This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: D4031 – 07 (Reapproved 2018)

Standard Test Method for Bulk Properties of Textured Yarns[1]

This standard is issued under the fixed designation D4031; 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 measurement of the change in length of a tensioned skein of textured yarn due to change in crimp characteristics brought about by exposure to wet or dry heat. The change in length, depending on procedure, is a measure of skein shrinkage, crimp contraction, bulk shrinkage, or crimp recovery.

1.2 This test method applies to crimped, continuous multifilament yarns ranging from 1.7 to 88.9 tex (15 to 800 denier).

1.3 Three conditions are provided for crimp development mediums, and loading routines are provided to be used on the yarn skeins to allow determination of yarn bulk by several different procedures.

1.4 The values stated in either SI units or inch-pound units are to be regarded as standard. Within the text, the inch-pound units are shown in parentheses. The values stated in each system are not exact equivalent; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

1.5 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D123 Terminology Relating to Textiles

D1059 Test Method for Yarn Number Based on Short-Length Specimens

D1776 Practice for Conditioning and Testing Textiles

D1907 Test Method for Linear Density of Yarn (Yarn Number) by the Skein Method

D2258 Practice for Sampling Yarn for Testing

D4849 Terminology Related to Yarns and Fibers

3. Terminology

3.1 For all terminology relating to D13.58, Yarns and Fibers, refer to Terminology D4849.

3.1.1 The following terms are relevant to this standard: bulk shrinkage, crimp contraction, crimp development medium, crimp recovery, skein shrinkage.

3.2 For all other terms are related to textiles, refer to Terminology D123.

4. Summary of Test Method

4.1 A skein of yarn of a prescribed size (linear density) is subjected to a crimp development medium using a specified loading routine. As the crimp is developed or shrinkage occurs in the yarn, the skein changes in length. The lengths of the skein under specified tension forces are used to calculate the value of bulk shrinkage, crimp contraction, skein shrinkage, or crimp recovery.

4.2 The test method offers three options for loading routine of the yarn skeins. Loading routines consist of using low-tension forces (light loads of 0.04 to 0.98 mN/tex (0.5 to 11 mgf/den)) that extend without removing crimp, and high-tension forces (heavy loads of 8.8 mN/tex (100 mgf/den)) that remove crimp without elongating the yarn. A list of weights to be used is given in Table 1. Weight option combinations are detailed in Table 2.

5. Significance and Use

5.1 The values obtained by this test method should not be used to predict similar properties in fabricated structures except in narrow well-defined comparisons, such as 16.7 tex (150-denier) polyester from the same feed yarn merge and textured on the same machine type. Attempts to relate yarn performance to fabric performance might result in poor correlations unless other factors affecting bulk such as yarn shrinkage and fabric finishing are eliminated.

[1] This test method is under the jurisdiction of ASTM Committee D13 on Textiles and is the direct responsibility of Subcommittee D13.58 on Yarns and Fibers.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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TABLE 1 Tension Forces Used and Required Weights

Tension-mN/tex	mgf/den	Weight Required in Grams	
		1.7 to 44.4 tex[A] (15 to 400 den)	44.5 to 89.0 tex[B] (401 to 800 den)
For Options A, B, C:			
0.04	0.5	2.5	3.8
0.13	1.5	7.5	11.3
0.22	2.5	12.5	18.8
0.44	5.0	25.0	37.5
0.88	10.0	50.0	75.8
8.83	100.0	500.0	750.0
For Option B Only:			
0.10	1.1	2.5[C]	...
0.98	11.1	25.0[C]	...
9.82	11.1	250.0[C]	...
For Option C Only:			
0.13	1.5	[D]	

[A] 555.5-tex (5000-denier) skein.
[B] 833.3-tex (7500-denier) skein.
[C] For 250-tex (2250-denier) skein.
[D] Variable, see Eq 1.

TABLE 2 Weight Option Combinations

Option	Loading			Recommended Crimp Development Condition	Results Obtained
	Before Development	During Development	After Development		
A	light heavy	light	light heavy light	1	CCBD, CCAD SS, CR
B	...	none	heavy light	1	CCAD
C	light	light	2nd light light	2 or 3	BKS

5.2 Elapsed time between processing and testing has a marked effect on the results of this test especially during the first 72 h. Therefore, specimens should only be compared if tested after the same elapsed time. This effect is caused by stress decay which is known to be minimal beyond the seventh day and after which time the sample remains relatively stable. Comparisons are preferably made after the seventh day.

5.3 In the case of yarns having a linear density near the upper limit of the skein size directed in Table 3, an error is introduced when rounding off to full revolutions. Therefore, the calculated values for crimp contraction, etc., should only be compared with other samples of yarn of the same linear density.

TABLE 3 Total Size (Linear Density) of Skein

Linear Density of Yarn	Linear Density of Skein[A]
Options A, B, C:	
1.7 to 44.4 tex (15 to 400 denier)	555.5 tex (5000 denier)
44.5 to 89.0 tex (401 to 800 denier)	833.5 tex (7500 denier)
Option B Only (for mechanical device):	
1.7 to 44.4 text (15 to 400 denier)	250 tex (2250 denier)
Option C Only:	
1.7 to 44.4 tex (15 to 400 denier)[B]	

[A] See Eq 2, and Note 1.
[B] 100 Revolutions, linear density of skein varies.

5.4 Option A used with crimp development Condition 1 (dry heat oven at 120°C (248°F)) and light loads of 0.04 mN/tex (0.5 mgf/den) and 0.44 mN/tex (5.0 mgf/den) are recommended for textured polyester yarns. All crimp parameters may be calculated.

5.5 Option B may also be used with crimp development Condition 1 (dry heat) for textured polyester yarns. Crimp contraction may be calculated. When used to duplicate or to utilize suitable mechanical yarn handling devices,[3] alternate skein size and weights may be used as described in 6.5.2 and 9.3.2.

5.6 Option C used with crimp development Condition 2 (water bath at 82°C (180°F)) and a light load of 0.13 mN/tex (1.5 mgf/den) is recommended for textured nylon yarns. For textured polyester yarns, Condition 3 (water bath at 97°C (206°F)) is recommended. Only bulk shrinkage is calculated.

5.7 This test method for the measurement of bulk properties is not recommended for acceptance testing of commercial shipments because of lack of precision data.

5.7.1 If there are differences or practical significance between reported test results for two laboratories (or more), comparative tests should be performed to determine if there is a statistical bias between them, using competent statistical assistance. As a minimum, test samples that are as homogeneous as possible, drawn from the material from which the disparate test results were obtained, and randomly assigned in equal numbers to each laboratory for testing. The test results from the two laboratories should be compared using a statistical test for unpaired data, at a probability level chosen prior to the testing series. If a bias is found, either its cause must be found and corrected, or future test results for that material must be adjusted in consideration of the known bias.

6. Apparatus[3]

6.1 *Skein Reel:*

6.1.1 *General*—A hand or motor-driven reel having a specified perimeter. The reel shall be fitted with a traversing mechanism that will avoid bunching the successive wraps, and with an indicator of the length wound. A warning bell that will ring at a specified length is recommended. A collapsible arm is recommended for ease of removal of skeins. A revolution counter is also recommended.

6.1.2 *Reel Perimeter*—The perimeter shall be 1.0 m (1.09 yd) with a tolerance of ±2 %. By agreement between purchaser and supplier, reels may be used having any perimeter between 0.9 to 2.3 m (1 to 2.5 yd).

6.1.3 *Yarn Tensioning*—To minimize differences in yarn tensioning a motor driven unit with speeds at 150 ± 20 revolutions/min is recommended. Tensions should be as low as possible and no additional tensioning device is required for a

[3] The sole source of supply of the Textured Yarn Apparatus known to the committee at this time is Lawson-Hemphill Sales, Inc., PO Drawer 6388, Spartanburg, SC 29304 or (International Sales) Lawson-Hemphill, Inc., 96 Hadwin Street, Central Falls, Rhode Island, 02863. If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, [1] which you may attend.