Designation: D 4975 – 96a

Standard Test Methods for Single-Filament Tire Bead Wire Made from Steel[1]

This standard is issued under the fixed designation D 4975; 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 These test methods cover testing of single-filament steel wires that are components of tire beads used in the manufacture of pneumatic tires. By agreement, these test methods may be applied to similar filaments used for reinforcing other rubber products.

1.2 These test methods describe test procedures only and do not establish specifications and tolerances.

1.3 These test methods are written in SI units. The inch-pound units which are provided are not necessarily exact equivalents of the SI units. Either system of units may be used in these test methods. In case of referee decisions the SI units will prevail.

1.4 These test methods cover the determination of the mechanical properties listed below:

1.5 *This standard does not purport to address all of the safety problems, 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.*

Property	Section
Breaking Force (Strength)	7-13
Yield Strength	7-13
Elongation	7-13
Torsion Resistance	14-20
Diameter (Gage)	21-27

2. Referenced Documents

2.1 *ASTM Standards:*

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products[2]

D 76 Specification for Tensile Testing Machines for Textiles[3]

D 123 Terminology Relating to Textiles[3]

D 2969 Test Method for Steel Tire Cords[3]

E 6 Terminology Relating to Methods of Mechanical Testing[4]

E 558 Test Method for Torsion Testing of Wire[4]

3. Terminology

3.1 *Definitions:*

3.1.1 *breaking force*, *n*—the maximum force applied to a material carried to rupture.

3.1.2 *percent elongation*, *n*—the increase in length of a specimen expressed as a percentage of the original length.

3.1.3 *tire bead*, *n*—that part of a tire that comes in contact with the rim and that is shaped to secure the tire to the rim.

3.1.4 *tire bead wire*, *n*—a monofilament steel wire with a metallic coating, usually bronze, used in forming a tire bead.

3.1.5 *torsion resistance*, *n*—*in tire bead wire*, the number of turns of twist in a short length of wire that causes rupture.

3.1.6 *yield strength*, *n*—the stress at which a material exhibits a specified limiting deviation from the proportionality of stress to strain.

3.1.6.1 *Discussion*—It is customary in this instance to express the deviation in terms of strain and to determine yield strength by the offset method where a strain of 0.2 % is specified (see 10.9.1).

3.1.7 For definitions of other textile terms, refer to Terminology D 123.

4. Summary of Test Methods

4.1 A summary of the directions prescribed for the determination of specific properties of tire bead wire is stated in the appropriate sections of the specific test methods that follow.

5. Significance and Use

5.1 The procedures for the determination of properties of single-filament bead wire made from steel are considered satisfactory for acceptance testing of commercial shipments of this product since the procedures are the best available and have been used extensively in the trade.

5.1.1 In case of a dispute arising from differences in reported test results when using these test methods for acceptance testing of commercial shipments, the purchaser and supplier should conduct comparative tests to determine if there is a statistical bias between their laboratories. Competent statistical assistance is recommended for the investigation of bias. As a minimum, the two parties should take a group of test specimens which are as homogeneous as possible and which are from a lot of material of the type in question. The test specimens then should be randomly assigned in equal numbers to each laboratory for testing. The average results from the two laboratories should be compared using Student's *t*-test for

[1] These test methods are under the jurisdiction of ASTM Committee D-13 on Textiles and are the direct responsibility of Subcommittee D13.19 on Tire Cord and Fabrics.

Current edition approved Aug. and Oct. 10, 1996. Published December 1997. Originally published as D 4975 – 89. Last previous edition D 4975 – 93.

[2] *Annual Book of ASTM Standards*, Vol 01.03.

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

[4] *Annual Book of ASTM Standards*, Vol 03.01.

unpaired data and an acceptable probability level chosen by the two parties before testing is begun. If a bias is found, either its cause must be determined and corrected or the purchaser and the supplier must agree to interpret future test results in the light of the known bias.

6. Sampling

6.1 *Lot Sample*—As a lot sample for acceptance testing, take at random the number of reels, coils, spools, or other shipping units of wire directed in an applicable material specification or other agreement between the purchaser and the supplier. Consider reels, coils, spools, or other shipping units of wire to be the primary sampling units.

NOTE 1—A realistic specification or other agreement between the purchaser and the supplier requires taking into account the variability between and within primary sampling units so as to provide a sampling plan which at the specified level of the property of interest has a meaningful producer's risk, acceptable quality level, and desired limiting quality level.

6.2 *Laboratory Sample*—Use the primary sampling units in the lot sample as a laboratory sample.

6.3 *Test Specimens*—For each test procedure, take the number of lengths of tire bead wire of the specified lengths from each laboratory sample as directed in the test procedure.

BREAKING FORCE, YIELD STRENGTH, AND ELONGATION

7. Summary of Test Method

7.1 The two ends of a specimen are clamped in a tensile testing machine; an increasing force is applied until the specimen breaks. The change in force is measured versus the increase in separation of the specimen clamps to form a force-extension curve. Breaking force is read directly from the curve and is expressed in newtons (pounds-force). Percent elongation at break is the extension at break divided by the original specimen length, × 100. The yield strength, the intersection of the force-extension curve with a line at 0.2 % offset, is read from the force-extension curve and is expressed in newtons (pounds-force).

8. Significance and Use

8.1 The load-bearing ability of a reinforced rubber product such as a tire bead is related to the strength of the single-filament wire used as the reinforcing material. The breaking force and yield strength of tire bead wire is used in engineering calculations when designing this type of reinforced product.

8.2 Elongation of tire bead wire is taken into consideration in the design and engineering of tire beads because of its effect on uniformity and dimensional stability during service.

9. Apparatus

9.1 *Tensile Testing Machine*, CRE (Constant-Rate-of-Extension) tensile testing machine of such capacity that the maximum force required to fracture the wire shall not exceed 90 % nor be of less than 10 % of the selected force measurement range. The specifications and methods of calibration and verification shall conform to Specification D 76.

9.2 In some laboratories, the output of CRE type of tensile testing machine is connected with electronic recording and computing equipment which may be programmed to calculate and print the results for each of these desired properties. Because of the variety of electronic equipment available and the various possibilities for recording test data, use of this type of equipment is not covered in this test method.

9.3 *Grips*, of such design that failure of the specimen does not occur at the gripping point, and slippage of the specimen within the jaws (grips) is prevented.

10. Procedure

10.1 Thermally age the specimen by placing it in a suitable oven for 1 h at 150°C (300°F).[5] Allow specimens to cool to room temperature before testing.

10.2 Select the proper force scale range on the tensile testing machine based on the estimated breaking force of the specimen being tested.

10.3 Adjust the distance between the grips of the testing machine, nip to nip, to a gage length of 250 mm (10 in.).

10.4 Secure the specimen in the upper grip sufficiently to prevent slippage during testing. While keeping the specimen straight and taut, place and secure the other end in the lower grip.

10.5 Apply a force of 1 N (0.2 lbf) on the clamped specimen to take out any residual slack before initiating the test. This will be considered the zero reference point for elongation calculations.

10.6 After setting the cross head speed at 25 mm (1 in.)/min and recorder chart speed at 250 mm (10 in.)/min, start the testing machine and record the force-extension curve generated.

10.6.1 If the specimen fractures at or within 5 mm (0.2 in.) of the gripping point, discard the result and test another specimen. If such jaw breaks continue to occur, insert a jaw liner such as an abrasive cloth between the gripping surface and the specimen in a manner so that the liner extends beyond the grip edge where it comes in contact with the specimen.

10.7 Conduct this test procedure on two specimens from each laboratory sampling unit.

10.8 Elongation, the increase in gage length of a tensile specimen, is usually expressed as a percentage of the original gage length and can be determined from the force-extension curve.

10.8.1 When a greater degree of accuracy is required in the determination of elongation, an extensometer can be attached to the specimen.

10.9 Yield strength is the stress at which a material exhibits a specified limiting deviation from the proportionality of stress to strain. Determine the yield strength by the 0.2 % offset method.

10.9.1 On the force-extension curve (Fig. 1) that has been generated (see 10.6) lay off *Om* equal to the specified value of the offset (0.2 % elongation); draw *mn* parallel to *OA* and locate *r*. This intersection of *mn* with the force-extension curve corresponds to force *R* which is the yield strength. Should the force-extension curve exhibit an initial nonlinear portion,

[5] Suitable electric ovens are manufactured by Blue M Electric Company, Blue Island, IL 60406.

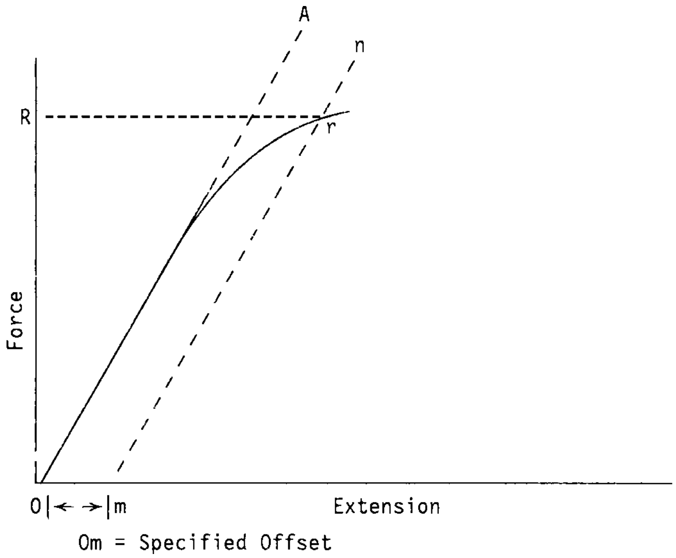

FIG. 1 Force-Extension Curve for Determination of Yield Strength by the Offset Method

extrapolate from the straight line portion to the base line. This intersection is point *O* used in this section.

11. Calculation

11.1 Calculate the average breaking force of the laboratory sample to the nearest 5 N (1 lbf).

11.2 Calculate the elongation to rupture from the force-extension curve to the nearest 0.1 %. Should the force-extension curve exhibit an initial nonlinear portion, extrapolate from the straight line portion of the curve to the base line. This intersection is the point of origin for the elongation determination. The extension from this point to the force at the point of rupture is the total elongation.

11.3 Calculate the average yield strength of each laboratory sample as directed in 10.9.1 to the nearest 5 N (1 lbf).

12. Report

12.1 State that the tests were performed as directed in Test Methods D 4975, describe the material or product tested, and report the following:

12.1.1 The test results of each specimen and the laboratory sample average. Calculate and report any other data agreed to between the purchaser and the supplier,

12.1.2 Date of test,

12.1.3 Type of tensile test machine and rate of extension, and

12.1.4 Any deviation from the standard test procedure.

13. Precision and Bias

13.1 *Summary*—In comparing two averages of two observations, the differences should not exceed the following critical differences 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 same sample of material and tested on the same day:

Breaking force	15 N
Yield strength	
0.965-mm diameter wire	15 N
1.295-mm diameter wire	40 N
Elongation	0.4 %

Materials were grouped by size for yield strength determinations due to the differences calculated.

13.1.1 The magnitude of the differences is likely to be affected adversely by different circumstances. The true values of breaking force, elongation, and yield strength can be defined only in terms of specific test methods. Within this limitation, the procedures in this test method for determining these properties have no known bias. Paragraphs 13.2-13.4 explain the basis for this summary and for evaluations made under other conditions.

13.2 *Interlaboratory Test Data*—An interlaboratory test was run in 1990 in which randomly drawn samples of four materials were tested in 13 laboratories. Each laboratory used two operators, each of whom tested two specimens of each material on two separate days.

NOTE 2—The bead wire products used in the interlaboratory evaluation were of the following diameter and strength levels:

Material	Diameter	Strength
1	0.965 mm	regular
2	0.965 mm	high
3	1.295 mm	regular
4	1.295 mm	high

13.3 *Precision*—For the property of interest, two averages of observed values should be considered significantly different at the 95 % probability level if the difference equals or exceeds the critical differences given in Table 1.

NOTE 3—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 concerning any 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 specimens taken from a lot of material of the type being evaluated so as to be as nearly homogeneous as possible and then assigned randomly in equal numbers to each of the laboratories.

13.4 *Bias*—The procedures in this test method for measuring breaking force, elongation, and yield strength have no known bias because the value of these properties can be defined only in terms of a test method.

TORSION RESISTANCE

14. Summary of Test Method

14.1 A single-filament of wire is tested in torsion by either holding one end of the wire fixed while rotating the other or by rotating both ends in opposite directions at the same time until fracture occurs.

15. Significance and Use

15.1 Complex stress and strain conditions, sensitive to variations in materials, occur in a wire specimen during torsion testing. The torsion test is a useful tool in assessing wire ductility under torsional loading. Defective wire lowers torsion resistance.

16. Apparatus

16.1 *Torsion Test Machine*, an automated drive apparatus

TABLE 1 Critical Differences for Conditions Noted

Name of Property	Number of Observations	Single Operator Precision		Within-Laboratory Precision		Between-Laboratory Precision	
		Single-Material Comparisons					
Breaking force, N	1	17		17		27	
	2	12		12		25	
	4	9		9		23	
	8	6		6		22	
	16	4		4		22	
		Multi-Material Comparisons					
	1	17		17		31	
	2	12		12		28	
	4	9		9		27	
	8	6		6		26	
	16	5		5		26	
		Single-Material Comparisons					
Yield strength, N		Group 1[A]	Group 2[B]	Group 1	Group 2	Group 1	Group 2
	1	19	57	20	61	28	81
	2	14	40	14	46	24	71
	4	10	28	11	36	22	65
	8	7	20	8	30	21	61
	16	5	14	7	26	21	60
		Multi-Material Comparisons					
	1	19	57	20	61	29	92
	2	14	40	14	46	26	83
	4	10	28	11	36	24	78
	8	7	20	8	30	23	75
	16	5	14	7	26	22	74
		Single-Material Comparisons					
Elongation,%	1	0.54		0.64		1.37	
	2	0.38		0.51		1.32	
	4	0.27		0.44		1.29	
	8	0.19		0.39		1.28	
	16	0.13		0.37		1.27	
		Multi-Material Comparisons					
	1	0.55		0.65		1.43	
	2	0.39		0.52		1.37	
	4	0.29		0.45		1.35	
	8	0.22		0.41		1.33	
	16	0.17		0.38		1.33	
		Single-Material Comparisons					
Torsion resistance	1	9		10		11	
	2	6		8		9	
	4	4		6		8	
	8	3		6		8	
	16	2		5		7	
		Multi-Material Comparisons					
	1	9		10		15	
	2	7		8		14	
	4	5		7		13	
	8	4		6		12	
	16	4		6		12	
		Single-Material Comparisons					
Diameter, mm	1	0.007		0.010		0.015	
	2	0.005		0.009		0.014	
	4	0.004		0.008		0.014	
	8	0.002		0.007		0.013	
	16	0.002		0.007		0.013	
		Multi-Material Comparisons					
	1	0.007		0.010		0.020	
	2	0.005		0.009		0.020	
	4	0.004		0.008		0.019	
	8	0.002		0.007		0.019	
	16	0.002		0.007		0.019	

[A] Group 1 = Materials 1 and 2 (0.965-mm regular and high-strength products).
[B] Group 2 = Materials 3 and 4 (1.295-mm regular and high-strength products).

that allows a single-filament wire under light tension to be tested in torsion. A counter is provided that registers the number of wire rotations to wire fracture.[6]

[6] Suitable torsion testing equipment is manufactured by Sjogren Tool and Machine Co., Inc., 14 Sword St., Auburn, MA 01501.

17. Procedure

17.1 Thermally age the specimen by placing it in a suitable oven for 1 h at 150°C (300°F).[6] Allow specimens to cool to room temperature before testing.

17.2 Cut the test specimen to the appropriate length so that a gage length of 200 mm (8 in.) between chuck or jaw edges is obtained.

17.3 Certain test equipment requires that a 90° bend be put in each end of the test specimen; if that is required, measure approximately 25 mm (1 in.) from each end and bend the wire 90° with both bends in the same direction.

17.4 Place the specimen in the clamping fixtures and tighten the jaws while keeping the wire in a straight alignment. A pretension 25 ± 5 N (5.5 ± 1 lbf) shall be applied to the specimen in the longitudinal direction to aid in keeping the wire straight during testing.

17.5 Set the rotation counter to zero.

17.6 Start the equipment and run until the specimen fractures. For wire sizes below 1.40 mm (0.055 in.) use a rotation speed of 60 ± 15 r/min. For wire sizes greater than 1.40 mm (0.055 in.) use a rotation speed of 45 ± 15 r/min. Speeds in excess of these cause excessive specimen heating and can cause inaccurate results.

17.6.1 If the specimen fails within twice its diameter from the jaw edge it is considered to be a jaw break, and the result should be discarded and another specimen tested.

17.7 Conduct this test procedure on two specimens from each laboratory sampling unit.

18. Calculation

18.1 Torsion resistance is expressed as the number of full rotational turns of the wire to fracture.

19. Report

19.1 State that the tests were performed as directed in Test Methods D 4975, describe the material or product tested, and report the following:

19.1.1 The results of each specimen and the laboratory sample average,

19.1.2 Date of test,

19.1.3 Type of torsion tester and the rate of rotation, and

19.1.4 Any deviation from the standard test procedure.

20. Precision and Bias

20.1 *Summary*—In comparing two averages of two observations, the difference should not exceed the following critical differences 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 same sample of material and tested on the same day:

Torsion resistance, 6 turns (1)

The magnitude of the differences is likely to be affected adversely by different circumstances. The true values of torsion resistance can be defined only in terms of specific test methods. Within this limitation, the procedure given in this test method for determining this property has no known bias. Paragraphs 20.2-20.4 explain the basis for this summary and for evaluations made under other conditions.

20.2 *Interlaboratory Test Data*—An interlaboratory test was run in 1990 in which randomly drawn samples of four materials were tested in 12 laboratories. Each laboratory used two operators, each of whom tested two specimens of each material on two separate days (see Note 2).

20.3 *Precision*—For the property of interest, two averages of observed values should be considered significantly different at the 95 % probability level if the difference equals or exceeds the critical differences given in Table 1 (see Note 3).

20.4 *Bias*—The procedure given in this test method for measuring torsional resistance has no known bias because the value of this property can be defined only in terms of a test method.

DIAMETER (GAGE)

21. Summary of Test Method

21.1 A length of the single-filament specimen is held between two circular shaped, flat faced anvils of a micrometer. The movable anvil is closed gradually and gently until it is in contact with the specimen. The wire diameter is determined by reading the micrometer scale. The roundness is determined by a comparison of diameter measurements made at one single location on the specimen.

22. Significance and Use

22.1 Diameter is one of the basic mechanical properties of single-filament wire. Tire bead dimensions and tensile properties are dependent on the wire diameter.

23. Apparatus

23.1 *Micrometer*, precision micrometer with a vernier capable of measuring to the nearest 0.01 mm (0.0004 in.) and with circular shaped, flat anvil faces that are parallel within 0.015 mm (0.0006 in.).[7]

23.1.1 Non-contact optical measuring systems are available, allowing for greater precision and ease of measurement, and may be used as an optical method of diameter determination.[8]

24. Procedure

24.1 Verify that the measuring instrument reads 0.00 mm when the anvils are closed. Determine the maximum and minimum diameter by measurements to the nearest 0.005 mm (0.0002 in.) in approximately the middle of one specimen from each laboratory sampling unit.

25. Calculation

25.1 Determine the diameter (gage) of the laboratory sample by calculating the arithmetic average of the minimum and maximum values.

25.2 Determine the out-of-roundness for each laboratory sample as the difference between the maximum and minimum diameter.

26. Report

26.1 State that the test specimens were tested as directed in Test Methods D 4975, describe the material or product tested, and report the following:

---

[7] A suitable micrometer would be No. 230 Series manufactured by the L. S. Starrett Company, Athol, MA 01331.

[8] A suitable optical micrometer system is produced by Techmet Company, Lasermike Division, 6060 Executive Blvd., Dayton, OH 45424.

26.1.1 The average laboratory sample diameter to the nearest 0.005 mm (0.0002 in.),

26.1.2 The out-of-roundness for the laboratory sample as determined in 25.2, and

26.1.3 Date of test.

27. Precision and Bias

27.1 *Summary*—In comparing two averages of two observations, the difference should not exceed the following critical differences 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 same sample of material and tested on the same day:

Diameter, 0.007 mm (2)

The magnitude of the differences is likely to be affected adversely by different circumstances. The true value of diameter can be defined only in terms of specific test methods. Within this limitation, the procedure given in this test method for determining this property has no known bias. Paragraphs 27.2-27.4 explain the basis for this summary and for evaluations made under other conditions.

27.2 *Interlaboratory Test Data*[7]—An interlaboratory test was run in 1990 in which randomly drawn samples of four materials were tested in 13 laboratories. Each laboratory used two operators, each of whom tested one specimen of each material on two separate days (see Note 2).

27.3 *Precision*—For the property of interest, two averages of observed values should be considered significantly different at the 95 % probability level if the difference equals or exceeds the critical differences given in Table 1 (see Note 3).

27.4 *Bias*—The procedure given in this test method for measuring diameter has no known bias because the value of this property can be defined only in terms of a test method.

28. Keywords

28.1 diameter; elongation; strength; tire bead wire; torsion.

APPENDIX

(Nonmandatory Information)

X1. SUGGESTED DATA FORM REPORTING TEST RESULTS

X1.1 To facilitate the reporting of test results for a lot of tire bead wire, especially when the data is to be transmitted electronically or recorded on diskettes designed to be read electronically, it is suggested that the data form in Table X1.1

TABLE X1.1 Data Form for Test Results from Lots of Tire Bead Wire

Line Sequence Number	**Lot Identification**						
1	Supplier Code:			Supplier Lot Number:			Supplier Category:
2	Purchaser Specification Number:			Purchaser Plant Code:			
3	Date Shipped			Date Tested:			
4	Purchase Order Number						
5	Reel Type:			Number of Reels:			
	Characteristic	Samples	Average	Std. Dev.	Minimum	Maximum	CpK or PpK Limit
6	Diamter	NN	N.NNN	N.NNNN	N.NNN	N.NNN	NN.NN
7	Breaking Strength	NN	NNNN.	NNNN.N	NNNN.	NNNN.	NN.NN
8	Yield Strength	NN	NNNN.	NNNN.N	NNNN.	NNNN.	NN.NN
9	Yield to Break Ratio	NN	NN.N	NN.NN	NN.N	NN.N	NN.NN
10	Elongation	NN	NN.N	NN.NN	NN.N	NN.N	NN.NN
11	Torsion Resistance	NN	NN.	NN.N	NN.	NN.	NN.NN
12	Adhesion Value	NN	NNNN.	NNNN.N	NNNN.	NNNN.	NN.NN
13	Percent Tin	NN	N.NN	N.NNN	N.NN	N.NN	NN.NN
14	Coating Weight	NN	N.NN	N.NNN	N.NN	N.NN	NN.NN
15	Straightness	NN	NN.N	NN.NN	NN.N	NN.N	NN.NN
16	Helix	NN	N.N	N.NN	N.N	N.N	NN.NN
17	Residual Twist	NN	N.N	N.NN	N.N	N.N	NN.NN
18	"Cumar" Resin	NN	N.NN	N.NNN	N.NN	N.NN	NN.NN
19	Spare	N	N	N	N	N	NN.NN
20	Spare	N	N	N	N	N	NN.NN
21	Spare	N	N	N	N	N	NN.NN
22	Spare	N	N	N	N	N	NN.NN
23	Spare	N	N	N	N	N	NN.NN
24	Spare	N	N	N	N	N	NN.NN
25	Spare	N	N	N	N	N	NN.NN

Symbol Dictionary
A-Alphanumeric Character
N-Numeric Chracter
YYMMDD-International Data Format
All test methods and reporting units must be in accordance with purchaser specifications.

be utilized.

X1.2 The key element in the suggested form is that neither the characteristic nor the lot identification associated with each line sequence number be violated. As as example, if the data on diamter is required, then it must be preceded by the line sequence number 10. If data on a certain characteristic is not required, then no adjustment should be made in the line sequence numbers for the subsequent characteristics; simply do not utilize the line sequence number shown for the characteristic for which no data is required.

X1.3 It is suggested that line sequence numbers of 13 or greater be used for characteristics that are not the subject of an ASTM standard. This procedure will facilitate the possible future expansion of ASTM standards.

X1.4 Addition, deletion, or reordering of columns within the form should be only by mutual agreement between the purchaser and the supplier.

X1.5 Restrictions on the values of entries within a row, between rows, and between groups of rows should be by mutual agreement between the purchaser and the supplier.