Designation: F 16 – 67 (Reapproved 2000)

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 F 16; 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. They 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.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values in parentheses are for information only.

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.*

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 measure mechanically 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 gage blocks or cylindrical master standards.

3. Apparatus

3.1 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 gage setting, as follows:

3.1.1 *Apparatus A*— For use with cylindrical master standards for gage setting.

3.1.2 *Apparatus B*— For use with gage block standards for gage setting.

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

3.2.1 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.

3.2.2 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.

3.2.3 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.

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

3.2.5 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.

3.3 *Apparatus B*, shown in Fig. 2, shall meet the requirements specified for Apparatus *A* in 3.2 with the following additional features:

3.3.1 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 opposite end of the movable anvil support shall terminate in a ball contact having a diameter from 0.19 to 0.25 in. (4.8 to 6.4 mm). The total pressure of the support and springs shall exert a force of 500 ± 10 *g* on the gage block.

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

3.3.3 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.

[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.

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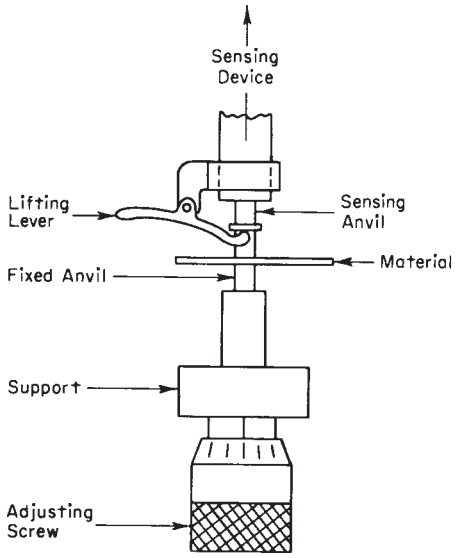

FIG. 1 Measuring Apparatus A for Use with Cylindrical Master Standards for Gage Setting

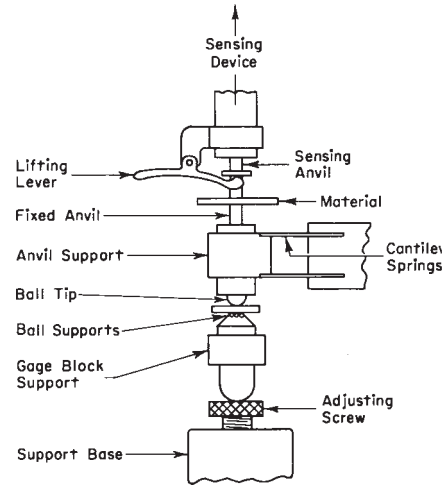

FIG. 2 Measuring Apparatus B for Use with Gage Block Standards for Gage Setting

4. Test Specimens

4.1 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.

4.2 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.

5. Test Conditions

5.1 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.

5.2 For fine wire, smaller than 0.0008 in. (0.02 mm) in diameter, extra precautions shall be taken to avoid all possible causes (see 5.1) of inaccurate measurements. The measuring devices shall be used in a small gage laboratory with temperature variations kept to within ± 5°C. The equipment shall be laid out on a clean surface with tools and gage blocks on foam rubber pads. All equipment used for measuring, and the material samples, shall be stabilized by leaving them together in the gage room for at least 1 h. Gage blocks shall be handled with tongs to prevent temperature variations.

5.3 Gage 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 gage setting.

5.4 The device shall be cleaned, calibrated, and set for measuring by means of certified gage blocks or cylindrical master standards as specified in Section 10.

6. Setting Measuring Apparatus

6.1 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 gage blocks for Apparatus *B*.

6.2 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 C63 to C65, and lapped to a finish of 1 µin. rms or a 4-µin. height (0.0001 mm).

6.3 Gage 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.

6.4 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.

6.5 Set Apparatus *B* for nominal material size to be measured by means of gage 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 gage 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 gage block in place while measurements are being made.

6.6 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.

7. Procedure A for Measuring Fine Round Wire

7.1 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.

7.2 Set the apparatus for measuring as specified in Section 10. 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.

7.3 The wire specimen may be rotated between the anvils for out-of-roundness measurements as specified in Section 10.

8. Procedure B for Measuring Large Round Wire

8.1 Measure round wire, which is between 0.010 and 0.060 in. (0.25 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 to 0.135 in. (2.93 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).

8.2 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.

8.3 Set the apparatus for measuring as specified in Section 6. Retract the sensing anvil and insert the wire specimen between the anvils and against the back wire positioning guide.

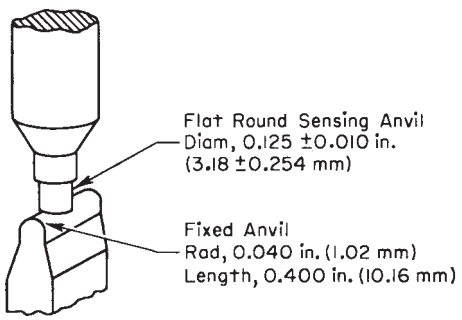

FIG. 3 Arrangement of Anvils for Measuring Large Round Wire

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.

8.4 The wire specimen may be rotated between anvils for out-of-roundness measurements as specified in Section 10.

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

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

9.1.1 For flat wire up to 0.060 in. (1.5 mm) in thickness use the anvils specified in 8.1 and illustrated in Fig. 3.

9.1.2 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).

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

9.3 The measuring apparatus shall be set, calibrated and used as specified in Section 6 and 8.3.

10. Measuring Out-of-Roundness

10.1 The apparatus specified in Sections 7 and 8 for measuring wire diameters shall be used for measuring out-of-roundness.

10.2 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.

10.3 For wire between 0.010 and 0.060 in. (0.25 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 anvils. One end of the wire may be turned up to form a flag so that the degree of rotation may be observed.

10.4 With a wire specimen between the anvils, retract the sensing anvil before each rotation of the wire and lower it again onto the specimen after the rotation has stopped. With heavier wire, having a degree of curvature, place the concave side of the curved surface against the fixed anvil and rotate the specimen a maximum of 180°, between points where the plane of curvature is parallel to the plane of the fixed anvil face.

10.5 Make sufficient readings to determine the minimum and maximum diameter of the material. Determine the extent of out-of-roundness by subtracting the minimum diameter from the maximum diameter reading. If the percent of out-of-roundness is required, calculate it as follows:

$$\text{Out-of-roundness, \%} = (\text{max diam} - \text{min diam}/\text{max diam}) \times 100$$

11. Checking Anvil Errors

11.1 A periodic check shall be made of the flatness and parallelism of the measuring anvils as follows:

11.1.1 *Apparatus*—The apparatus shall consist of a monochromatic light source having a wavelength of 2946 Å, a small optical parallel having an accuracy of 2 µin. r/s (0.00005 mm),

TABLE 1 Requirements for Measuring Round Wire Under 0.010 in. (0.25 mm) in Diameter

Wire Diameter		Anvil Pressure		Smallest Indicator Graduation		Maximum Error Due to Anvils and Apparatus	
in.	mm	oz	g	in.	mm	in.	mm
0.0001 to 0.0003	0.0025 to 0.0076	½ ± 1/16	14 ± 1.8	0.000001	0.000025	0.000001	0.000025
0.00031 to 0.0008	0.0077 to 0.0203	1 ± ⅛	28 ± 3.5	0.000002	0.000051	0.000002	0.000051
0.00081 to 0.002	0.0204 to 0.0508	2 ± ¼	57 ± 7	0.000005	0.00013	0.000005	0.00013
0.0021 to 0.005	0.0509 to 0.127	4 ± ½	113 ± 14	0.000010	0.00025	0.000010	0.00025
0.0051 to 0.010	0.128 to 0.254	8 ± 1	227 ± 28	0.000020	0.00051	0.000020	0.0005 1

TABLE 2 Requirements for Measuring Round Wire 0.010 to 0.060 in. (0.25 to 1.5 mm) in Diameter

Wire Diameter		Anvil Pressure		Smallest Indicator Graduation		Maximum Error Due to Anvils and Apparatus	
in.	mm	oz	g	in.	mm	in.	mm
0.010 to 0.035	0.254 to 0.889	4 ±½	113 ± 14	0.000025	0.00064	0.000020	0.00051
0.0351 to 0.060	0.890 to 1.524	8 ± 1	227 ± 28	0.000050	0.0013	0.000025	0.00064

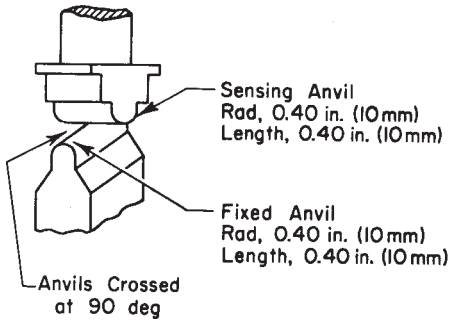

FIG. 4 Arrangement of Anvils for Measuring Ribbon

a small ball gage of about 0.0625-in. (1.59-mm) radius, and a cylindrical master standard wire gage of about 0.025 in. (0.635).

11.1.2 *Procedure*:

11.1.2.1 *Flatness*—With parallel anvils, check the flatness with the small optical parallel. First clean the anvils with a suitable solvent and polish with a lint-free cloth or lens tissue. Rest the optical parallel on the surface of the fixed anvil and close the sensing anvil on the parallel using approximately 16-oz (450-g) pressure. Observe the location, shape, number of interference bands and determine the maximum deviation from flatness for each anvil. The error due to lack of flatness shall not exceed 5 µin. (0.00013 mm).

11.1.2.2 *Parallelism*— With flat parallel anvils, determine the lack of parallelism by exploring the entire surface of the anvils with a small ball gage with the anvils closed on the gage. Read the maximum lack of parallelism from the indicator of the sensing device. With anvils having line contact, with flat top anvil and cylindrical bottom anvil, explore the entire length of the contacting edge with the cylindrical master standard gage and determine the maximum deviation from the indicator. In no case shall the maximum deviation from parallelism exceed 5 µin. r/s (0.00013 mm).

12. Calibration of Anvil Pressure

12.1 *Apparatus*—Calibrate the anvil pressures with any small force gage having an extension arm that can be set directly against the sensing anvil. The force gage shall be prechecked for calibration against dead weights through the full range.

12.2 *Procedure*—Attach the force gate to an adjustable stand so the force measuring tip at the end of the gage arm can be set directly under and in contact with the sensing anvil as illustrated in Fig. 5. Adjust the force gage until the pointer on

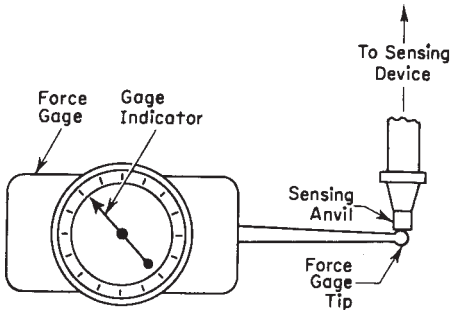

FIG. 5 Force Gage for Measuring Anvil Pressure

the sensing device is near zero and read the pressure directly from the force gage dial. If the sensing device has calibrated pressure settings, check each setting for accuracy. If not, calibrate and mark the sensing device or set it to the specified measuring pressure before making measurements.

13. Measuring Diameter of Short Lengths

13.1 The diameter of short wire sections welded between other sections, and too short to accept the standard mea-suring anvil may be checked with a smaller sensing anvil. This anvil shall be approximately 0.040 in. (1.0 mm) in diameter. The measuring pressure shall be the same as that specified in Table 2.

14. Keywords

14.1 anvil-type measuring devices; diameter and roundness measurements for wire; thickness measurements for ribbon

TABLE 3 Requirements for Measuring Flat Wire and Ribbon from 0.0005 to 0.060 in. (0.013 to 1.5 mm) in Thickness

Material Thickness		Anvil Pressure For Flat Wire Anvils (Fig. 3)		Anvil Pressure For Ribbon Anvils (Fig. 4)		Smallest Indicator Graduation		Maximum Error Due to Anvils and Apparatus	
in.	mm	oz	g	oz	g	in.	mm	in.	mm
0.0005 to 0.0035	0.0127 to 0.0889	8 ÷ 1	227 ÷ 28	2 ÷ 1/4	57 ÷ 7	0.000010	0.00025	0.000010	0.00025
0.0036 to 0.0300	0.090 to 0.762	16 ÷ 2	454 ÷ 57	4 ÷ 1/2	113 ÷ 14	0.000025	0.00064	0.000020	0.00051
0.0301 to 0.0600	0.763 to 1.524	32 ÷ 4	908 ÷ 104	...	...	0.000050	0.0013	0.000020	0.00051