an accuracy of 1 mm. Remove weight and skein after measurement. Take the skein and suspend it from a holder in the oven. Repeat above procedures in sequence, till all skeins have been tested.

Thermal Treatment of the Test Specimens - Preheat the oven to the specified temperature and keep temperature steady. Place the holder into the oven quickly (within 5 s or less), to minimize the temperature decrease in the oven. When the oven reaches the specified temperature, begin measuring treatment time.

Equilibrium after Thermal Treatment - After treatment, carefully take out the holder with skeins. Condition the skeins in loose and tension-free state.

Measuring the Length of the Test Specimens after Treatment - Follow procedures measure the straightened length (Ls) to an accuracy of 1 mm.

***7.1.2.2 Skein Method B (Automatic Measurement)***

Measuring the Initial Length of the Test Specimens - Hang the conditioned skeins sequentially from the hook at the top of the specimen holder, with knots placed at the hook. Apply a 2.5 cN load to the bottom of each skein to avoid entanglement and hold skein downwards. Place the specimen holder into the automatic shrinkage tester and set tension. After automatically applying and maintaining the tension for (30 ± 3) s, measure the straightened length ($L_0$) of a skein to an accuracy of 0.1 mm.

Repeat auto-loading and auto-measuring procedure in sequence, until all skeins in the specimen holder have been tested.

Thermal Treatment of the Test Specimens - Following the procedures, place the specimen holder with a 2.5 cN load applied to each skein into the oven and conduct thermal treatment.

Equilibrium after Thermal Treatment - Condition the skeins on the specimen holder with a 2.5 cN load applied to each skein.

Measuring the Length of the Test Specimens after Treatment - Place the specimen holder into the tester and measure the straightened length (Ls ) of each skein to an accuracy of 0.1 mm.

***7.1.2.3 Single-end Method***

Measuring the Initial Length of the Test Specimens - Hang the conditioned single yarn sequentially from the clamp at the top of the length-measuring stand. Carefully add sufficient weight on the bottom of the yarn, to produce the tension. This tension shall be reached slowly to prevent any over-tensioning. Maintain the tension for (30 ± 3) s.

Mark yarn at the zero index and at the 50 cm index of the scale. Measure the distance between the two marks to get the straightened length ($L_0$) to an accuracy of 1 mm. Remove weight and single yarn after measurement. Suspend the single yarn from the holder, with the middle part placed at the hook. Repeat loading and measuring procedure in sequence, until all the single yarns have been tested.

Thermal Treatment of the Test Specimens - Follow the procedures to conduct thermal treatment.

Equilibrium after Thermal Treatment - Follow the procedures to condition the treated skeins.

Measuring the Length of the Test Specimens after Treatment - Measure the distance between the two marks made before thermal treatment, which is the straightened length (Ls), to an accuracy of 1 mm.

***7.1.3 Calculations***

The shrinkage in dry-hot air (HAS) is calculated according to formula

$$\text{HAS} = \frac{L_0 - L_s \times 100}{L_0}$$

Where, HAS= is the shrinkage in dry-hot air, in percent;

$L_0$ = is the length of the test specimen before treatment, in mm; and

*Ls* = is the length of the test specimen after treatment, in mm.

The result is expressed as an arithmetic mean value of all the test specimens, accurate to the first decimal place.

## 7.2 Shrinkage in Boiling Water

**7.2.1** Manmade thermoplastic filament yarns can be shortened by various influencing factors during processing and use. Usually heating, wetting, or wet-heating process that leads to shrinkage. Depending upon raw material, a filaments reacts more strongly to heat, moisture or moist heat. The dimensional stability of manmade thermoplastic filament yarns is decided by the residual shrinkage present in the yarn. The residual shrinkage is measured by either boiling water method or hot air method. Shrinkage is an important property because it determines the fabric behavior during end use. **IS 17087 : 2019 Textiles - Manmade filament yarns - Determination of shrinkage in boiling water** covers the general method of skein preparation, method of test for determining shrinkage in hot water.

### *7.2.2 Measuring the Initial Length of the Test Specimens*

Hang the skeins sequentially on the specimen holder of automatic shrinkage tester, while knots placed at the hook. Attach a tension load of 2.5 cN to the bottom of each skein so as to avoid entanglement and keep skein vertically downwards.

Place the holder into the automatic shrinkage tester and set the tension according to formula 2. After automatically applying and maintaining the tension for (10 ± 1) s, auto-measure the straightened length L0 of a skein, to an accuracy of 0.1 mm.

$F = P \times T_t$

Where, F = tension, in cN;

P = tension per unit linear density, in cN/dtex; — non-textured yarns, (0.05 ± 0.005) cN/dtex, — textured yarns, (0.20 ± 0.02) cN/dtex.

$T_t$ = set linear density of the skein, in dtex.

Repeat auto-loading and auto-measuring procedures in sequence, until all skeins in the specimen holder have been tested.

### *7.2.3 Boiling and Drying Treatment*

Fill the container with reagent. The quantity of reagent shall be sufficient to make the specimen holder completely immersed. Place the specimen holder with the specimens and tensioning weights into the boiling water container preheated to the required temperature. Maintain it vertically, immerse it completely in water and keep it there for (30 ± 5) min. After treatment, take the specimen holder out carefully and let the water drip away for 10 min. Then place the specimen holder into the oven at a temperature of (80 ± 3)°C for 10 min. If the specimens are not completely dry, extend the drying time accordingly. Afterwards, expose the specimens in standard atmosphere to reach moisture equilibrium. Alternatively, the specimens may be just exposed in standard atmosphere, without oven-drying, to reach moisture equilibrium.

NOTE — Since the boiling point of water depends on the air pressure, the shrinkage in boiling water would change subject to air pressure.

**7.2.4** Measuring the Length of the Test Specimens after Treatment

Place the specimen holder into the automatic shrinkage tester and measure the straightened length $L_1$ of each skein to an accuracy of 0.1 mm.

### *7.2.5 Calculation*

The shrinkage in boiling water is calculated according to the following formula and shall be accurate to the first decimal place.

$$BWS = \frac{L_0 - L_1 \times 100}{L_0}$$

Where, *BWS* = shrinkage in boiling water, in percentage;

$L_0$ = length before treatment, in mm; and

$L_1$= length after treatment, in mm.

# CHAPTER VIII
# COMMERCIAL MASS

# CHAPTER VIII

## 8 COMMERCIAL MASS

### 8.1 Commercial Mass of Consignments

**8.1.1** The commercial mass of a textile material in a consignment calculated from its oven-dry weight by adding to it the proportionate commercial moisture regain. **IS/ISO 6741-1 : 1989/ISO 6741-1 : 1989 Textiles - Fibres and yarns - Determination of commercial mass of consignments Part 1 Mass determination and calculations** specifies methods for the determination of the commercial mass of homogeneous consignments of those textile fibres and yarns composed of a single generic species listed in part 4. The methods specified in this part of IS0 6741 do not apply to beamed yarns, to coated yarns, to fibres and yarns put up for retail sale or to fibre blends.

***8.1.2 Principle***

The commercial mass of a consignment is the calculated mass that a consignment of textile material would have if either the mass corresponding to the commercial moisture regain was added to the dried mass of the material or the mass corresponding to the commercial allowance was added to the extracted and dried mass of the material. The following operations are necessary to determine commercial mass:

a) take a representative consignment sample;

b) either determine the net mass of the consignment or determine the net and invoice masses of each container in this consignment sample;

c) assemble laboratory sample containers from the contents of each sample

d) weigh and, if necessary, sub-divide each laboratory sample;

e) clean each laboratory sample by washing, extraction with an organic solvent or ;

f) dry each laboratory sample;

g) determine the clean dry mass (or the dry mass) of each laboratory sample;

h) calculate the commercial mass of the consignment. In some circumstances, operation c) precedes operation b); operation e) may sometimes be omitted. When the commercial mass of a consignment is determined by drying without cleaning, the commercial mass is to be adjusted to a specified extractible content.

### 8.2 Commercial Mass of Man-Made Fibre Filament Yarns

**8.2.1 IS 7703 (Part 3) : 1991 Methods of test for man-made fibre continuous filament flat yarn – Part 3 Commercial mass (*first revision*)** prescribes method for determination of commercial mass of consignments of individual man-made fibre continuous filament flat yarns.

***8.2.2 Principle***

The net mass of the conditioned yarn at equilibrium with the standard atmosphere for testing may be taken as the commercial mass if agreed to between the buyer and the seller. Alternatively, the commercial mass may be obtained by adding a mass corresponding to the commercial (standard) moisture regain to the oven-dry mass of the consignment.

### *8.2.3 Procedure*

Remove top few layers from each selected sample package and make two skeins of 100 m each and determine the net mass of each at the prevailing atmospheric conditions to an accuracy of 1 mg. Determine the average net mass of the skeins ($M_n$).

Place the skeins in the ventilated drying oven maintained at 105 ± 3°C and fed with air from the standard atmosphere. Continue drying until constant mass is attained. The mass shall be taken as constant when the difference between any two successive weighings made at intervals of 20 minutes does not exceed 0.1 percent.

Determine the mass of each skein sample without removing it from the oven, with the airflow stopped. In case the drying oven is not provided with a weighing balance, remove the test sample from the oven and transfer it into aweighing container of known mass and close the lid tightly. The transfer of the skein shall be done in as quickly as possible. Cool the skein and the container in a desiccator to room temperature before weighing. Determine the mass of each skein and the container and then deduct from this the tare of the container to find out the oven-dry mass of each skein. All weighings shall be correct to 1 mg. Determine the average oven dry mass of the skeins ($M_o$).

Determine the net mass of yarn of each sample container (box) ($M_c$), correct to 1 g, by deducting the mass of the packing material and the corresponding mass of supports of packages and tare of the container from the total mass. The total mass of the sample container represents the mass of the supports of packages, packing material, the yarn and the container in which the packages are packed.

### *8.2.4 Calculations*

Calculate the commercial mass in kilograms of each selected container by the following formula:

Commercial mass of the material selected container $= \frac{100 + R}{100} \times \frac{M_o}{M_n} \times M_c$

Where,

$R$ = commercial moisture regain percent,

$M_o$ = average oven-dry mass of the yam skeins,

$M_n$ = average net mass of the yam skeins, and

$M_c$ = net mass of the material of the selected container (box).

NOTE — Unless otherwise agreed to between the buyer and the seller, commercial moisture regain values for various man-made fibres as given below may be used:

| Sl No. | Material | Commercial Moisture Regain, percent |
|---|---|---|
| (1) | (2) | (3) |
| i) | Polyester | 0.4 |
| ii) | Polyamide | 4.5 |
| iii) | Rayon | 11.0 |
| iv) | Acetate | 6.5 |
| v) | Acrylic | 1.5 |
| vi) | Olefins | Zero |
| vii) | Triacetate (primary) | 3.5 |
| viii) | Glass | Zero |
| ix) | Modacrylic:<br>Class 1<br>Class 2<br>Class 3 | <br>0.4<br>2.0<br>3.0 |

Determine the commercial mass of the consignment by the following formula:

Commercial mass of the consignment =

$$\text{Net Mass of contignment}^{X} \quad \frac{\textit{Commercial mass of the material of the selected container}}{\textit{Net Mass of material of the selected container}}$$

# CHAPTER IX

# YARN APPEARANCE AND DEFECTS

# CHAPTER IX

## 9 YARN APPEARANCE AND DEFECTS

### 9.1 Glossary of Defects

**IS 11265 : 1985 Glossary of terms pertaining to defects in yarns made from natural fibres** prescribes definitions of terms pertaining to defects in yarns. This standard clarifies various types of defects in spun yarns made from natural fibres or their blends. It is based on the prevalent practices and interpretations in the textile industry and trade.

### 9.2 Grading of Yarn Appearance

**9.2.1 IS 13260 : 1993 Method of grading for appearance of cotton yarn using photographic standards** prescribes a method of grading for appearance of single cotton yarn, carded or combed, with the use of BIS Photographic Cotton Yarn Appearance Standards (SP 54). A set of BIS Photographic Cotton Yarn Appearance Standards consists of five series, covering five ranges of yarn counts. Each series has four photographs representing grades, A, B, C and D. Grade A is the highest and others are progressively lower. The range of counts covered by each series.

***9.2.2 Description of Yarn Grades***

*Grade A Yarn*

Grade A yarn may have no large neps which are over three times the normal diameter of the yarn and very few small ones. Grade A yarn should have good centimetre-to centimetre uniformity and good cover without excessive fuzziness. No leaf nor other foreign matter may be present in Grade A yarn.

*Grade B Yarn*

Grade B yarn may have no large neps, but may have a few small ones. Grade B yarn may have no more than three small pieces of foreign matter per board or specimen provided they do not form slubs. Grade B yarn may be slightly more irregular and may have slightly more fuzz' than a Grade A yarn.

*Grade C Yarn*

Grade C yarn may have more neps, and larger ones as well as more fuzziness and a greater amount of foreign matter than Grade B yarn. The contrast between the thick and thin places and the normal diameter of the yarn may be greater than in Grade B yarn resulting in an overall rougher appearance.

*Grade D Yarn*

Grade D yarn may have some slubs that are more than three times the average diameter of the yarn. Grade D yarn may have more neps, neps of a larger size, more thick and thin places, more fuzz and more foreign matter than Grade C yarn. When slubs or large neps are present, Grade D yarn may have fewer neps than Grade C yarn. Grade D yarn may have an overall rougher appearance than Grade C yarn.

*Yarn Below Grade D*

Yarn below Grade D may have more defects and an overall rougher appearance than Grade D yarn.

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