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Standard Specification for Strapping, Nonmetallic (and Joining Methods)[1]

This standard is issued under the fixed designation D 3950; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification covers nonmetallic strapping and joining methods intended for use in closing, reinforcing, and bundling articles for shipment, unitizing, palletizing, and bracing for car loading and truck loading.

~~1.2The values stated in inch-pound units are to be regarded as standard.~~

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3 The following safety hazards caveat pertains only to the test method portion, Section 12, of this specification: *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:*[2]

D 996 Terminology of Packaging and Distribution Environments

D 3951 Practice for Commercial Packaging

D 4332 Practice for Conditioning Containers, Packages, or Packaging Components for Testing

2.2 *Other Standards:*

ANSI/ASQC Z 1.4 Sampling Procedures and Tables for Inspection by Attributes[3]

ANSI/ASQC Z 1.9 Sampling Procedures and Tables for Inspection by Variables for Percent Nonconforming[3]

3. Terminology

3.1 For general definitions of packaging and distribution environments, see Terminology D 996.

4. Classification

4.1 *Types and Grades*:

Type I	— Strapping, bonded rayon cord.
	Grade 1—Light duty.
	Grade 2—Regular duty.
	Grade 3—Heavy duty.
Type IA	— Strapping, bonded, or woven polyester cord.
	Grade 1—Light duty.
	Grade 2—Regular duty.
	Grade 3—Heavy duty.
	Grade 4—Extra heavy duty.
	Grade 5—Special duty.
	Grade 6—Special duty.
	Grade 7—Special duty.
Type II	— Strapping, polypropylene plastic.
Type III	— Strapping, nylon plastic.
Type IV	— Strapping, polyester plastic.

[1] This specification is under the jurisdiction of ASTM Committee D10 on Packaging and is the direct responsibility of Subcommittee D10.25 on Palletizing and Unitizing of Loads.

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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.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

5. Ordering Information

5.1 The inquiry and order shall indicate the following:
5.1.1 Type, grade, and dimensions required (see 4.1 and 7.1),
5.1.2 Length per coil (see 8.1),
5.1.3 Joining method (see 6.2), type and size required (if needed),
5.1.4 If an embossed finish on strapping is desired or allowed (see Footnote in Table 1, Table 2, and Table 3),
5.1.5 Make and model of strapping equipment that the strapping and joining method must work in, if applicable,
5.1.6 Coil dimensions (see 8.1),
5.1.7 Level of packaging and packing if other than commercial (see Section 15), and
5.1.8 ASTM designation and date of issue.

6. Materials and Manufacture

6.1 Materials shall be of the quality necessary to meet the physical requirements within the allowable dimensions.
6.1.1 *Type I*—Strapping shall consist of longitudinal rayon cords bonded with a plastic binder so that a nonwoven material is formed.
6.1.1.1 *Type IA*—Strapping shall consist of longitudinal polyester cords bonded with a plastic binder to form a nonwoven material or longitudinal polyester cords woven with a weft thread and treated with a plastic binder to form a woven material.
6.1.2 *Type II*—Strapping shall be an extruded, oriented polypropylene.
6.1.3 *Type III*—Strapping shall be an extruded, oriented nylon.
6.1.4 *Type IV*—Strapping shall be an extruded, oriented polyester.
6.2 *Joining Methods*— If seals or buckles are to be used, they shall be steel and have a coating of zinc, black iron oxide, or equivalent protection from corrosion, or buckles may be made of plastic.

7. Mechanical Properties

7.1 *Breaking Strength and Elongation* (see 12.2):
7.1.1 Type I and Type IA strapping shall conform to the breaking strengths and elongations prescribed in ~~Table 2~~Table 4 and ~~Table 3~~Table 5.
7.1.2 Type II strapping shall conform to the breaking strengths and elongations prescribed in Table 1.
7.1.3 Type III strapping shall conform to the breaking strengths and elongations prescribed in ~~Table 4~~Table 2.
7.1.4 Type IV strapping shall conform to the breaking strengths and elongations prescribed in ~~Table 5~~Table 3.
7.2 Transverse strength of Types I and IA strapping shall be a minimum of 2.75 lbf (12.2 N) and 2.25 lbf (10 N), respectively, when tested in accordance with 12.4.
7.3 *Joint Strength* (see 12.3).
7.3.1 Type I and Type IA Grade 1 and Grade 2 joined strapping shall have a strength of not less than 45% of the minimum breaking strength of the strapping grade and size listed in ~~Table 2~~ Table 4 and ~~Table 3~~Table 5.
7.3.2 Type IA Grade 3, Grade 4, Grade 5, Grade 6, and Grade 7 joined strapping shall have a strength of not less than 55 % of the minimum breaking strength of the strapping grade and size listed in ~~Table 3~~Table 5. Test data are available to substantiate this conclusion.
7.3.3 Types II, III, and IV joined strapping shall have a strength of not less than 45 % of the minimum breaking strength corresponding to the dimensions of the strap listed in Table 1, ~~Table 4~~Table 2, or ~~Table 5~~Table 3.

8. Dimensions and Permissible Variations

8.1 The minimum length per coil of strapping shall be as specified in the following tables according to type, grade, size, and coil width. The coil shall be an oscillating or ribbon wind.
8.1.1 Type I and Type IA strapping shall be furnished with the minimum feet per coil according to size and grade as prescribed in Table 6.
8.1.2 Types II, III, and IV strapping shall be furnished with the minimum feet per coil in accordance with the size and coil width in Table 7.

9. Workmanship, Finish, and Appearance

9.1 Type I and Type IA strapping shall be straight, clean, have good webbing, and be free of cracks and other defects that may affect the serviceability.
9.2 Types II, III, and IV strapping shall be straight, clean, and free of kinks, edge curvature, cracks, and other defects that may affect the serviceability.
9.3 Splices may be made if they do not affect the serviceability of the strapping in strapping equipment and have a break strength equal to at least 50% of the strap break strength. No more than one splice per coil will be permitted.

10. Sampling Plan

10.1 Where it can be demonstrated that a supplier's quality control system provides a similar degree of assurance as that

TABLE 1 Breaking Strengths of Type II Strapping (PP)

Nominal Width of Strapping		Nominal Thickness of Strapping		Minimum Breaking Strength	
in.	(mm)	in.	(mm)[A]	lb	(N)[B]
0.197	(5.0)	0.0120	(0.30)	80	(360)
0.197	(5.0)	0.0145	(0.37)	100	(440)
0.234	(5.9)	0.0135	(0.34)	130	(580)
0.234	(5.9)	0.0140	(0.36)	155	(690)
0.236	(6.0)	0.0130	(0.33)	135	(600)
0.234	(5.9)	0.0160	(0.41)	180	(800)
0.236	(6.0)	0.0173	(0.44)	190	(850)
¼	(6.4)	0.0135	(0.34)	134	(600)
¼	(6.4)	0.0150	(0.38)	180	(800)
¼	(6.4)	0.0250	(0.64)	200	(890)
0.351	(8.9)	0.0130	(0.33)	200	(899)
0.354	(9.0)	0.0142	(0.36)	225	(1 000)
0.351	(8.9)	0.0160	(0.41)	270	(1 200)
0.354	(9.0)	0.0173	(0.44)	270	(1 200)
0.354	(9.0)	0.0181	(0.46)	270	(1 200)
⅜	(9.5)	0.0180	(0.46)	250	(1 110)
⅜	(9.5)	0.0150	(0.38)	290	(1 290)
⅜	(9.5)	0.0200	(0.51)	390	(1 730)
⅜	(9.5)	0.0250	(0.64)	400	(1 780)
0.413	(10.5)	0.0190	(0.48)	360	(1 600)
0.413	(10.5)	0.0201	(0.51)	360	(1 600)
0.413	(10.5)	0.0248	(0.63)	460	(2 050)
0.413	(10.5)	0.0295	(0.75)	550	(2 450)
0.413	(10.5)	0.0295	(0.75)	540	(2 400)
0.413	(10.5)	0.0230	(0.58)	450	(2 000)
7/16	(11.1)	0.0140	(0.36)	300	(1 330)
7/16	(11.1)	0.0190	(0.48)	350	(1 560)
7/16	(11.1)	0.0230	(0.58)	420	(1 870)
7/16	(11.1)	0.0250	(0.64)	450	(2 000)
7/16	(11.1)	0.0300	(0.76)	550	(2 450)
0.468	(11.9)	0.0215	(0.55)	450	(2 000)
0.472	(12.0)	0.0169	(0.43)	360	(1 600)
0.472	(12.0)	0.0212	(0.54)	460	(2 050)
0.472	(12.0)	0.0252	(0.64)	550	(2 450)
0.480	(12.2)	0.0190	(0.48)	400	(1.780)
½	(12.7)	0.0150	(0.38)	390	(1.750)
½	(12.7)	0.0170	(0.43)	350	(1 570)
½	(12.7)	0.0220	(0.56)	450	(2 020)
½	(12.7)	0.0200	(0.51)	530	(2 360)
½	(12.7)	0.0250	(0.64)	660	(2 940)
½	(12.7)	0.0260	(0.66)	550	(2 450)
½	(12.7)	0.0300	(0.76)	810	(3 600)
0.468	(12.0)	0.0255	(0.65)	540	(2 400)
0.591	(15.0)	0.0410	(1.04)	1 050	(4 660)
⅝	(15.9)	0.0150	(0.38)	500	(2 200)
⅝	(15.9)	0.0200	(0.51)	680	(3 020)
⅝	(15.9)	0.0300	(0.76)	950	(4 220)
0.728	(18.5)	0.0410	(1.04)	1 300	(5 770)
¾	(19.1)	0.0200	(0.51)	725	(3 220)
1¼	(31.8)	0.0350	(0.89)	2 200	(9 790)
1¼	(31.8)	0.0500	(1.27)	3 100	(13 790)

[A] When specified (see 5.1.4), the strapping as measured by a flat anvil micrometer shall have an embossed finish which yields an overall nominal thickness no greater than twice the nominal thickness of smooth-surfaced strapping of the same width and breaking strength.

[B] Range of elongation at break is from 7 to 35 %.

obtained through the use of this specification, the supplier may use that system in place of the system described in this specification. In case of conflict, provisions set forth in ANSI/ASQC Z1.4 shall be used.

10.2 *Lot Size*—The lot size shall be expressed in units of coils or joining methods, or both, and shall consist of all products of one type, grade, and size offered for acceptance at one time.

10.3 *Unit Sample*— One coil or one joining method shall be considered a unit. A minimum of 10 ft (3.05 m) per coil of strapping is required to perform the tests.

TABLE 4 2 Breaking Strengths of Type III Strapping (Nylon)

Nominal Width of Strapping, in. (mm)	Nominal Thickness of Strapping, in. (mm)[A]	Minimum Breaking Strength, lbf (N)[AB]
7/16 (11.1)	0.017 (0.43)	420 (1870)
	0.023 (0.58)	560 (2490)
	0.029 (0.74)	700 (3110)
½ (12.7)	0.015 (0.38)	420 (1870)
	0.020 (0.51)	560 (2490)
	0.025 (0.64)	700 (3110)
	0.030 (0.76)	900 (4000)

[A] When specified (see 5.1.4), the strapping as measured by a flat anvil micrometer shall have an embossed finish which yields an overall nominal thickness no greater than twice the nominal thickness of smooth-surfaced strapping of the same width and breaking strength.

[B] Range of elongation at break is from 12 to 25 %.

10.4 *Rate of Sampling*— The rate of sampling shall be in accordance with ANSI/ASQC Z1.9; Table A-2 reduced inspection level shall be used.

11. Number of Tests

11.1 *Tests*—For the determination of break strength, elongation, transverse strength, and sealed joint strength, an average of three specimens per coil shall be considered a complete test.

11.2 *Retests*—When testing for elongation, if the specimen fails outside of the center third of the gage length or within 1 in. of the jaws, a retest shall be made. If the percentage of elongation or the break strength is less than the specified minimum, a retest is permitted. In this retest, three consecutive specimens must meet the minimum requirements.

12. Test Methods

12.1 The purpose of these test methods is to determine the strength of the strapping and elongation, and the strength when the ends of the strapping are joined together.

12.2 The major properties of strapping used to reinforce packages or bundle objects are the strapping tensile strength, elongation, and the joint strength. A proper balance of these three properties is required for maximum performance.

12.3 *Apparatus*:

12.3.1 *Tensile Tester*— A test machine capable of load accuracies to within ±1 %. For greater accuracy in performing the elongation test, use an extensometer.

12.3.2 *Clamps*—Capstan or split-barrel-type gripping clamp 2 to 4 in. (51 to 100 mm) in diameter with adequate load capacity. Any grips chosen are to yield failures (specimen) within the effective gage length of the sample. For referee testing use Instron 4-in. Webbing Capstan grips.

12.4 *Sampling*—See Sections 10 and 11 for plan and number of tests.

12.5 *Conditioning*— Condition all samples in a standard atmosphere as described in Practice D 4332 for a minimum of 24 h. Conduct all tests at these conditions.

12.6 *Test Procedures*:

12.6.1 *Breaking Strength*—Select a load range of the tensile tester in which the point of maximum force will fall between 30 to 90 % of full scale. The crosshead speed shall be 5 in. (127 mm)/min with the free length between the clamps sufficient to accept the strap sample and the elongation measuring device, generally 6 to 10 in. (150 to 250 mm). Insert the sample of strap of a length adequate to accommodate the minimum gage length and clamping arrangement into the clamps. Manually adjust the sample to remove any slack and activate the tester. Read the breaking strength directly from the recording device to the nearest 5 lbf (22 N) or 10 lbf (44 N) for breaking strengths in excess of 1000 lbf (4448 N).

12.6.2 *Elongation*—Measure elongation at break at the same time as breaking strength using the same procedure (see 12.6.1), except use a chart recorder to measure the crosshead displacement. If greater accuracy is desired, use an extensometer to measure extension as errors due to slippage or slack removal can be introduced if crosshead separation is used.

12.6.3 *Joint Strength*— Determine the joint strength by the same procedure used for breaking strength (see 12.6.1), except for utilization of the elongation measuring technique. Elongation is not measured during a joint strength test. Read the maximum force directly from the recording device to the nearest 5 lbf (22 N).

12.6.3.1 *Percent of Breaking Strength* —The joint strength is recorded as a percentage of the minimum breaking strength of the parent material which is determined in accordance with the type, grade, and dimension tested (see 7.1).

12.7 *Precision and Bias*:

12.7.1 *Precision*:

12.7.1.1 An interlaboratory test program has been conducted using nine laboratories and nine different materials. Ten samples

TABLE ~~5~~ 3 Breaking Strengths of Type IV Strapping (PET)

Nominal Width of Strapping		Nominal Thickness of Strapping		Minimum Breaking Strength	
~~in.~~	~~(mm)~~	~~in.~~	~~(mm)~~	~~lb~~	~~(N)[A]~~
in.	(mm)	in.	(mm)[A]	lb	(N)[B]
0.351	(8.9)	0.0190	(0.48)	390	(1 730)
0.354	(9.0)	0.0205	(0.52)	400	(1 780)
3/8	(9.5)	0.0150	(0.38)	310	(1 380)
3/8	(9.5)	0.0200	(0.51)	420	(1 870)
0.413	(10.5)	0.0195	(0.50)	430	(1 910)
0.413	(10.5)	0.0205	(0.52)	460	(2 050)
0.413	(10.5)	0.0220	(0.56)	500	(2 220)
0.413	(10.5)	0.0240	(0.61)	560	(2 490)
0.413	(10.5)	0.0255	(0.65)	575	(2.550)
0.413	(10.5)	0.0265	(0.67)	600	(2 660)
7/16	(11.1)	0.0160	(0.41)	360	(1 600)
7/16	(11.1)	0.0200	(0.51)	460	(2 050)
7/16	(11.1)	0.0220	(0.56)	500	(2 220)
7/16	(11.1)	0.0240	(0.61)	560	(2 490)
0.468	(11.9)	0.0168	(0.43)	470	(2 090)
0.468	(11.9)	0.0175	(0.44)	470	(2 090)
0.468	(11.9)	0.0205	(0.52)	560	(2 490)
0.468	(11.9)	0.0275	(0.70)	750	(3 340)
0.468	(11.9)	0.0280	(0.71)	750	(3 340)
0.472	(12.0)	0.0175	(0.44)	470	(2 090)
0.472	(12.0)	0.0205	(0.52)	560	(2 490)
0.472	(12.0)	0.0280	(0.71)	750	(3 340)
1/2	(12.7)	0.0150	(0.38)	420	(1 870)
1/2	(12.7)	0.0170	(0.43)	470	(2 090)
1/2	(12.7)	0.0200	(0.51)	560	(2 490)
1/2	(12.7)	0.0250	(0.64)	700	(3 110)
1/2	(12.7)	0.0280	(0.71)	750	(3 340)
1/2	(12.7)	0.0300	(0.76)	850	(3 780)
0.615	(15.6)	0.0300	(0.76)	1 000	(4 440)
0.615	(15.6)	0.0350	(0.89)	1 100	(4 890)
0.615	(15.6)	0.0360	(0.91)	1 150	(5 120)
0.615	(15.6)	0.0380	(0.97)	1 200	(5 328)
~~0.615[B]~~	~~(15.6)~~	~~0.0400~~	~~(1.02)~~	~~1 200~~	~~(5 328)~~
0.615[C]	(15.6)	0.0400	(1.02)	1 200	(5 328)
0.615	(15.6)	0.0400	(1.02)	1 500	(6 670)
~~0.615[B]~~	~~(15.6)~~	~~0.0410~~	~~(1.04)~~	~~1 200~~	~~(5 328)~~
0.615[C]	(15.6)	0.0410	(1.04)	1 200	(5 328)
0.615	(15.6)	0.0450	(1.14)	1 600	(7 120)
5/8	(15.9)	0.0200	(0.51)	700	(3 110)
5/8	(15.9)	0.0250	(0.64)	870	(3 870)
5/8	(15.9)	0.0300	(0.76)	1 000	(4 450)
~~5/8[B]~~	~~(15.9)~~	~~0.0350~~	~~(0.89)~~	~~1 200~~	~~(5 340)~~
5/8[C]	(15.9)	0.0350	(0.89)	1 200	(5 340)
5/8	(15.9)	0.0350	(0.89)	1 300	(5 780)
3/4	(19.1)	0.0400	(1.02)	1 750	(7 780)
3/4	(19.1)	0.0500	(1.27)	2 250	(10 010)
3/4	(19.1)	0.0550	(1.40)	2 400	(10 680)
3/4	(19.1)	0.0600	(1.52)	2 500	(11 120)
0.985	(25.0)	0.0400	(1.02)	2 300	(10 210)
0.985	(25.0)	0.0500	(1.27)	2 800	(12 460)
1 1/4	(32.0)	0.0320	(0.82)	2 250	(10 010)
1 1/4	(32.0)	0.0400	(1.02)	2 800	(12 460)

[A] When specified (see 5.1.4), the strapping as measured by a flat anvil micrometer shall have an embossed finish which yields an overall nominal thickness no greater than twice the nominal thickness of smooth-surfaced strapping of the same width and breaking strength.

[B] Ultimate Elongation Range: 5 to 20 % (Standard Elongation PET), 10 to 25 % (High Elongation PET)

~~[B]~~[C] Denotes High Elongation (H.E.) PET strapping.

of each material were tested within each laboratory.[4] See Table 8.

12.7.1.2 Breaking strength and elongation precision are given as coefficient of variation for three types of materials. These may be used as estimates of precision, but depending on the specific material, higher or lower values may be observed.

12.7.1.3 Joint strength precision is also given as a coefficient of variation but for only one type of material and joining system (cord strap with buckle). These values may be used as estimates of precision but, depending on the specific material and joining system, higher or lower values may be observed.

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: D10-1010.

TABLE 2 4 Breaking Strengths[A] of Type I Bonded Rayon Cord Strapping

Nominal Width of Strapping, in. (mm)	Grade	Minimum Breaking Strength, lbf (N)
¼ (6.4)	2	235 (1045)
⅜ (9.5)	1	290 (1290)
	2	350 (1555)
½ (12.7)	1	410 (1820)
	2	465 (2070)
⅝ (15.9)	1	525 (2335)
	2	585 (2600)
	3	765 (3400)
¾ (19.1)	1	640 (2845)
	2	700 (3110)
	3	900 (4000)
1¼ (31.8)	3	157 (7005)

[A] Range of elongation at break is from 10 to 15 %.

TABLE 3 5 Breaking Strengths[A] of Type IA Bonded or Woven Polyester Cord Strapping

Nominal Width of Strapping, in. (mm)	Grade	Minimum Breaking Strength, lbf (N)
¼ (6.4)	2	300 (1 335)
(6.0)	3	540 (2 400)
⅜ (9.5)	2	450 (2 000)
(9.0)	3	780 (3 480)
½ (12.7)	1	400 (1 780)
(12.7)	2	600 (2 670)
(13.0)	3	1 050 (4 670)
(13.0)	4	1 360 (6 050)
⅝ (15.9)	1	500 (2 225)
(15.9)	2	725 (3 225)
(16.0)	3	1 310 (5 830)
(16.0)	4	1 650 (7 340)
¾ (19.1)	2	900 (4 000)
(19.0)	3	1 585 (7 060)
(19.0)	4	1 830 (8 150)
(19.0)	5	2 600 (11 570)
1¼ (32.0)	2	1 830 (8 150)
(32.0)	3	2 105 (9 370)
(32.0)	4	3 285 (14 620)
(32.0)	5	4 200 (18 680)
1½ (38.0)	4	4 400 (19 570)
1½ (38.0)	5	5 400 (24 030)
1⅝ (40.0)	6	7 700 (34 265)
1⅝ (40.0)	7	11 000 (48 950)

[A] Range of elongation at break is from 9 to 15 %.

12.7.2 *Bias*—Bias is the difference between an average test value and the reference (true) test property value. Reference values do not exist for this test method since the value or level of the test property is exclusively defined by the test method. Therefore, no statement on bias is being given.

13. Rejection and Retesting

13.1 Material that fails to conform to the requirements of this specification may be rejected. Rejection should be reported to the producer or supplier promptly and in writing. In case of dissatisfaction with the results of the test, the producer or supplier may request retesting.

14. Certification

14.1 When specified in the purchase order or contract, a producer's or supplier's certification shall be furnished to the purchaser.