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Standard Guide for Determination of Thickness of Plastic Film Test Specimens[1]

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1. Scope

1.1 This guide covers the determination of the thickness of plastic films where the thickness is used directly in determining the results of tests for various properties. Use this practice except as otherwise required in material specifications or in applicable test standards.

NOTE 1—Films are defined as having thicknesses ≤ 0.250 mm [≤ 0.010 in.].

NOTE 2—Alternative methods are acceptable if they meet the requirements of measurement precision as noted in this guide.

NOTE 3—This guide is not intended to address the sampling techniques or the measurement of film thickness for the commercial classification of commercial products or for quality control purposes.

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 requirements prior to use.*

NOTE 4—ISO 4593 is similar but differs in technical content and scope.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 618 Practice for Conditioning Plastics Material for Testing

D 883 Terminology Relating to Plastics

D 4805 Terminology for Plastics Standards

D 5947 Test Methods for Physical Dimensions of Solid Plastics Specimens

D 6287 Practice for Cutting Film and Sheeting Test Specimens

2.2 *ISO Standard:*

ISO 472 Plastics—Vocabulary[3]

3. Terminology

3.1 *Definitions*—See Terminologies D 883 and D 4805, and ISO 472 for definitions pertinent to this guide.

3.2 *Definitions of Terms Specific to This Standard:*

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

3.2.2 *calibration, n*—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 *dead-weight micrometer, n*—an instrument capable of measuring the thickness of thin films utilizing a weight to apply uniform pressure to the specimen.

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

4. Summary of Methods

4.1 This guide describes four different methods for the thickness measurement of plastic film specimens. The methods (identified as Methods A, B, C, and D) use different micrometers that actuate the weights in different manners or utilize different means of reading the thickness.

4.2 It is permissible to use other instruments, including non-contact instruments and instruments using alternative readout systems in place of dials provided they meet or exceed the precision requirements noted in this practice.

5. Significance and Use

5.1 This guide shall be followed where precise dimensions are necessary for the calculation of properties expressed in physical units. It is 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 The instruments described in this guide share many common features:

[1] This guide is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.19 on Films and Sheeting.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

6.1.1 A dead-weight gage calibrated in accordance with the guidelines described in Appendix X2 and consisting of the following:

NOTE 5—Additional guidance for calibration and verification of gages can be found in Test Methods D 5947.

NOTE 6—Since there is such a wide variety of instruments in use, there can be significant differences in the accuracy of different instrument types. The values stated for each type of apparatus are intended to be typical of that type of instrument.

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

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

6.1.1.3 A spindle, vertically oriented if a dead-weight apparatus;

6.1.1.4 An indicator essentially capable of repeatable readings within ± 0.001 mm at zero setting, or on a steel gage block;

6.1.1.5 A frame, housing the indicator, of such rigidity that a load of 15 N applied to the 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 or digital count on the indicator;

6.1.1.6 If employed, a dial diameter of at least 50 mm and graduated continuously to read directly to the nearest 2.5 µm. The dial can be equipped with a revolution counter that displays the number of complete revolutions of the large hand, or

6.1.1.7 An electronic instrument having a digital readout in place of the dial indicator if that instrument meets all of the other requirements of this guide, and

6.1.1.8 The force applied to the presser foot spindle and the force necessary to register a change in the indicator reading shall be less than the force that will cause deformation of the specimen. The force applied to the presser foot spindle and the force necessary to just prevent a change in the indicator reading shall be more than the minimum permissible force specified for a specimen.

6.2 *Apparatus A—Manually Operated Thickness Gage*:

6.2.1 An instrument having a presser foot and spindle that is manually lifted and lowered.

6.3 *Apparatus B—Automatically Operated Thickness Gage*:

6.3.1 A pneumatic or motor-operated instrument having a presser foot spindle that is lifted and lowered either by a pneumatic cylinder or 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.

6.3.2 A preferred drop rate between 0.750 and 1.500 mm/s between 0.625 and 0.025 mm on the dial and a capacity of at least 0.775 mm.

6.4 *Apparatus C—Manually Operated Thickness Gage with Linear Optical Encoder*:

6.4.1 Similar to Apparatus A except it employs a digital device with an electronic readout capable of repeatable readings to within ± 1 µm at zero setting or on a steel gage block and a linear optical encoder using a scale of increments not less than 100 lines/mm and capable of reading within 0.5 µm with a 10 mm range.

6.5 *Apparatus D—Automatically Operated Thickness Gage with Digital Display*:

6.5.1 Similar to Apparatus B except it employs an electronic device with a digital readout capable of a resolution not less than 0.5 µm and repeatable readings to within ± 1 µm at zero setting or on a steel gage block.

6.5.2 A preferred drop rate between 0.750 and 1.500 mm/s between 0.625 and 0.025 mm on the dial and a capacity of at least 0.775 mm.

6.6 *Other Instruments*:

6.6.1 Other instruments are commercially available that utilize different methods of measuring thickness. These are generally non-contact devices employing ultrasonic response, electrical capacitance, or similar material properties that can be correlated to thickness. Some of these devices are also designed to provide a means of measuring discreet sections of film in a continuous scanning mode. Instruments of this nature are acceptable provided they meet or exceed the precision requirements noted in this practice and the requirements of the applicable material or product specifications or applicable test standards.

7. Test Specimens

7.1 The test specimens shall be prepared from plastic films that have been cut to the required dimensions according to Practice D 6287.

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

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

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

8. Procedure

8.1 *General Guidelines*:

NOTE 7—In this section, the word "method" denotes a combination of both a specific apparatus and a procedure describing its use.

8.1.1 The selection of a method for measurement of film thickness is influenced by the characteristics of the film for measurement. Each material and, in some cases, film construction in the case of multi-layer structures, will differ in its response to test method parameters, which include, but are not limited to, compressibility, rate of loading, ultimate load, dwell time, and dimensions of the presser foot and anvil. For a specific plastic material or structure, these responses can, in some cases, 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 Appendix X1.

NOTE 8—The pressure exerted by the gage on the specimen being measured shall not distort or deform the specimen. For thin films, ≤ 0.025 mm [0.001 in.], or films which exhibit visual deformation during

measurement, a maximum pressure of 70 kPa [10 psi] is suggested. For thicker or stiffer films, a pressure range between 160 and 185 kPa [23 and 27 psi] is suggested. See Table 1.

NOTE 9—An electronic gage can be substituted for the dial gage in Method A or B if the presser foot and anvil meet the requirements of that method.

8.1.2 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. **Warning—**Cleaning the presser foot and anvil surfaces as described in X2.1 can cause damage to digital electronic gages resulting in very expensive repairs by the instrument manufacturer. Obtain procedures for cleaning such electronic gages from the instrument manufacturer to prevent these costs.

8.1.3 One thickness determination per specimen or the average thickness determined by a continuous scanning instrument is acceptable if it can be demonstrated that the overall thickness does not deviate > ± 10 % from the average. This is especially applicable if measurements are being made for reference, that is, to report nominal film thickness, and are not required for the determination of specific properties.

8.1.4 Some instruments do not require calibration. For these instruments, periodic verification procedures should be conducted according to the recommendations of the instrument supplier.

8.2 *Method A*:

8.2.1 Using Apparatus A and specimens in conformance with Section 7, place the instrument 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.

8.2.2 Lower the presser foot on an area of the specimen for measurement. Observe this reading.

8.2.3 Raise the presser foot slightly.

8.2.4 Move the specimen to the first measurement location, and lower the presser foot to a reading approximately 0.007 to 0.010 mm higher than the initial reading of 8.2.2.

8.2.5 Drop the foot onto the specimen (see **Warning** in 8.1.2).

NOTE 10—This procedure minimizes small errors present when the pressure foot is lowered slowly onto the specimen and does not allow the presser foot to seat properly.

TABLE 1 Instrument Guidelines

Method	Diameter of Presser Foot or Spindle, mm[A]	Pressure on Specimen, Approximate, kPa[B]
A	3.2 to 12.7	160 to 185
B	3.2 to 12.7	160 to 185
C	3.2 to 12.7	160 to 185
D	3.2 to 12.7	160 to 185

[A] It is known that the diameters of the pressure foot and spindle can influence the results. Data obtained from instruments with different geometries may not be comparable.

[B] The total force applied to the specimen shall be less than the force that will cause permanent deformation or distortion of the specimen. For very thin or deformable films, a practical pressure range of 5 to 70 kPa has been found to be suitable.

8.2.6 Observe the reading. After correcting the observed indicated dimension, record the corrected dimension value. A method for developing a calibration correction curve is described in X2.4.

8.2.7 Move the specimen to another measurement position, and repeat the steps given in 8.2.3 through 8.2.6.

8.2.8 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.

8.2.9 Recheck the instrument zero setting after measuring each specimen. If a change is observed, this is usually indicative of contamination on the contact surfaces and will require cleaning. (See **Warning** in 8.1.2 and Note 9.)

8.3 *Method B*:

8.3.1 Using Apparatus B and specimens in conformance with Section 7, place the instrument on a solid, level, clean table or bench that is free of excessive vibration. Confirm that the anvil and presser foot surfaces are clean.

8.3.2 Apply power to the motor or air to the pneumatics, 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 or remove the air 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.

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

8.3.4 Observe the dial reading while the presser foot is at rest on the specimen surface. After correcting the observed indicated dimension, record the corrected dimension value. A method for developing a calibration correction curve is described in X2.4.

8.3.5 While the presser foot is near its maximum lift, move the specimen to another measurement position, and repeat the steps given in 8.3.3 and 8.3.4.

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

8.3.7 Recheck the instrument zero setting after measuring each specimen. If a change is observed, this is usually indicative of contamination on the contact surfaces and will require cleaning. (See **Warning** in 8.1.2 and Note 9.)

8.4 *Method C*:

8.4.1 Using Apparatus C and specimens in conformance with Section 7, place the instrument 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.

8.4.2 Drop the presser foot on an area of the specimen for measurement. Observe and record this reading.

8.4.3 Raise the presser foot as high as possible in the range of allowable motion and move the specimen to the next location. Observe and record this reading. (See **Warning** in 8.1.2.)

8.4.4 Move the specimen to another position and repeat step 8.4.3 as needed.

8.4.5 Unless otherwise specified, observe and record at least three thickness measurements on each specimen. The arithmetic mean of all values is the thickness of the specimen.

8.4.6 Recheck the instrument zero after measuring each specimen. If a change is observed, this is usually indicative of contamination on the contact surfaces and will require cleaning. (See **Warning** in 8.1.2 and Note 9.)

8.5 *Method D*:

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

8.5.2 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.

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

8.5.4 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 X2.4, record the corrected dimension value.

8.5.5 While the presser foot is near its maximum lift, move the specimen to another measurement position, and repeat the steps given in 8.3.3 and 8.3.4.

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

8.5.7 Recheck the instrument zero setting after measuring each specimen. If a change is observed, this is usually indicative of contamination on the contact surfaces and will require cleaning. (See **Warning** in 8.1.2 and Note 9.)

9. Report

9.1 Report the following information:

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

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

9.1.3 Method used and details of any deviation therefrom;

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

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

10. Precision and Bias

10.1 *Precision*—Since the 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 methods is not practicable. There will be different precisions between 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 methods.

10.2 *Bias*—The bias of any one of these methods is unknown. A standard film specimen of known thickness is not available for measurement of thickness by each of these methods.

11. Keywords

11.1 dial gage; dimensions; film; plastics; thickness

APPENDIXES

(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 can be found in treatises on elasticity.[4]

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.

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

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.

X1.2 Cylindrical Pressure Foot

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

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

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:

$$P = W/[2\pi R(R^2 - r2)^{0.5}] \quad \text{(X1.2)}$$

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:

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

where:
- To = 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 *To*. Data for the plot can 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 can 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:

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

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:

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

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:

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

where:
- T = thickness read, and
- To = 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 *To*.

X2. INSTRUMENT CALIBRATION

INTRODUCTION

The techniques for proper instrument calibration are often manufacturer-specific. Always consult and follow the directions of the instrument manufacturer. The following practices are provided as alternatives or when specific directions are not available. Reference should also be made to Test Methods D 5497.

X2.1 Good measurement 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. Dirt on the surfaces can be a cause of a failure to repeat the zero setting.

NOTE X2.1—Avoid pulling any edge of the bond paper between the surfaces to reduce the probability of depositing any lint particles on the surfaces.

X2.2 Lacking a detailed procedure supplied by the instrument manufacturer, confirm the requirements for parallelism of dial gages given in 6.1.1.2 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 0.002 mm.

NOTE X2.2—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.

X2.2.1 Observe and record the diameter as measured by the dial gage at one location.

X2.2.2 Move the ball to another location and repeat the measurement.

X2.2.3 If the difference between any pair of readings is greater than 0.0025 mm, the surfaces are not parallel.

X2.3 Lacking a detailed procedure supplied by the instrument manufacturer, confirm the flatness of the anvil and the presser foot of a dial gage by the use of an optical flat that has clean surfaces. Surfaces shall be flat within 0.0011 mm.

X2.3.1 After cleaning the surfaces (see X2.1) place the optical flat on the anvil and close the presser foot on the anvil.

X2.3.2 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 0.00025 mm.

X2.3.2.1 A flat surface forms straight parallel fringes at equal intervals.

X2.3.2.2 A grooved surface forms straight parallel fringes at unequal intervals.

X2.3.2.3 A symmetrical concave or convex surface forms concentric circular fringes. Their number is a measure of the deviation from flatness.

X2.3.2.4 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.

X2.4 *Calibration of Gages*:

X2.4.1 Calibrate all dial gages 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 0.002 mm, the standard gage block dimension shall be known to within ±0.0002 mm. Perform calibration procedures only after the instrument has been checked and found to meet the requirements of the pertinent preceding paragraphs of these methods. Perform procedures at least once every 30 days.

X2.4.2 Using the procedures detailed in Section 8 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.

X2.4.3 Construct a calibration correction curve that will provide the corrections for application to the observed dimensions of specimens measured using this calibrated micrometer.