INTERNATIONAL

**Designation: D 3937 – ~~94~~01**

# Standard Test Method for Crimp Frequency of ~~Man-Made~~ manufactured Staple Fibers[1]

This standard is issued under the fixed designation D 3937; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This test method covers the determination of the crimp frequency of ~~man-made~~ manufactured staple fibers. This test method is applicable to all crimped provided the crimp can be viewed two-dimensionally as a sine-wave configuration. ~~NOTE 1—For determination of crimp in wool, refer to Test Method D 2491.~~

1.1.1 It should be recognized that yarn manufacturing processes or treatments to manufactured yarns can influence or modify crimp in fiber. Hence, the value for crimp of fibers taken from spun yarns may be different than that of the same fiber prior to the manufacturing or treatment processes.

1.2 Three options are provided for preparation of the specimens. Option One (preferred) uses single fibers for the specimens with a low magnification available, Option Two (optional for staple or tow samples) uses fiber chips as the specimens, and Option Three uses projected images of single fibers.

1.3 The values stated in SI units are to be regarded as the standard. The inch-pound units in parentheses are for information only.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

2.1 *ASTM Standards:*

[1] This test method is under the jurisdiction of ASTM Committee D~~-~~13 on Textiles and is the direct responsibility of Subcommittee D13.5~~7~~8 on Yarn and Fiber Test ~~Methods, General.~~ Methods.

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D 123 Terminology Relating to Textiles[2]
D 1776 Practice for Conditioning ~~Textiles for~~ and Testing Textiles[2]
D 2258 Practice for Sampling Yarn for Testing[2]
D 3333 Practice for Sampling ~~Man-Made~~ manufactured Staple Fibers, Sliver, or Tow for Testing[3]

## 3. Terminology

3.1 *Definitions:*

3.1.1 *crimp*, *n—in a textile strand*, the undulations, waviness, or succession of bends, curls, or waves in the strand induced either naturally, mechanically, or chemically.

3.1.1.1 *Discussion*—Crimp has many characteristics, among which are its amplitude, frequency, index, and type. In this test method, crimp is characterized by a change in the directional rotation of a line tangent to the fiber as the point of tangent progresses along the fiber. Two changes in rotation constitute one unit of crimp.

3.1.2 *crimp frequency*, *n*— ~~*in man-made*~~*in manufactured staple fibers*, the number of crimps or waves per unit length of extended or straightened fiber.

3.1.3 *crimp index*, *n*—an indirect measure of the amplitude of crimp.

3.1.3.1 *Discussion*—Crimp index is calculated as the difference in the distance between two points on the fiber as it lies in an unstretched condition in one plane and the distance between the same two points when the fiber is straightened under a specified tension expressed as a percentage of the unstretched distance. To improve reproducibility, the unstretched distance may be measured under a specified, very low tension to align the fiber in one plane.

3.1.4 *fiber chip*, *n—in ~~man-made~~ manufactured textiles*, staple fibers that are massed together as a unit and that maintain a single geometry or alignment.

3.1.5 For definitions of other textile terms used in this test method, refer to Terminology D 123.

## 4. Summary of Test Method

4.1 For Option One, a fiber specimen of ~~man-made~~ manufactured staple is placed on a short pile or plush surface. The crimps along the entire length of the specimen is counted. After the specimen is counted, the fiber is straightened without deformation and its uncrimped length measured. Crimp frequency is reported as the number of crimps per unit of extended length.

4.2 For Option Two, the number of crimps is counted in fiber chip specimens. The specimen length is measured on fibers taken from each of the chips.

4.3 For Option Three, the fiber specimen is mounted between microscope slides. The image of the specimen is projected and its crimp is counted. The extended length of the specimen is measured as in Option One.

4.4 In each option, the crimp frequency is calculated from the numbers of crimp counted and the fiber lengths measured.

## 5. Significance and Use

5.1 Test Method D 3937 for the determination of crimp frequency of ~~man-made~~ manufactured staple fibers may be used for the acceptance testing of commercial shipments but caution is advised since between-laboratory precision is known to be poor. Comparative tests conducted as directed in 5.1.1 may be advisable.

~~5.1.1 In case of a dispute arising from~~

5.1.1 If there are differences or practical significance between reported test results ~~when using Test Method D 3937~~ for ~~acceptance testing of commercial shipments, the purchaser and the supplier should conduct~~ two laboratories (or more), comparative tests should be performed to determine if there is a statistical bias between ~~their laboratories. Competent~~ them, using competent statistical ~~assistance is recommended for the investigation of bias.~~ assistance. As a minimum, ~~the two parties should take a group of~~ test ~~specimens which~~ samples that are as homogeneous as ~~possible and which are~~ possible, drawn from ~~a lot of~~ the material ~~of~~ from which the ~~type in question. The~~ disparate test ~~specimens should then be~~ results were obtained, and randomly assigned in equal numbers to each laboratory for testing. The ~~average~~ test results from the two laboratories should be compared using ~~Students's *t*-test and an acceptable~~ a statistical test for unpaired data, at a probability level chosen ~~by the two parties before the~~ prior to testing ~~began.~~ series. If a bias is found, either its cause must be found and corrected, or ~~the purchaser and the supplier must agree to interpret~~ future test results ~~with~~ for that material must be adjusted in consideration ~~to~~ of the known bias.

5.2 This test method is used for quality control. It is an unsophisticated procedure which is particularly useful in detecting major differences in crimp frequency. This test method is not considered to be useful in research and development where minor differences or more complete crimp characterization, including amplitude and index, may be necessary.

5.3 Crimp in fiber affects the carding and subsequent processing of the fiber into either a yarn or a nonwoven fabric.

5.4 Staple crimp in fiber will also affect the bulk or openness of a yarn and therefore the hand and visual appearance of the finished textile product.

## 6. Apparatus

6.1 *Short Pile or Plush Surface*, of a color contrasting with color of fibers under investigation.

[2] *Annual Book of ASTM Standards*, Vol 07.01.
[3] *Annual Book of ASTM Standards*, Vol 07.02.

6.2 *Magnifier*, with no greater than 10× magnification, optional for counting crimp of fibers of low linear density in Option One or in measuring lengths.

6.3 *For Option Three*:

6.3.1 *Projector*, capable of a magnification of 10×.

6.3.2 *Microscope Slides*, 25 by 75 mm (1 by 3 in.).

6.4 *Specimen Board*, covered with a short pile or plush.

6.5 *Tweezers*, two pair.

6.6 *Scale*, graduated in millimetres or 1⁄16-in. units.

## 7. Sampling

7.1 *Lot sampling*—As a lot sample for acceptance testing, take at random the number of shipping containers directed in the applicable material specification or other agreement between the purchaser and the supplier, such as an agreement to use Practice D 3333 or Practice D 2258. Consider shipping containers to be the primary sampling units.

NOTE 21—An adequate specification or other agreement between the purchaser or the supplier requires taking into account the variability between shipping units, between packages, ends, or other laboratory sampling unit within a shipping unit if applicable, and within specimens from a single package, end or other laboratory sampling unit to provide a sampling plan with a meaningful producer's risk, consumer's risk, acceptable quality level, and limiting quantity level.

7.2 *Laboratory Sample*—As a laboratory sample for acceptance testing, take at random from each shipping container in the lot sample the number of laboratory sampling units as directed in an applicable material specification or other agreement between the purchaser and the supplier such as an agreement to use Practice D 3333 or Practice D 2258. Preferably, the same number of laboratory sampling units are taken from each shipping container in the lot sample. If differing numbers of laboratory sampling units are to be taken from shipping containers in the lot sample, determine at random which shipping containers are to have each number of laboratory units drawn.

7.2.1 *For Staple Fiber*—Take 50-g samples from laboratory sampling units.

7.2.2 *For Sliver (or Top) or Tow*—Take 1 m from the leading end which has a clean, uniform appearance.

7.3 *Test Specimens*—From each laboratory sampling unit, take twenty-five specimens at random. For Options One and Three, each specimen is a fiber, and for Option Two, the specimen is a fiber chip. If the standard deviation determined for the ten specimens is more than a value agreed upon between the purchaser and the supplier, continue testing in groups of ten specimens from the same laboratory sampling unit until the standard deviation for all specimens tested is not more than the agreed to value or, by agreement, stop testing after a specified number.

## 8. Conditioning

8.1 Condition the specimens as directed in Practice D 1776.

## 9. Procedure

9.1 Test conditioned specimens in the standard atmosphere for testing textiles, which is 21 ± 1°C (70 ± 2°F) and 65 ± 2 % relative humidity.

9.2 *Specimen Preparation Options*:

9.2.1 *Option One Single Fiber (Preferred)*—Carefully remove 25 fibers at random from each laboratory sampling unit, using tweezers. Place these specimens on a specimen board. Using fingertip pressure, flatten each specimen with the crimp in a plane parallel with the board. Take care not to destroy the crimp.

9.2.2 *Option Two Fiber Chip*—Carefully remove 25 fiber chips at random from each laboratory sampling unit using tweezers. Place these specimens on a specimen board and flatten with fingertip pressure as in 9.2.1. Take care not to destroy the crimp.

9.2.3 *Option Three Fiber Projection*—Carefully remove 25 fiber at random from each laboratory sampling unit, using tweezers. Place these specimens on microscope slides without disturbing the crimp. Place the prepared slide on the stage of the projector. Project the image onto a smooth white surface.

9.3 *Counting Crimp*:

9.3.1 For all options, count and record the number of crimp units along the entire length of the specimen (see Fig. 1). Note any gross differences observed in crimp distribution or evenness.

9.3.2 Where possible count the crimp in at least 50 mm (2 in.). If fibers are longer than 50 mm, they may be cut to approximately 50-mm lengths before counting the crimp.

NOTE 32—Low-power magnification, no greater than 10×, may be useful in counting the number of crimp units.

NOTE 43—Users of this test method should be aware of the fact that crimp configuration in a man-made manufactured fiber is not always uniform over the length of the fiber.

9.4 *Measuring Fiber Length*:

9.4.1 For all options, hold one end of the fiber with a finger of one hand and gently straighten the fiber with the other hand. Be careful not to stretch the fiber. If Option 2 is used, remove a fiber from each chip, place these fibers on a specimen board and measure the lengths as being representative of the chips. If Option 3 is used, transfer fiber from the slide to the pile or plush surface to measure the extended length. Do not measure the projected image.

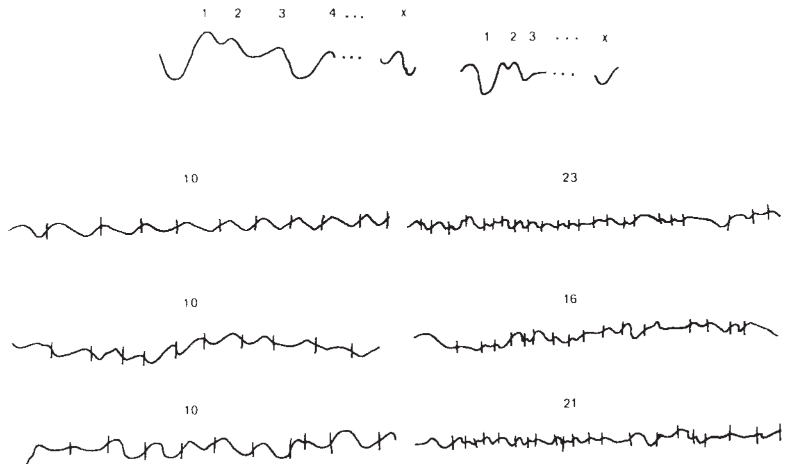


FIG. 1 Standard Reference Chart for Crimp Counting

9.4.2 For all options, place the scale on the specimen board. Grip one end of a fiber near the tip with tweezers and hold the tip of the fiber aligned with the zero on the scale. Then, grip the other end of the fiber near its tip with a second pair of tweezers and gently straighten the fiber along the scale. Be careful not to stretch the fiber.

9.4.2.1 From the scale, read the extended specimen length to the nearest 1 mm (1⁄16 in.).

9.5 Continue counting and measuring as directed in 9.3 and 9.4 to test the remaining specimens.

## 10. Calculation

10.1 Calculate the crimp frequency of each specimen to the nearest 0.1 crimp per 25 mm (crimp per inch), using Eq 1 or Eq 2:

$$F = C \times 25/L \quad (1)$$

$$F = C/L \quad (2)$$

where:

$F$ = crimp frequency, crimp/25 mm (crimp/1 in.),
$C$ = number of crimps counted, and
$L$ = extended length of the crimp-counted segment, mm (in.).

10.2 Calculate the average crimp frequency for each laboratory sampling unit and for the lot.

10.3 If requested, calculate the standard deviation or coefficient of variation, or both, for each laboratory sampling unit and for the lot sample container and the lot.

## 11. Report

11.1 State that the specimens were tested as directed in Test Method D 3937 for crimp frequency. Describe the material or product sampled and the method of sampling used.

11.2 Report the following information:

11.2.1 Average crimp frequency for each lot sample container tested and for each laboratory sampling unit and for the lot.

11.2.2 Any gross differences in crimp configuration uniformity observed,

11.2.3 Standard deviation or coefficient of variation, or both, for the lot sample container and for each laboratory sampling unit and for the lot, if calculated.

11.2.4 The specimen preparation option used, and

11.2.5 Magnification, if used.

## 12. Precision and Bias

12.1 *Summary*—In comparing two averages of 25 observations, the differences should not exceed 1.15 crimps per inch in 95 out of 100 cases when all of the observations are taken by the same well-trained operator using the same piece of test equipment and specimens randomly drawn from the sample of material. Larger differences are likely to occur under all other circumstances.

12.2 *Interlaboratory Test Data*—An interlaboratory test was run in 1980 in which randomly drawn samples of five materials were tested in each of six laboratories. Each laboratory used two operators, each of whom tested 25 specimens of each material. The components of variance for crimps per unit length results expressed as standard deviations were calculated to be as follows:

| | Crimps per Inch |
|---|---|
| Single-material comparisons: | |
| Single-operator component | 2.07 |

| | |
|---|---|
| Within-laboratory component | 0.49 |
| Between-laboratory component | 1.90 |
| Multi-material comparisons: | |
| Single-operator component | 0.78 |
| Within-laboratory component | 0.49 |
| Between-laboratory component | 2.35 |

NOTE ~~5~~4—Where separate components of variance are shown for multi-material comparisons, (*1*) the multi-material, single-operator component is due to an operator times material (within-laboratories) interaction and is combined with the single-material, single-operator component in calculating critical differences, and (*2*) any increase in the multi-material, between-laboratory component over the single-material, between-operator component is due to a material times laboratory interaction.

12.3 *Precision*—For the components of variance reported in 12.2, two averages of observed values should be considered significantly different at the 95 % probability level if the difference equals or exceeds critical differences as shown in Table 1.

NOTE ~~6~~5—The tabulated values of the critical differences should be considered to be a general statement. Particularly with respect to between-laboratory precision. Before a meaningful statement can be made about two specific laboratories, the amount of statistical bias, if any, between them must be established, with each comparison being based on recent data obtained on randomized specimens from one sample of the material to be tested.

12.4 *Bias*—The ~~true~~ value of crimps per unit length can be defined only in terms of a specific test method. Within this limitation, Test Method D 3937 for testing crimp frequency has no known bias.

## 13. Keywords

13.1 crimp; textile fibers



**TABLE 1 Critical Differences,[A] Crimps per Inch for the Conditions Noted**

| Number of Observations in Each Average | Single-Operator Precision | Within-Laboratory Precision | Between-Laboratory Precision |
|---|---|---|---|
| Single-material comparisons: | | | |
| 5 | 2.57 | 2.90 | 6.01 |
| 10 | 1.81 | 2.27 | 5.73 |
| 25 | 1.15 | 1.78 | 5.56 |
| 50 | 0.81 | 1.58 | 5.50 |
| Multi-material comparisons: | | | |
| 5 | 3.35 | 3.62 | 7.45 |
| 10 | 2.82 | 3.13 | 7.23 |
| 25 | 2.45 | 2.80 | 7.09 |
| 50 | 2.31 | 2.68 | 7.04 |

[A] The critical differences were calculated using $t = 1.960$ which is based on infinite degrees of freedom.