Designation: F16 – 12 (Reapproved 2022)

Standard Test Methods for Measuring Diameter or Thickness of Wire and Ribbon for Electronic Devices and Lamps[1]

This standard is issued under the fixed designation F16; 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 procedures for measuring the diameter or thickness of round and flat wire (ribbon) 0.060 in. (1.52 mm) maximum used in electronic devices and lamps.

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

1.4 *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. Summary of Test Method

2.1 In order to provide reliable determinations of physical dimensions of wire and ribbon products, these test methods are designed to mechanically measure the diameter or thickness with a high degree of precision. These test methods are based on the use of a sensitive measuring head with calibrated pressure settings, shaped measuring anvils to reduce errors caused by material curvature or waviness, and a method for presetting the anvil spacing by means of gauge blocks or cylindrical master standards.

3. Significance and Use

3.1 The methods contained in this standard are intended primarily for referee use, for laboratory measuring, and for certifying size of standard samples used for checking other measuring equipment that may be agreed upon between the supplier and the purchaser.

4. Apparatus

4.1 Either of two general types of apparatus may be used for measuring, depending on the accuracy desired and on the availability of certified cylindrical master standards for gauge setting, as follows:

4.1.1 *Apparatus A*—For use with cylindrical master standards for gauge setting.

4.1.2 *Apparatus B*—For use with gauge block standards for gauge setting.

4.2 *Apparatus A,* shown in Fig. 1, shall have the following features:

4.2.1 An adjustable anvil of the size and shape specified for the material to be inspected. The anvil shall be nonrotating and shall be adjustable for position by means of a micrometer or precision adjusting screw, with means for locking the anvil in any set position after adjustments have been made.

4.2.2 A sensing anvil of the size and shape specified for the material to be measured, linked directly to a sensing and indicating device of specified precision and sensitivity.

4.2.3 The adjustable fixed anvil and sensing anvil and the sensing device shall be rigidly mounted with both anvils in alignment on the same axis. The sensing anvil shall be movable with provisions for retracting the anvil for placing the specimen in the measuring position.

4.2.4 Both anvils shall be properly fitted, lapped, and polished so the contacting surfaces are flat and parallel within the accuracy specified.

4.2.5 The sensing device shall be provided with a means for setting the indicator hand or scale to zero, and a calibrated scale or dial for setting the sensing anvil measuring pressure to the specified value required for measuring. This setting shall be accurate to within± 10 % of the set value.

4.3 *Apparatus B,* shown in Fig. 2, shall meet the requirements specified for Apparatus *A* in 4.2 with the following additional features:

4.3.1 The fixed anvil and support to which it is attached shall be free to move along the measuring axis but shall be held in line with the sensing anvil by means of cantilever springs so that parallelism with the sensing anvil is maintained. The

[1] These test methods are under the jurisdiction of ASTM Committee F01 on Electronics and are the direct responsibility of Subcommittee F01.03 on Metallic Materials, Wire Bonding, and Flip Chip.

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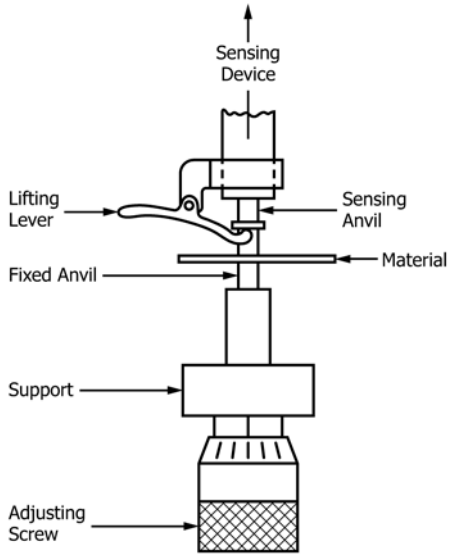

FIG. 1 Measuring Apparatus A for use with Cylindrical Master Standards for Gauge Setting

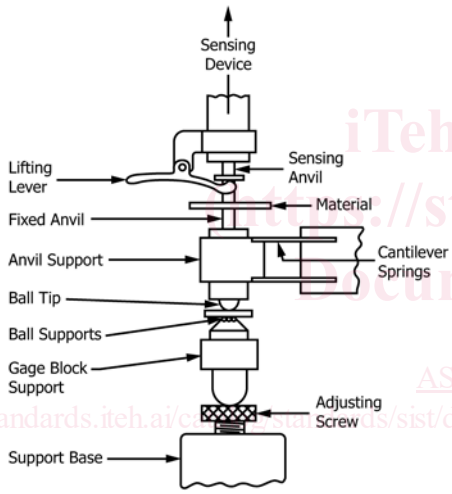

FIG. 2 Measuring Apparatus B for use with Gauge Block Standards for Gauge Setting

opposite end of the movable anvil support shall terminate in a ball contact having a diameter from 0.19 in. to 0.25 in. (4.8 mm to 6.4 mm). The total pressure of the support and springs shall exert a force of 500 ± 0 *g* on the gauge block.

4.3.2 The gauge block for setting shall be located directly in contact with the movable anvil support ball contact. The opposite side of the gauge block shall be supported at three places by hardened steel balls 0.09 in. to 0.12 in. (2.4 mm to 3.2 mm) in diameter and equilaterally spaced to form a triangle.

4.3.3 The three ball contacts shall be securely fixed to a support table and shall be movable for setting the measuring device by means of a precision adjusting screw. Provision shall be made for securely locking the table in place after setting.

5. Test Specimens

5.1 Test specimens shall be selected at least 3 ft (0.9 m) from the end of a spool or coil of material and shall be straight and free from kinks, dents, or other damage that would interfere with measuring accuracy.

5.2 Wire or fine ribbon shall be drawn from the spool under uniformly low tension to prevent elongation. If the material is obviously contaminated with oil, dirt, or other foreign matter, it shall be drawn gently through a lint-free cloth, wet with a suitable solvent.

6. Test Conditions

6.1 The measuring device shall be used in a location that is clean and free of dust and lint. Vibration, drafts, direct heat from lamps, and temperature variations shall be minimized. The equipment shall be kept clean and covered when not in use.

6.2 For fine wire, smaller than 0.0008 in. (0.02 mm) in diameter, extra precautions shall be taken to avoid all possible causes (see 6.1) of inaccurate measurements. The measuring devices shall be used in a small gauge laboratory with temperature variations kept to within ±5 °C. The equipment shall be laid out on a clean surface with tools and gauge blocks on foam rubber pads. All equipment used for measuring, and the material samples, shall be stabilized by leaving them together in the gauge room for at least 1 h. Gauge blocks shall be handled with tongs to prevent temperature variations.

6.3 Gauge blocks shall be recalibrated at least once every year, using the block calibration size for the calibration setting. Blocks must be carefully cleaned and handled to prevent uneven wear with consequent introduction of errors into the gauge setting.

6.4 The device shall be cleaned, calibrated, and set for measuring by means of certified gauge blocks or cylindrical master standards as specified in Section 11.

7. Setting Measuring Apparatus

7.1 Set the measuring apparatus by means of standards so that the indicator hand or scale of the sensing device is at zero when adjusted for the nominal size of the material to be measured. This shall be done by means of certified cylindrical master standards for Apparatus *A* and by means of certified gauge blocks for Apparatus *B*.

7.2 Cylindrical master standards shall be certified for diameter, roundness, and surface finish by a metrology laboratory. The master cylinders of wire shall be made of hardened steel having a Rockwell hardness of 63 to 65 HRC, and lapped to a finish of 1 µin. rms or a 4-µin. height (0.0001 mm).

7.3 Gauge blocks shall be certified for length, flatness, parallelism, and surface finish by a metrology laboratory. The exact thickness of the blocks shall be reported to the nearest microinch (0.000025 mm) as measured near the center of each block. The surface finish shall be equivalent to 1 µin. rms or a 4-µin. (0.0001 mm) height or better.

7.4 Set Apparatus *A* for the nominal material size to be measured by placing a cylindrical master standard between the two anvils and adjusting the fixed anvil adjusting screw to get a zero reading on the sensing device. Raise and lower the

sensing anvil against the standard several times and readjust the screw until three consecutive zero readings are obtained.

7.5 Set Apparatus *B* for nominal material size to be measured by means of gauge blocks. Select two blocks with a difference equal to the nominal size of the material. Use the exact length of the blocks as taken from the last certification. Place the longer block between the three-ball support table and the ball end of the anvil support block, and carefully seat near the center of the block. Turn the adjusting screw until the indicator on the sensing device is on zero. Raise the ball end of the anvil support block, remove the longer gauge block, and replace it with the shorter block in the same position. This in effect lowers the fixed measuring anvil from the first zero setting by an amount equal to the nominal size of the material to be measured. Leave this gauge block in place while measurements are being made.

7.6 To keep the effect of temperature variations to a minimum, handle each block with insulated tongs when placed into position. Both blocks may also be inserted and interchanged by means of a shifting device for moving either block into the proper position. This keeps handling to a minimum and prevents hands from contacting the blocks when changing.

8. Procedure A for Measuring Fine Round Wire

8.1 Measure fine round wire less than 0.0008 in. (0.0203 mm) in diameter with anvils as illustrated in Fig. 3 except fixed anvil shall have a radius of 1 in. (25.4 mm). Measure fine round wire more than 0.0008 in. (0.0203 mm) and less than 0.010 in. (0.25 mm) in diameter with flat parallel anvils having a diameter from 0.115 in. to 0.135 in. (2.9 to 3.4 mm). Lap both anvils flat and parallel and polish to a surface finish of 1 µin. r/s or a 4-µin. (0.0001 mm) height. Observe the basic requirements for measuring, including anvil pressure and overall precision of the anvils and measuring apparatus, as specified in Table 1.

8.2 Set the apparatus for measuring as specified in Section 11. Retract the upper anvil by means of the lifting level and insert the wire specimen between the anvils. Lower the sensing anvil against the specimen and read the deviation of the diameter from the nominal size directly on the indicator and scale of the sensing device. Report the wire size as the average of three separate determinations made on specimens from the same spool.

8.3 The wire specimen may be rotated between the anvils for out-of-roundness measurements as specified in Section 11.

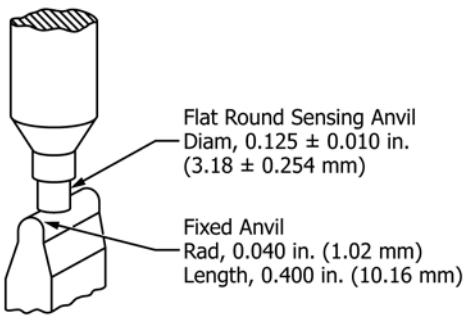

FIG. 3 Arrangement of Anvils for Measuring Large Round Wire

9. Procedure B for Measuring Large Round Wire

9.1 Measure round wire, which is between 0.010 in. and 0.060 in. (0.25 mm and 1.5 mm) in diameter, with combination flat and cylindrical anvils as illustrated in Fig. 3. Lap the measuring surface of the sensing anvil 0.115 in. to 0.135 in. (2.93 mm to 3.43 mm) diameter) and polish to a surface finish of 1 µin. r/s or a 4-µin. (0.0001 mm) height. The fixed anvil shall be cylindrical in shape with a radius of approximately 0.040 in. (1.0 mm) and a length of approximately 0.4 in. (10 mm). Adjust the fixed anvil so that the contacting surfaces of the anvils are parallel within 0.00001 in. (0.00025 mm).

9.2 A wire location guide may be used on one side of the fixed anvil for locating each piece of wire in approximately the same position between the anvils. Observe the requirements for measuring, including anvil pressure and maximum overall precision of the anvils and measuring apparatus, as specified in Table 2.

9.3 Set the apparatus for measuring as specified in Section 7. Retract the sensing anvil and insert the wire specimen between the anvils and against the back wire positioning guide. Lower the sensing anvil slowly against the specimen and read the deviation of the wire diameter from the nominal size on the scale and indicator of the sensing device. Report the wire diameter as the average of three separate determinations made on specimens from the same spool.

9.4 The wire specimen may be rotated between anvils for out-of-roundness measurements as specified in Section 11.

10. Procedure C for Measuring Thickness of Flat Wire and Ribbon

10.1 Measure flat wire and ribbon by means of the following anvils:

10.1.1 For flat wire up to 0.060 in. (1.5 mm) in thickness use the anvils specified in 9.1 and illustrated in Fig. 3.

10.1.2 For ribbon and strip materials up to 0.030 in. (0.8 mm) in thickness measure with two cylindrical anvils crossed at right angles as illustrated in Fig. 4. The sensing anvil and the fixed anvil shall have a radius of 0.40 in. (10 mm) and a length of approximately 0.40 in. (10 mm).

10.2 Observe the requirements of measuring, including anvil pressure and maximum overall precision of the anvils and apparatus, as specified in Table 3.

10.3 The measuring apparatus shall be set, calibrated and used as specified in Section 7 and 9.3.

11. Measuring Out-of-Roundness

11.1 The apparatus specified in Sections 8 and 9 for measuring wire diameters shall be used for measuring out-of-roundness.

11.2 For wire under 0.010 in. (0.25 mm) in diameter, hold the wire in a rotating device designed to turn the wire about its longitudinal axis between the anvils of the measuring device.

11.3 For wire between 0.010 in. and 0.060 in. (0.25 mm and 1.5 mm) in diameter, hold one end of the wire in a small pin vice or between the fingers and rotate it between the measuring