Designation: D 5947 – 96

AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Test Methods for Physical Dimensions of Solid Plastics Specimens[1]

This standard is issued under the fixed designation D 5947; 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 determination of the physical dimensions of solid plastic specimens where the dimensions are used directly in determining the results of tests for various properties. Use these test methods except as otherwise required in material specifications.

1.2 The values stated in SI units are to be regarded as the 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.*

NOTE 1—There is no similar or equivalent ISO standard.

2. Referenced Documents

2.1 *ASTM Standards:*

D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing[2]

D 883 Terminology Relating to Plastics[2]

D 4805 Terminology for Plastics Standards[3]

2.2 *ISO Standard:*

ISO 472 Plastics—Vocabulary[4]

3. Terminology

3.1 *Definitions*—See Terminologies D 883 and D 4805, and ISO 472 for definitions pertinent to these test methods.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *absolute uncertainty (of a measurement), n*—the smallest division that may be read directly on the instrument used for measurement.

3.2.2 *calibration*—the set of operations that establishes, under specified conditions, the relationship between values measured or indicated by an instrument or system, and the corresponding reference standard or known values derived from the appropriate reference standards.

3.2.3 *micrometer, n*—an instrument for measuring any dimension within absolute uncertainty of 25 µm or smaller.

3.2.4 *verification*—proof, with the use of calibrated standards or standard reference materials, that the calibrated instrument is operating within specified requirements.

3.2.5 *1 mil, n*—a dimension equivalent to 25 µm (0.0010 in.).

4. Summary of Test Methods

4.1 These test methods provide five different test methods for the measurement of physical dimensions of solid plastic specimens. The test methods (identified as Test Methods A through D, and H) use different micrometers that exert various pressures for varying times upon specimens of different geometries. Tables 1 and 2 display the basic differences of each test method and identify methods applicable for use on various plastics materials.

5. Significance and Use

5.1 These test methods shall be used where precise dimensions are necessary for the calculation of properties expressed in physical units. They are not intended to replace practical thickness measurements based on commercial portable tools, nor is it implied that thickness measurements made by the procedures will agree exactly.

6. Apparatus

6.1 *Apparatus A—Machinist's Micrometer Caliper[5] with Calibrated Ratchet or Friction Thimble:*

6.1.1 Apparatus A is a micrometer caliper without a locking device but that is equipped with either a calibrated ratchet or a friction thimble. The pressure exerted on the specimen is controllable by the use of a proper manipulative procedure and a calibrated spring (see Annex A1).

6.1.2 Use an instrument constructed with a vernier capable of measurement to the nearest 2.5 µm.

6.1.3 Use an instrument with the diameter of the anvil and spindle surfaces (which contact the specimen) of 6.4 ± 0.1 mm.

6.1.4 Use an instrument conforming to the requirements of 8.1, 8.2, 8.5, 8.6.1, and 8.6.2.

6.1.5 Test the micrometer periodically for conformance to the requirements of 6.1.4.

6.2 *Apparatus B—Machinist's Micrometer Without a Ratchet*:

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[1] These test methods are under the jurisdiction of ASTM Committee D-20 on Plastics and are the direct responsibility of Subcommittee D20.10 on Mechanical Properties.

Current edition approved April 10, 1996. Published June 1996.

[2] *Annual Book of ASTM Standards*, Vol 08.01.

[3] *Annual Book of ASTM Standards*, Vol 08.03.

[4] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

[5] Hereinafter referred to as a machinist's micrometer.

TABLE 1 Test Methods Suitable for Specific Materials

Material	Test Method
Plastics specimens	A, B, C, or D
Other elastomers	H

6.2.1 Apparatus B is a micrometer caliper without a locking device.

6.2.2 Use an instrument constructed with a vernier capable of measurement to the nearest 2.5 µm.

6.2.3 Use an instrument with the diameter of the anvil and spindle surfaces (which contact the specimen) of 6.4 ± 0.1 mm.

6.2.4 Use an instrument conforming to the requirements of 8.1, 8.2, 8.5.1, 8.5.2, 8.5.3, 8.6.1, and 8.6.3.

6.2.5 Examine and test the micrometer periodically for conformance to the requirements of 6.2.4.

6.3 *Apparatus C—Manually Operated, Dead-Weight, Dial-Type Thickness Gage:*[6]

6.3.1 Use a dead-weight, dial-type gage in accordance with the requirements of 8.1, 8.3, 8.4, 8.6.1, and 8.6.4 having the following:

6.3.1.1 A presser foot that moves in an axis perpendicular to the anvil face;

6.3.1.2 The surfaces of the presser foot and anvil (which contact the specimen) parallel to within 2.5 µm (see 8.3);

6.3.1.3 A vertical dial spindle;

6.3.1.4 A dial indicator essentially friction-free and capable of repeatable readings within ±1 µm at zero setting, or on a steel gage block;

6.3.1.5 A frame, housing the indicator, of such rigidity that a load of 15 N applied to the dial housing, out of contact with the presser foot spindle (or any weight attached thereto), will produce a deflection of the frame not greater than the smallest scale division on the indicator dial; and

6.3.1.6 A dial diameter at least 50 mm and graduated continuously to read directly to the nearest 2.5 µm. If necessary, equip the dial with a revolution counter that displays the number of complete revolutions of the large hand.

6.3.1.7 An electronic instrument having a digital readout in place of the dial indicator is permitted if that instrument meets the other requirements of 6.3.

6.3.2 The preferred design and construction of manually operated, dead-weight, dial-type micrometers calls for a limit on the force applied to the presser foot. The limit is related to the compressive characteristics of the material being measured.

6.3.2.1 The force applied to the presser foot spindle and the weight necessary to move the pointer upward from the zero position shall be less than the force that will cause permanent deformation of the specimen. The force applied to the presser foot spindle and the weight necessary to just prevent movement of the pointer from a higher to a lower reading shall be more than the minimum permissible force specified for a specimen.

6.4 *Apparatus D—Motor-Operated, Dead-Weight Dial Gage*:

6.4.1 Except as additionally defined in this section, use an instrument that conforms to the requirements of 6.3. An electronic instrument having a digital readout in place of the dial indicator is permitted if that instrument meets the other requirements of 6.3 and 6.4.

6.4.2 Use a motor-operated instrument having a presser foot spindle that is lifted and lowered by a constant-speed motor through a mechanical linkage such that the rate of descent (for a specified range of distances between the presser foot surface and anvil) and dwell time on the specimen are within the limits specified for the material being measured. Design the mechanical linkage so that the only downward force on the presser foot spindle is that of gravity on the weighted spindle assembly, without any additional force exerted by the lifting/lowering mechanism.

6.4.2.1 The preferred design and construction of motor operated, dead-weight, dial-type micrometers calls for a limit on the force applied to the presser foot. The limit is related to the compressive characteristics of the material being measured.

6.4.2.2 The force applied to the presser foot spindle and the weight necessary to move the pointer upward from the zero position shall be less than the force that will cause permanent deformation of the specimen. The force applied to the presser foot spindle and the weight necessary to just prevent movement of the pointer from a higher to a lower reading must be more than the minimum permissible force specified for a specimen.

7. Test Specimens

7.1 The test specimens shall be prepared from plastics materials in sheet, plate, or molded shapes that have been cut to the required dimensions or molded to the desired finished dimensions for the particular test.

7.2 Prepare and condition each specimen in equilibrium with the appropriate standard laboratory test conditions in accordance with the test method applicable to the specific material for test.

7.3 For each specimen, take precautions to prevent damage or contamination that might affect the measurements adversely.

7.4 Unless otherwise specified, make all dimension measurements at the standard laboratory atmosphere in accordance with Practice D 618.

8. Calibration (General Considerations for Care and Use of Each of the Various Pieces of Apparatus for Dimensional Measurements)

8.1 Good testing practices require clean anvil and presser foot surfaces for any micrometer instrument. Prior to calibration or dimensional measurements, clean such surfaces by inserting a piece of smooth, clean bond paper between the anvil and presser foot and slowly moving the bond paper between the surfaces. Check the zero setting frequently during measurements. Failure to repeat the zero setting may be evidence of dirt on the surfaces.

NOTE 2—Avoid pulling any edge of the bond paper between the surfaces to reduce the probability of depositing any lint particles on the surfaces.

8.2 The parallelism requirements for machinist's micrometers demand that observed differences of readings on a pair of screw-thread-pitch wires or a pair of standard 6.4-mm nominal diameter plug gages be not greater than 2.5 µm. Spring-wire stock or music-wire of known diameter are suitable substitutes.

[6] Herein referred to as a dial gage.

TABLE 2 Test Method Parameter Differences

Test Method	Apparatus	Diameter of Presser Foot or Spindle, mm	Pressure on Specimen, Approximate, kPa
A	machinist micrometer with calibrated ratchet or thimble	6.4	not specified
B	machinist micrometer without ratchet/thimble	6.4	unknown
C	dead-weight dial-type bench micrometer—manual	3.2 to 12.7	5 to 900
D	dead-weight dial-type bench micrometer—motor operated	3.2 to 12.7	5 to 900
H	dead-weight dial-type bench micrometer—manual	6.4	30

The wire (or the plug gage) has a diameter dimension that is known to be within ±1 µm. Diameter dimensions may vary by an amount approximately equal to the axial movement of the spindle when the wire (or the plug gage) is rotated through 180°.

8.2.1 Lacking a detailed procedure supplied by the instrument manufacturer, confirm the parallelism requirements of machinist's micrometers using the following procedure:

8.2.1.1 Close the micrometer on the screw-thread-pitch wire or plug gage according to the calibration procedure of 8.6.2 or 8.6.3, as appropriate;

8.2.1.2 Observe and record the thickness indicated;

8.2.1.3 Move the screw-thread-pitch wire or plug gage to a different position between the presser foot and anvil, and repeat 8.2.1.1 and 8.2.1.2; and

8.2.1.4 If the difference between any pair of readings is greater than 2.5 µm, the surfaces are not parallel.

8.3 Lacking a detailed procedure supplied by the instrument manufacturer, confirm the requirements for parallelism of dial-type micrometers given in 6.3.1.2 by placing a hardened steel ball (such as that used in a ball bearing) of suitable diameter between the presser foot and anvil. Mount the ball in a fork-shaped holder to allow it to be moved conveniently from one location to another between the presser foot and anvil. The balls used commercially in ball bearings are almost perfect spheres having diameters constant within 0.2 µm.

NOTE 3—Exercise care with this procedure. Calculations using the equations given in X1.3.2 show that the use of a 680 g mass weight on a ball between the hardened surfaces of the presser foot and anvil can result in dimples in the anvil or presser foot surfaces caused by exceeding the yield stress of the surfaces.

8.3.1 Observe and record the diameter as measured by the micrometer at one location.

8.3.2 Move the ball to another location and repeat the measurement.

8.3.3 If the difference between any pair of readings is greater than 2.5 µm, the surfaces are not parallel.

8.4 Lacking a detailed procedure supplied by the instrument manufacturer, confirm the flatness of the anvil and the spindle surface of a micrometer or dial gage by the use of an optical flat that has clean surfaces. Surfaces shall be flat within 1 µm.

8.4.1 After cleaning the micrometer surfaces (see 8.1), place the optical flat on the anvil and close the presser foot as described in 8.6.2, 8.6.3, 8.6.4, or 8.6.5, as appropriate.

8.4.2 When illuminated by diffused daylight, interference bands are formed between the surfaces of the flat and those of the micrometer. The shape, location, and number of these bands indicate the deviation from flatness in increments of half the average wavelengths of white light, which is taken as 0.25 µm.

8.4.2.1 A flat surface forms straight parallel fringes at equal intervals.

8.4.2.2 A grooved surface forms straight parallel fringes at unequal intervals.

8.4.2.3 A symmetrical concave or convex surface forms concentric circular fringes. Their number is a measure of the deviation from flatness.

8.4.2.4 An unsymmetrical concave or convex surface forms a series of curved fringes that cut the periphery of the micrometer surface. The number of fringes cut by a straight line connecting the terminals of any fringes is a measure of the deviation from flatness.

8.5 *Machinist's Micrometer Requirements*:

8.5.1 The requirements for a zero reading of machinist's micrometers are met when ten closings of the spindle onto the anvil, in accordance with 8.6.2.3 or 8.6.3.3, as appropriate, result in ten zero readings. The condition of zero reading is satisfied when examinations with a low-power magnifying glass show that at least 66 % of the width of the zero graduation mark on the barrel coincides with at least 66 % of the width of the reference mark.

8.5.2 Proper maintenance of a machinist's micrometer may require adjusting the instrument for wear of the micrometer screw so that the spindle has no perceptible lateral or longitudinal looseness, yet rotates with a torque load of less than 1.8 E to 03 Nm. Replace the instrument if this is not achievable after disassembly, cleaning, and lubrication.

8.5.3 After the zero reading has been checked, use the calibration procedure of 8.6.2 and 8.6.3 (as appropriate, for the machinist's micrometer under examination) to check for the maximum acceptable error in the machinist's micrometer screw.

8.5.3.1 Use selected feeler-gage blades with known thicknesses to within ±0.5 µm to check micrometers calibrated in metric units at approximately 50, 100, and 200-µm points. Use standard gage blocks at points greater than 200 µm.

8.5.3.2 Take ten readings at each point checked. Calculate the arithmetic mean of these ten readings.

8.5.3.3 The machinist's micrometer screw error is within requirements if the difference between the mean value of 8.5.3.2 and the gage block (or feeler-gage blade) thickness is not more than 2.5 µm.

8.5.4 *Calibration of Spindle Pressure in Machinist's Micrometer with Ratchet or Friction Thimble*:

8.5.4.1 See Annex A1, which details the apparatus and procedure required for this calibration.

8.6 *Calibration of Micrometers*:

8.6.1 Calibrate all micrometers in a standard laboratory atmosphere maintained at 50 % relative humidity and 23°C or some other standard condition as mutually agreed upon between the seller and the purchaser. Use standard gage blocks or other metallic objects of known dimension. The known dimensional accuracy of such blocks shall be within ±10 % of the smallest scale division of the micrometer dial or scale. Thus, if an instrument's smallest scale division is 2 µm, the standard gage block dimension shall be known to within ±0.2 µm. Perform calibration procedures only after the instrument has been checked and found to meet the requirements of the pertinent preceding paragraphs of these test methods. Perform procedures at least once every 30 days.

8.6.2 *Calibration Procedure for Apparatus A, Machinist's Micrometer with Ratchet or Friction Thimble*:

8.6.2.1 Calibrate the ratchet spring or friction thimble in accordance with Annex A1.

8.6.2.2 Rotate the spindle so as to close the micrometer on the gage block or other calibrating device. Reverse the rotation so as to open the micrometer 100 to 150 µm.

8.6.2.3 Using the ratchet knob or friction thimble, close the micrometer again slowly on the calibrating device so that the scale divisions may be counted easily as they move past the reference mark. This rate approximates about 50 µm/s.

8.6.2.4 Continue the closing motion until the ratchet clicks three times or the friction thimble slips.

8.6.2.5 Observe and record the dimension reading.

8.6.2.6 Repeat the procedures described in 8.6.2.2-8.6.2.5 using several gage blocks (or other calibration devices) of different dimensions covering the range of measurement with this micrometer.

8.6.2.7 Construct a calibration correction curve that will provide the corrections for application to the observed dimension of specimens tested, using this calibrated micrometer.

8.6.3 *Calibration Procedure for Apparatus B, Machinist's Micrometer Without Ratchet or Friction Thimble*:

8.6.3.1 Rotate the spindle so as to close the micrometer on the gage block or other calibrating device. Reverse the rotation so as to open the micrometer 100 to 150 µm.

8.6.3.2 Close the micrometer again so slowly on the calibrating device that the scale divisions may be counted easily as they move past the reference mark. This rate approximates about 50 µm.

8.6.3.3 Continue the closing motion until the spindle face contacts the surface of the gage block (or other calibrating device). Contact is made when frictional resistance develops initially to the movement of the calibrating device between the anvil and spindle face.

8.6.3.4 Observe and record the dimension reading.

8.6.3.5 Repeat the procedures described in 8.6.3.1-8.6.3.4 using several gage blocks (or other calibration devices) of different dimensions covering the range of measurement with this micrometer.

8.6.3.6 Construct a calibration correction curve that will provide the corrections for application to the observed dimensions of specimens tested using this calibrated micrometer.

8.6.4 *Calibration Procedure for Apparatus C, Manually Operated, Dial-Type Micrometers*:

8.6.4.1 Using the procedures detailed in Section 9 pertinent to the material to be measured, collect calibration data from observations using several gage blocks (or other calibration devices) of different dimensions covering the range of measurement with this micrometer.

8.6.4.2 Construct a calibration correction curve that will provide the corrections for application to the observed dimensions of specimens tested using this calibrated micrometer.

8.6.5 *Calibration Procedure for Apparatus D, Motor-Operated, Dial-Type Micrometers*:

8.6.5.1 Using the procedures detailed in Section 9 pertinent to the material to be measured, collect calibration data from observations using several gage blocks (or other calibration devices) of different dimensions covering the range of measurement with this micrometer.

8.6.5.2 Construct a calibration correction curve that will provide the corrections for application to the observed dimensions of specimens tested using this calibrated micrometer.

9. Procedure

NOTE 4—In this section, the word "method" denotes a combination of both a specific apparatus and a procedure describing its use.

9.1 The selection of a method for measurement of dimension is influenced by the characteristics of the solid plastic for measurement. Each material will differ in its response to test method parameters, which include, but may not be limited to, compressibility, rate of loading, ultimate load, dwell time, and dimensions of the presser foot and anvil. For a specific plastic material, these responses may cause measurements made using one method to differ significantly from measurements made using another method. The procedures that follow are categorized according to the materials to which each applies. See also Appendix X1.

9.2 *Test Methods Applicable to Solid Plastic Specimens*:

9.2.1 Except as otherwise specified in other applicable documents, use either Test Methods A, B, C, or D for plastic specimens.

9.2.2 When testing specimens by Test Methods A, B, C, or D, use apparatus that conforms to the requirements of the appropriate parts of Sections 6 and Table 2, including the requirement for accuracy of zero setting.

NOTE 5—An electronic gage may be substituted for the dial gage in Test Method C if the presser foot and anvil meet the requirements of that test method.

NOTE 6—**Caution:** Cleaning the presser foot and anvil surfaces as described in 8.1 can cause damage to digital electronic gages, which may then require very expensive repairs by the instrument manufacturer. Obtain procedures for cleaning such electronic gages from the instrument manufacturer to prevent these costs.

9.2.3 When testing specimens using Test Method D, use an instrument that has a drop rate between 750 and 1500 µm/s between 625 and 25 µm on the dial and a capacity of at least 775 µm.

9.2.4 The presence of contaminating substances on the surfaces of the test specimens, presser foot, anvil, or spindle can interfere with dimension measurements and result in erroneous readings. To help prevent this interference, select only clean specimens for testing, and keep them and the dimension measuring instrument covered until ready to make measurements.

9.2.5 *Test Method A*:

9.2.5.1 Using Apparatus A and specimens in conformance with Section 7, close the micrometer on an area of the specimen for measurement. Observe this reading, then open the micrometer approximately 100 µm beyond the expected reading, and move the specimen to the measurement position.

9.2.5.2 Using the ratchet, or the friction thimble, close the micrometer at such a rate that the scale divisions may be counted easily as they pass the reference mark. This rate is approximately 50 µm/s.

9.2.5.3 Continue the closing motion until the ratchet clicks three times or the friction thimble slips. Observe the indicated dimension.

9.2.5.4 Correct the observed indicated dimension using the calibration chart obtained in accordance with 8.6, and record the corrected dimension value.

9.2.5.5 Move the specimen to another measurement position, and repeat the steps given in 9.2.7.1-9.2.7.4.

9.2.5.6 Unless otherwise specified, make and record at least three dimension measurements on each specimen. The arithmetic mean of all dimension values is the dimension of the specimen.

9.2.6 *Test Method B*:

9.2.6.1 Using Apparatus B and specimens in conformance with Section 7, close the micrometer on an area of the specimen for measurement. Observe this reading, then open the micrometer approximately 100 µm beyond the expected reading, and move the specimen to the measurement position.

9.2.6.2 Close the micrometer slowly at such a rate that the scale divisions may be counted easily as they pass the reference mark. This rate is approximately 50 µm/s.

9.2.6.3 Continue the closing motion until contact with the specimen surface is just made as evidenced by the initial development of frictional resistance to movement of the micrometer screw. Observe the indicated dimension.

9.2.6.4 Correct the observed indicated dimension using the calibration correction curve obtained in accordance with 8.6, and record the corrected dimension value.

9.2.6.5 Move the specimen to another measurement position, and repeat the steps given in 9.2.8.1-9.2.8.4.

9.2.6.6 Unless otherwise specified, make and record at least three dimension measurements on each specimen. The arithmetic mean of all dimension values is the dimension of the specimen.

9.2.7 *Test Method C*:

9.2.7.1 Using Apparatus C and specimens in conformance with Section 7, place the dial gage on a solid, level, clean table or bench that is free of excessive vibration. Confirm that the anvil and presser foot surfaces are clean. Adjust the zero point.

9.2.7.2 Using Apparatus C and specimens in conformance with Section 7, close the micrometer on an area of the specimen for measurement. Observe this reading, then open the micrometer approximately 100 µm beyond the expected reading, and move the specimen to the measurement position.

9.2.7.3 Raise the presser foot slightly.

9.2.7.4 Move the specimen to the first measurement location, and lower the presser foot to a dial reading approximately 7 to 10 µm higher than the initial reading of 9.2.9.2.

9.2.7.5 Drop the foot onto the specimen (see also Note 7).

NOTE 7—This procedure minimizes small errors present when the pressure foot is lowered slowly onto the specimen.

9.2.7.6 Observe the dial reading. After correcting the observed indicated dimension using the calibration correction curve obtained in accordance with 8.6, record the corrected dimension value.

9.2.7.7 Move the specimen to another measurement position, and repeat the steps given in 9.2.9.1 through 9.2.9.6.

9.2.7.8 Unless otherwise specified, make and record at least three dimension measurements on each specimen. The arithmetic mean of all dimension values is the dimension of the specimen.

9.2.7.9 Recheck the instrument zero setting after measuring each specimen. A change in the setting is usually the result of contaminating particles carried from the specimen to the contacting surfaces of the presser foot and anvil. This condition necessitates the cleaning of these surfaces (see 8.1 and Note 6).

9.2.8 *Test Method D*:

9.2.8.1 Using Apparatus D and specimens in conformance with Section 7, place the motor-operated dial gage on a solid, level, clean table or bench that is free of excessive vibration. Confirm that the anvil and presser foot surfaces are clean.

9.2.8.2 Apply power to the motor, and allow the instrument to reach a thermal equilibrium with the ambient. Equilibrium is attained when the zero point adjustment becomes negligible. Do not stop the motor until all of the measurements are made. This will minimize any tendency to disturb the thermal equilibrium between the instrument and ambient during the dimension measurements.

9.2.8.3 Insert and position a specimen for the first measurement when the opening between the presser foot and anvil is near its maximum.

9.2.8.4 Observe the dial reading while the presser foot is at rest on the specimen surface. After correcting the observed indicated dimension using the calibration correction curve obtained in accordance with 8.6, record the corrected dimension value.

9.2.8.5 While the presser foot is near its maximum lift, move the specimen to another measurement position, and repeat the steps given in 9.2.10.1 through 9.2.10.4.

9.2.8.6 Unless otherwise specified, make and record at least three dimension measurements on each specimen. The arithmetic mean of all dimension values is the dimension of the specimen.

9.2.8.7 Recheck the instrument zero setting after measuring each specimen. A change in the setting is usually the result of contaminating particles carried from the specimen to the contacting surfaces of the presser foot and anvil. This condition necessitates the cleaning of these surfaces (see 8.1 and Note 6).

9.3 *Test Methods Applicable to Other Elastomers*:

9.3.1 Test Method H is applicable to other elastomeric materials that have a Shore A durometer hardness between 30 and 80.

9.3.2 Test Method H uses a manually operated, deadweight, dial-type micrometer described as Apparatus C in 6.3 that conforms to the requirements given in 8.1, 8.3, 8.4, 8.6.1, and 8.6.4 and has the following:

9.3.2.1 A presser foot diameter of 6.4 ± 0.1 mm;

9.3.2.2 An anvil diameter of at least 50 mm;

9.3.2.3 A capacity of at least 7.50 mm; and

9.3.2.4 A design and construction capable of applying a pressure of 26 ± 9 kPa on the elastomeric material specimen. This pressure is the result of the ratio of the force on the specimen (exerted by gravity on the 3-oz (0.83-N) weight of the presser foot assembly, out of contact with the lifting mechanism) to the specified area of the presser foot.

9.3.3 Using the apparatus as described in 9.3.2 and specimens in conformance with Section 7, place the manually-operated dial gage on a solid, level, clean table or bench that is free of excessive vibration. Confirm that the anvil and presser foot surfaces are clean and that the accuracy of zero reading has been determined.

9.3.4 Test Method H involves two different procedures for dimension measurements of elastomeric materials. One procedure uses the dial micrometer as a comparison gage. The other procedure uses the dial micrometer as a direct dimension reading instrument. Test results using either procedure are not significantly different.

9.3.5 Satisfactory accuracy of dimension measurements on elastomeric materials is obtained by using the dial gage as a comparison measuring instrument. The use of this technique does not require the construction of a calibration curve. Details of the comparison procedure follow:

9.3.5.1 Do not drop the presser foot, but lower it slowly onto the surface of a specimen. Make an initial reading 5 s after the presser foot has contacted the specimen surface. The initial reading estimates the specimen dimension.

9.3.5.2 Raise the presser foot and remove the specimen.

9.3.5.3 Select a gage block that approximates the initial reading observed in 9.3.5.1 most closely. Place the gage block on the anvil, and lower the presser foot slowly. DO NOT DROP THE PRESSER FOOT.

9.3.5.4 After the presser foot comes to rest, adjust the zero setting of the dial micrometer so that the dial reading is exactly the dimension of the gage block.

9.3.5.5 Lift the presser foot, remove the gage block, and place the specimen on the anvil.

9.3.5.6 Lower the presser foot slowly onto the specimen, and allow it to come to rest for 5 s before reading the dial.

9.3.5.7 Repeat the steps given in 9.3.5.2-9.3.5.6 until at least five dimension readings are obtained. The arithmetic mean of the five readings is taken as the dimension of the specimen.

9.3.6 Test Method H uses the dial micrometer as a direct dimension measurement instrument using the following procedure:

9.3.6.1 Do not drop the presser foot, but lower it slowly onto the surface of a specimen. Make an initial reading 5 s after the presser foot has contacted the specimen surface. The initial reading estimates the specimen dimension.

9.3.6.2 Raise the presser foot no more than 500 µm above the dimension observed in 9.3.6.1, and move the specimen to the first measurement location.

9.3.6.3 Do not drop the presser foot, but lower it gently onto the specimen, and allow it to rest on the specimen for 5 s before reading the indicator dial.

9.3.6.4 Observe the dimension indicated on the dial, and apply any correction from the calibration curve generated in accordance with 8.6. Record the corrected dimension value.

9.3.6.5 Repeat the procedure described in 9.3.6.1-9.3.6.4 on different areas of the specimen until at least five dimension measurements have been recorded. The arithmetic average of the five corrected values is the dimension of the specimen.

9.3.7 There will be some compression of low-durometer hardness elastomeric materials due to the force exerted by the presser foot. That error magnitude will increase as the specimen dimension decreases.

9.3.8 For measurements of dimension on low-durometer hardness, the most significant and precise values are obtained by the use of Apparatus C modified so that the presser foot simulates the total load force expected in the intended application.

10. Report

10.1 Report the following information:

10.1.1 Complete identification of the material tested, including the type, grade, source, and lot number;

10.1.2 Date of testing, identity of the testing laboratory, and identity of the responsible personnel;

10.1.3 Test method used, details of any deviation therefrom, and choice of any options in the standard procedure;

10.1.4 Number of specimens per sample and number of measurements per specimen; and

10.1.5 Arithmetic mean and range of all measurements made on a sample.

11. Precision and Bias

11.1 *Precision*—Since the test methods herein use different pieces of apparatus, call for one of several magnitudes of forces to be exerted on specimens of widely different geometries for varying periods of time, and are used for a wide variety of materials, it is the consensus that a precision statement in these test methods is not practicable. There will be different precisions between test methods and between materials. The reader is directed to seek precision statements in those other ASTM standards that deal with specific plastics or elastomeric material measured by any of these test methods.

11.2 *Bias*—The bias of any one of these test methods is unknown. A standard specimen of known thickness of solid electrical insulation is not available for measurement of thickness by each of these test methods.

12. Keywords

12.1 caliper; dimensions; elastomers; micrometer; plastics

ANNEX

(Mandatory Information)

A1. CALIBRATION OF MACHINIST'S MICROMETER RATCHET SPRING OR SPINDLE FORCE

A1.1 Introduction

A1.1.1 This annex describes apparatus and procedures suitable for ascertaining the pressure exerted by the spindle on a machinist's micrometer equipped with a calibrated-spring actuated ratchet or friction thimble. Such a micrometer is described in Section 6 as Apparatus A.

A1.2 Apparatus for Calibration

A1.2.1 *Balance*, triple-beam, single plate, graduated to 0.1 g, having a maximum capacity of approximately 2.6 kg using auxiliary weights. Equip the balance with an adjustable counterbalance.

A1.2.2 *Attachment,*[7] mounted vertically on the plate of the balance so as to support a universal joint, one face of which is lapped flat.

A1.2.3 *Vertical Arm Support*, mounted at right angles to the balance plate that will hold the machinist's micrometer for testing. Hold the micrometer by this arm in such a way that the clamping pressure of the arm support will not distort the micrometer frame.

[7] This attachment can be adapted from a Starrett Center Tester No. 65, L. S. Starret Co., Athol, MA 01331.

A1.2.4 Refer to Fig. A1.1, which shows the assembled apparatus.

A1.3 Procedure

A1.3.1 Place the micrometer in position on the supporting arm.

A1.3.2 Adjust the support arm position to allow the balance pointer free travel between ±50 mg.

A1.3.3 Lock the support arm in this position.

A1.3.4 Place a specimen, such as a 10-layer pad of capacitor paper, between the spindle foot of the micrometer and the lapped surface of the universal joint.

A1.3.5 Adjust the micrometer spindle so that the pointer of the balance reads 50 mg.

A1.3.6 Apply a weight, from among the weights given in Table A1.1, to the balance arm. Select a weight of 600 g for other pressures to calibrate a micrometer that will exert a pressure of 200 kPa. Refer to Table A1.1.

A1.3.7 Turn the micrometer spindle until the ratchet clicks three times or until the friction thimble slips.

A1.3.8 The ratchet should click, or the thimble should slip, if a 600-g weight is selected. The ratchet or thimble should bring up the pointer easily if a 510-g weight is selected.

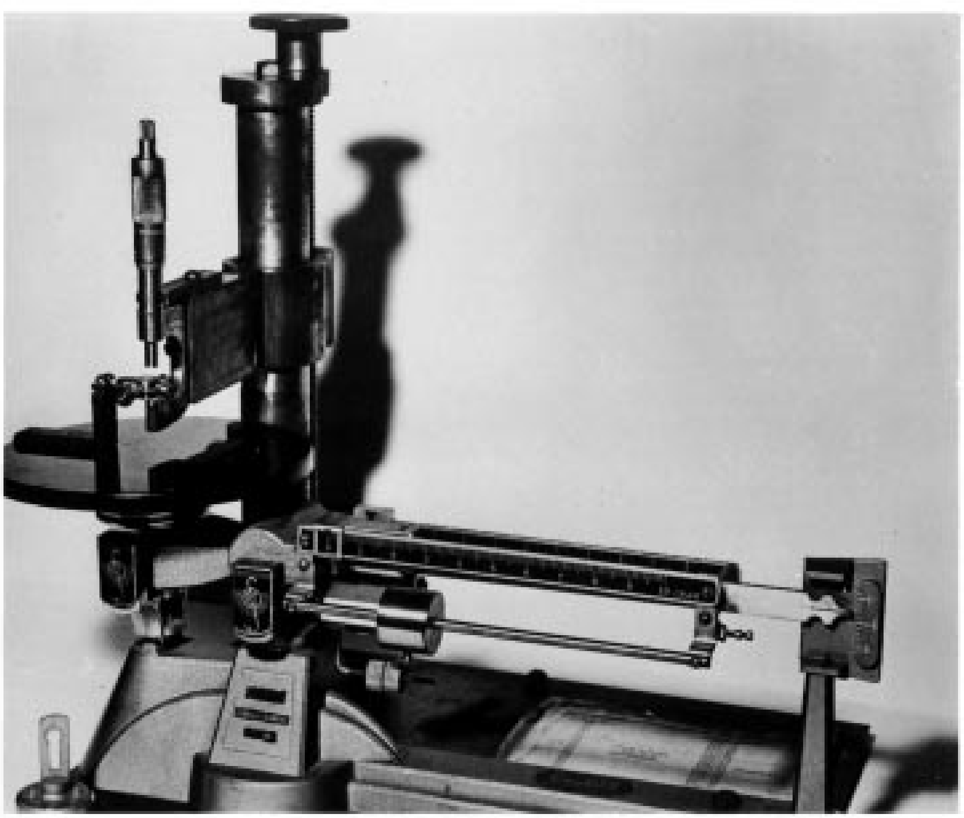

FIG. A1.1 Balance

TABLE A1.1 Applicable Weights and Pressures for 6.4-mm Diameter Spindles

Pressure, kPa	Mass, g
145	470
151	490
157	510
163	530
169	550
175	570
182	590
188	610
194	630
200	650

A1.3.9 If the pressure for a micrometer with ratchet is high, clip the spring until the proper range is observed. If the pressure is too low, discard the spring and replace it with a new spring.

NOTE A1.1—Obtain a new micrometer spring from the micrometer manufacturer, or make one from a coil spring wire of 450-µm nominal diameter. Make the inside diameter of the coiled wire 5.0 ± 0.1 mm, with a 2 ± 0.1-mm spacing between coil turns. Grind the ends of the spring flat.

A1.3.10 If it is necessary to elongate a spring so as to increase pressure, the maximum permitted elongation is 25 %.

A1.3.11 Make certain that the spring seats properly in the ratchet assembly, and assemble the ratchet completely before making any tests.

A1.3.12 Do not use oil in the ratchet assembly.

A1.3.13 If the pressure for a micrometer with a friction thimble is outside the permissible limits, consult the manufacturer for procedures to remedy the non-conformance.

APPENDIX

(Nonmandatory Information)

X1. ELASTICITY THEORY ADAPTED TO THICKNESS MEASUREMENT

X1.1 Introduction

X1.1.1 Theoretical dissertations pertinent to the problems involved when a rigid cylindrical die is pressed into a semi-infinite elastic solid may be found in treatises on elasticity.[8]

X1.1.2 The equations derived therein indicate that the distance of penetration of the die (analogous to the presser foot of a micrometer) into the elastic solid (analogous to a thickness specimen) is proportional to the ratio of the applied force to the diameter of the cylinder.

X1.1.3 Other mechanical properties of the materials involved also have some influence on the distance of penetration.

X1.1.4 If a plot of measured thickness versus the ratio of applied force to presser foot diameter is made for each of several materials (including rubbers and recorder tapes), a linear relationship is found.

X1.1.5 In the absence of any better theoretical model, the equations for a cylinder die and a spherical die indenting a semi-infinite solid are presented and adapted to thickness measurements in the hope that further work is stimulated based on adapting the semi-infinite model to finite size models.

X1.1.6 In thickness measurements, keeping the average pressure constant when changing the diameter of presser feet has never been satisfactory, and this old notion needs to be discarded.

X1.1.7 The theory developed in the treatises does not give any information on how to handle the effects due to time of loading. Until something better is established, the effects of time need evaluation for each material over the range of thicknesses, forces, and foot diameters expected in testing.

[8] Timoshenko, S., *Theory of Elasticity*, McGraw-Hill Book Co., New York, NY, 1934, p. 338.

X1.2 Cylindrical Pressure Foot

X1.2.1 For the cylindrical presser foot, the expression for penetration, *d*, is as follows:

$$d = (W/D) \times [(1 - \sigma^2)/E] \qquad \text{(X1.1)}$$

where:
W = force downward on the foot,
D = diameter of the face,
σ = Poisson's ratio = 0.40 to 0.45 for plastics in general, and
E = Young's modulus of the specimen.

The presser foot and anvil are regarded as infinitely rigid.

X1.2.2 As a result, the amount of penetration is determined by the ratio of force, or load, to the diameter of the presser foot. Data on rubber and recorder tape confirm this finding. Consequently, if the radius of the presser foot is reduced by a factor, reduce the load by the same factor to keep the penetration and, therefore, the apparent thickness constant. This is in contrast to previously held perceptions of the necessity for maintaining constant average pressure.

X1.2.3 The pressure, *P*, applied at any point on the specimen inside the perimeter of the foot is given by the following:

$$P = W/[2\,\pi\,R(R^2 - r^2)^{0.5}] \qquad \text{(X1.2)}$$

where:
W = force,
R = radius, and
r = radial distance of the point being discussed from the center of the surface.

This brings out the important point that at the periphery of the foot surface (where *r* approaches *R*), *P* approaches infinity and the specimen is stressed beyond its yield point so that an imprint of the outline of the presser foot surface remains on the specimen surface. Dressing the edge of the presser foot to have a slight radius prevents this effect.

X1.2.4 Assuming that the equations apply to a relatively thin specimen, the actual thickness measured will be the no-load thickness minus the penetration, and the equation for thickness becomes the following:

$$T = T_o - d = T_o - W/D(1 - \sigma^2)/E \tag{X1.3}$$

where:
T_o = no-load thickness.

X1.2.5 A plot of T versus W/D results in a straight line. The intercept at $W/D = 0$ provides a value for T_o. Data for the plot may be obtained by making a series of measurements on a specimen using different weights with a fixed diameter of presser foot or a fixed weight with presser feet of differing diameters.

X1.2.6 If such a plot is made for polymeric film and the slope of the line is established from the plot or by regression analysis of the data, a number of characteristics of the film may be obtained.

X1.2.7 The plot can also be useful in estimating the effects of making thickness measurements on the material using different dimensions of the presser foot and different applied forces to the specimen.

X1.3 Hemisphere-Shaped Foot

X1.3.1 For a hemisphere pressing a semi-infinite specimen, the penetration, d, into the surface is given by the equation:

$$d = 0.8255 \times (W^2/R)^{1/3} \times [(1 - \sigma^2)/E]^{2/3} \tag{X1.4}$$

where:
W = force downward on the hemisphere,
R = radius of the hemisphere, which is assumed incompressible,
σ = Poisson's ratio = 0.40 to 0.45 for plastics, and
E = Young's modulus of the specimen.

Consequently, the amount of elastic displacement observed for a given material depends on the ratio W/R. If the radius of the hemisphere is reduced by four, the load on the gage must be reduced by a factor of two to maintain the same penetration.

X1.3.2 Permanent indentation will occur if the elastic yield point of the specimen is exceeded. This occurs unless the loads and radius are such that

$$Y > 0.5784 \times [E/(1 - \sigma^2)]^{2/3} \times (W/R^2)^{1/3} \tag{X1.5}$$

where:
Y = yield stress of the material.

In selecting loads to apply to the specimen, make a calculation to determine whether the resulting load and radius combination is too near the yield strength.

X1.3.3 Assuming that the equation will still hold for a finite specimen, the reading obtained for the thickness is the no-load thickness of the specimen minus the amount of penetration. An equation can be

written expressing this idea using the equation for penetration written above:

$$T = T_o - [0.8255\ (W^2/R)^{1/3} \times [(1 - \sigma^2)/E]^{2/3} \tag{X1.6}$$

where:
T_o = thickness read, and
T_o = no-load thickness.

A plot of T versus either $W^{2/3}$ or $(W^2/R)^{1/3}$ should result in a straight line that, when extrapolated to $W = 0$, gives the no-load thickness T_o.