Designation: B986 – 13ε1

Standard Test Method for
Determination of Tensile Strength by Mass Method for Stranded Conductors Intended for use in Electronic Application[1]

This standard is issued under the fixed designation B986; 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.

ε1 NOTE—The units for CM in Section 7.1 were editorially corrected in August 2013.

1. Scope

1.1 This test method covers the procedure for determining the tensile strength by a mass method for uninsulated stranded electrical conductors intended for use in electronic application (Explanatory Note 1).

1.1.1 The test method is intended for conductors that are one type of wire (non-composite). The wire type being plain, clad, or coated and stranded together to operate mechanically and electrically as a single conductor.

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 *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. Some specific hazards statements are given in Section 7 on Hazards.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

B354 Terminology Relating to Uninsulated Metallic Electrical Conductors

B800 Specification for 8000 Series Aluminum Alloy Wire for Electrical Purposes—Annealed and Intermediate Tempers

E4 Practices for Force Verification of Testing Machines

E8/E8M Test Methods for Tension Testing of Metallic Materials

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this test method, refer to Terminology B354.

4. Significance and Use

4.1 This test method is designed as an inspection or acceptance test of tensile strength for stranded metallic conductors.

5. Apparatus

5.1 *Tensile Testing Machine*—Machines used for tension testing shall conform to the requirements of Practices E4.

5.2 *Balance,* for measurement of mass, accurate to 0.1 %.

5.3 *Steel Scale,* for measurement of length, with smaller divisions, not greater than 1/32 in. (1 mm).

5.4 *Jig, or equivalent equipment,* for cutting the conductor to length and at right angles to its axis.

6. Procedure

6.1 *Breaking Load:*

6.1.1 Conduct tensile test in accordance with Test Methods E8/E8M and with a rate of loading not to exceed 10 in./min (250 mm/min.) (Explanatory Note 2 and Note 3).

6.2 *Specimen Mass/Unit Length:*

6.2.1 Cut the test specimens, making sure that the ends are at right angles to the axis of the conductor. The length of test specimens shall be 2 ft (610 mm) minimum (Explanatory Note 2).

6.2.2 Measure the length of the specimen at room temperature (see Note 1) to the nearest 1/32 in. (1 mm) and measure the mass to within ±0.1 % accuracy, converting to lb/1000 ft or kg/km, if weighed in other units.

NOTE 1—Correction for temperature variation need not be made, since the error introduced in the length measurement by the temperature variation is less than the required accuracy of the length measurement.

7. Calculation

7.1 Calculate the tensile strength of the stranded conductor as follows (Explanatory Note 1):

$$TS = (BL/CM) \times MF \times [(100 + k)/100]$$

where:

TS = tensile strength of the stranded conductor, lb/in.^{2} (N/mm^2),

BL = breaking load measurement read directly from the tensile tester, lb (N),

CM = mass of conductor per unit length, lb/1000 ft (kg/km),

MF = material factor, lb/in^2 · 1000 ft (kg/mm^2 · km), (Table 1 and Explanatory Note 4 and Note 5), and

k = increment (increase) in mass and electrical resistance (from product specification), %. If no k value is given, the use $k = 0$.

8. Precision and Bias

8.1 *Precision and Bias*—The precision and bias of this test method for tensile strength are essentially as specified in Test Methods E8/E8M.

9. Keywords

9.1 breaking loads; mass methods; metallic conductors; tensile strength

EXPLANATORY NOTES

NOTE 1—Cross-sectional area of a stranded conductor used in electronic applications can be difficult to determine since single wire diameters measured from the completed conductor can be deformed. The formula for tensile strength based on a mass method can be derived as follows:

The basic equation for tensile strength is:

$$TS = BL/A, \text{ where breaking load is a}$$
$$\text{direct test measurement} \quad (1)$$

The cross-sectional area can be derived based on density and mass per unit length. Thus, the generalized formula for stranded conductor cross-sectional area based on mass is:

$$A = [M/(L \times D)] \times [100/(100 + k)] \quad (2)$$

The generalized formula for tensile strength of the stranded conductor based on a mass method can be derived as follows:

$$TS = [BL/M] \times L \times D \times [(100+k)/100] \quad (3)$$

where:

TS = tensile strength of the stranded conductor, lb/in.^{2} (N/mm^2),

BL = breaking load measurement read directly form the tensile tester, lb (N),

A = cross-sectional area, in.^{2} (mm^2),

M = mass, lb (kg),

L = length, in. (mm),

D = density, lb/in.^{3} (kg/mm^3), and

k = increment (increase) in mass and electrical resistance, %.

The condensed formula in 7.1 is based on conductor mass in lbs/1000 ft (kg/km).

The material factor in 7.1 is the density (lb/in.^3)
$$\times (12\,000 \text{ in./1000 ft}), \text{ or} \quad (4)$$

The material factor in 7.1 is the density (kg/mm^3)
$$\times (1 \times 10^6 \text{ mm/km}) \quad (5)$$

NOTE 2—For rope constructions, where the sample may exceed the capacity of the scale or the breaking load may exceed the extensometer loading capacity, the user of the standard may elect to break the sample down into smaller constructions (that is, members of a rope) and average the results depending on the number of members tested.

NOTE 3—Should a failure occur, the manufacturer may retest if the cause of the failure is suspected to be an error in the testing procedure, set-up, or factors other than non-conformance with the tensile requirements. For example, if a tensile test fails due to a break within the gripping region, the failure may be due to a gripping deficiency, and that would be a valid cause for retesting the production unit.

TABLE 1 Material Factory, MF[A]

Metal	Density, lb/in.³ (g/cm³)	Material Factor, MF, lb/in.² · 1000 ft (kg/mm² · km)
Copper-Bare, Nickel coated copper	0.32117 (8.89)	3854 (8.89)
Copper-Silver coated Class A (1.25 %)	0.32179 (8.91)	3861 (8.91)
Copper-Silver coated Class B (2.50 %)	0.32241 (8.93)	3869 (8.93)
Copper-Silver coated Class C (4.00 %)	0.32315 (8.95)	3787 (8.95)
Copper-Silver coated Class D (6.10 %)	0.32420 (8.97)	3890 (8.97)
Copper-Silver coated Class E (10.0 %)	0.32617 (9.03)	3914 (9.03)
Copper-Clad Steel (CCS30)	0.29440 (8.15)	3533 (8.15)
Copper-Clad Steel (CCS40)	0.29750 (8.24)	3570 (8.24)
Aluminum 1350	0.09750 (2.70)	1170 (2.70)
Copper-Clad Aluminum (10A and 10H)	0.12000 (3.32)	1440 (3.32)
Copper-Clad Aluminum (15A and 15H)	0.13118 (3.63)	1574 (3.63)
Aluminum Alloy Series 8000 (per ASTM B800)	0.098000 (2.71)	1176 (2.71)

[A] See Explanatory Note 4 and Note 5.

NOTE 4—The calculations and method can be applied to metals, copper-alloys, or proprietary copper-alloys not covered in Table 1 by calculating the appropriate material factor based on metal density. Refer to Eq 4 and Eq 5 from Explanatory Note 1 for material factor calculation.

NOTE 5—The effective density of a coated conductor is not constant, but a variable function of coating %. For the purposes of this standard, silver coating density is taken as 0.37933 lb/in.^{3} (10.5 g/cm^3) and tin coating density is taken as 0.2640 lb/in.^{3} (7.31 g/cm^3). For the purposes of this standard, the density of nickel shall be considered the same as copper. Refer to Eq 4 and Eq 5 from Explanatory Note 1 for material factor

calculation using the calculated effective density.

$$\text{Effective Density} = 1 / \big[\big((\text{coating \% / 100}) / \text{coating density} \big) +$$
$$\big((1 - (\text{coating \% / 100})) / \text{base metal density} \big) \big]$$

where:

Density = coating or base metal density, lb/in.^{3} (g/cm^3). Note that 1.0 g/cm^3 = 1.0 kg/mm^3 when referring to Eq 5 from Explanatory Note 1 to determine the metric material factor.