



Standard Test Methods for Physical Dimensions of Solid Plastics Specimens¹

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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 Testing²

D 883 Terminology Relating to Plastics²

D 4805 Terminology for Plastics Standards³

2.2 ISO Standard:

ISO 472 Plastics—Vocabulary⁴

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 di-

mension 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 Caliper⁵ 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:*

⁵ Hereinafter referred to as a machinist's micrometer.

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.

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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.

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 $\pm 1 \mu\text{m}$. 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 $2.5 \mu\text{m}$, 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 $0.2 \mu\text{m}$.

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 $2.5 \mu\text{m}$, 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 $1 \mu\text{m}$.

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 $0.25 \mu\text{m}$.

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 $\pm 0.5 \mu\text{m}$ 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 $2.5 \mu\text{m}$.

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 $\pm 10\%$ of the smallest scale division of the micrometer dial or scale. Thus, if an instrument's smallest scale division is $2\ \mu\text{m}$, the standard gage block dimension shall be known to within $\pm 0.2\ \mu\text{m}$. 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 $\mu\text{m/s}$.

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 $\mu\text{m/s}$ 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: