This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: D8136 – 17

# Standard Test Method for Determining Plastic Film Thickness and Thickness Variability Using a Non-Contact Capacitance Thickness Gauge[1]

This standard is issued under the fixed designation D8136; 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 This test method covers the determination of the thickness of plastic film, ranging in thickness from 2.5 to 250 µm, with a non-contact thickness gauge that uses capacitance-based technology. It includes a method to generate a series of thickness data points that can be used to characterize the variability patterns of film for both transverse or machine direction (profiling).

NOTE 1—Thicker specimens, typically 250 µm to 2500 µm thick, can utilize this test method if the apparatus is designed to measure and handle materials of this thickness range, and the apparatus complies with the requirements as defined in this standard.

1.2 This test method provides a method for buyers and sellers of film to communicate the thickness and pattern of thickness variability of the product they are buying/selling.

1.3 This test method does not apply to textured or porous films or films that are conductive or coated with a conductive substance.

NOTE 2—Films that contain excessive levels of anti-static additive can be conductive and need to be tested to verify that they do not cause a negative reading on the instrument.

1.4 *Units*—The values stated in SI units are to be regarded as the standard. No other units of measurement are included in this standard.

NOTE 3—There is no known ISO equivalent to this standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

D618 Practice for Conditioning Plastics for Testing
D883 Terminology Relating to Plastics
D1505 Test Method for Density of Plastics by the Density-Gradient Technique
D4805 Terminology for Plastics Standards (Withdrawn 2002)[3]
D6988 Guide for Determination of Thickness of Plastic Film Test Specimens
E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E252 Test Method for Thickness of Foil, Thin Sheet, and Film by Mass Measurement
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

2.2 *ISO Standard:*

ISO 472 Plastics—Vocabulary[4]

## 3. Terminology

3.1 *Definitions*—See Terminologies D883, D4805, D6988, and ISO 472 for definitions pertinent to this test method.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *calibration, n*—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.



[1] This is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.19 on Film, Sheeting, and Molded Products.

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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] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

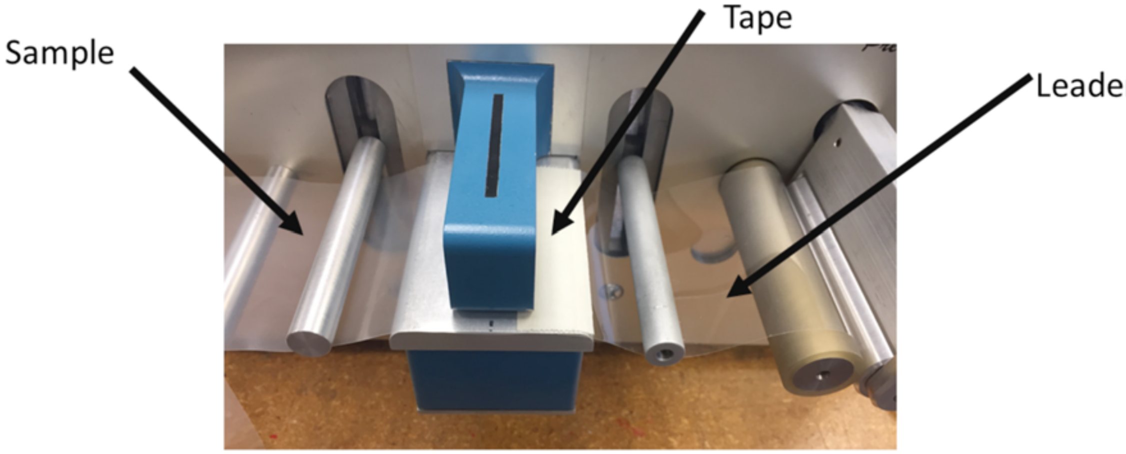


FIG. 1 Leader Attached to a Specimen with Tape

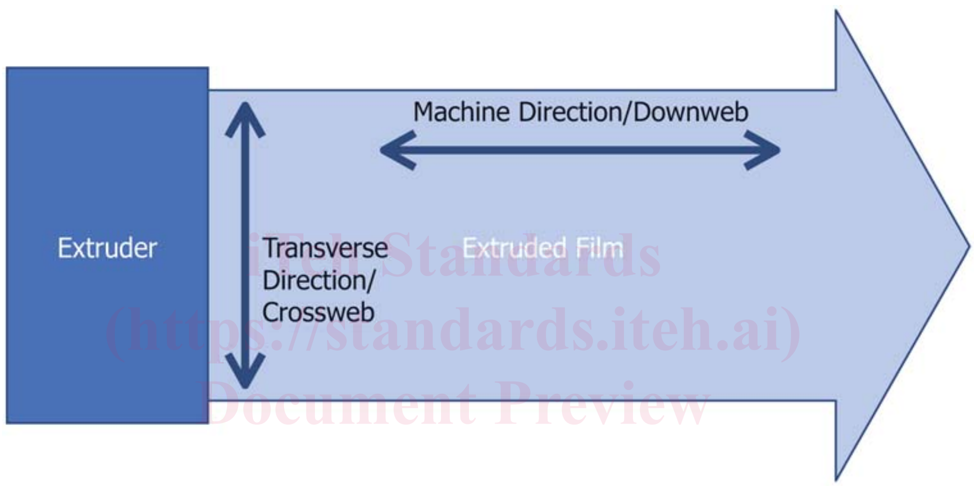




FIG. 2 Illustration of the Machine/Downweb Direction and the Transverse/Crossweb Direction



3.2.2 *calibration recipe, n*—computer-stored calibration that relates the response of the instrument to a thickness or basis weight of a given specimen.

3.2.3 *guide posts, n*—posts that protrude from the front face of a profiler apparatus that apply tension and help guide the specimen as it is profiled.

3.2.4 *guide tray, n*—tray, which can also include a weight that is placed on top of the film, that protrudes from the front face of a profiler apparatus that applies tension and helps guide the specimen as it is profiled.

3.2.5 *leader, n*—piece of film that is attached to the leading edge of the specimen to bridge the distance from the edge of the specimen being measured to the drive roller of an automated profiler allowing the user to measure as close to the edge of the specimen as possible (see Fig. 1).

3.2.6 *loop tensioner, n*—device that places tension on a loop of film, typically produced when making blown film, to flatten the film as it is pulled through the profiler.

3.2.7 *machine direction, n*—direction of the flow of the film out of the extrusion die.

3.2.7.1 *Discussion*—It is also commonly referred to as the "downweb direction" (see Fig. 2).

3.2.8 *measurement footprint, n*—area over which the capacitance response is measured.

3.2.9 *non-contact capacitance thickness gauge, n*—instrument that measures the thickness of a specimen without touching it by sensing the capacitance response created by the material when placed in an electric field.

3.2.10 *profiling, v*—obtaining an array of data points, each point being the average thickness under the measurement area, across a specimen (see Fig. 3).

3.2.11 *spooling, n*—optional feature offered on some profilers that automatically wraps the film around a take-up roller after the film has been profiled.

3.2.11.1 *Discussion*—It is typically used to facilitate the handling of long specimens.

3.2.12 *trailer, n*—piece of material attached to the trailing edge of the specimen that is being profiled.

3.2.12.1 *Discussion*—This material helps maintain consistent tension on the film as it is pulled through the device (see Fig. 4).

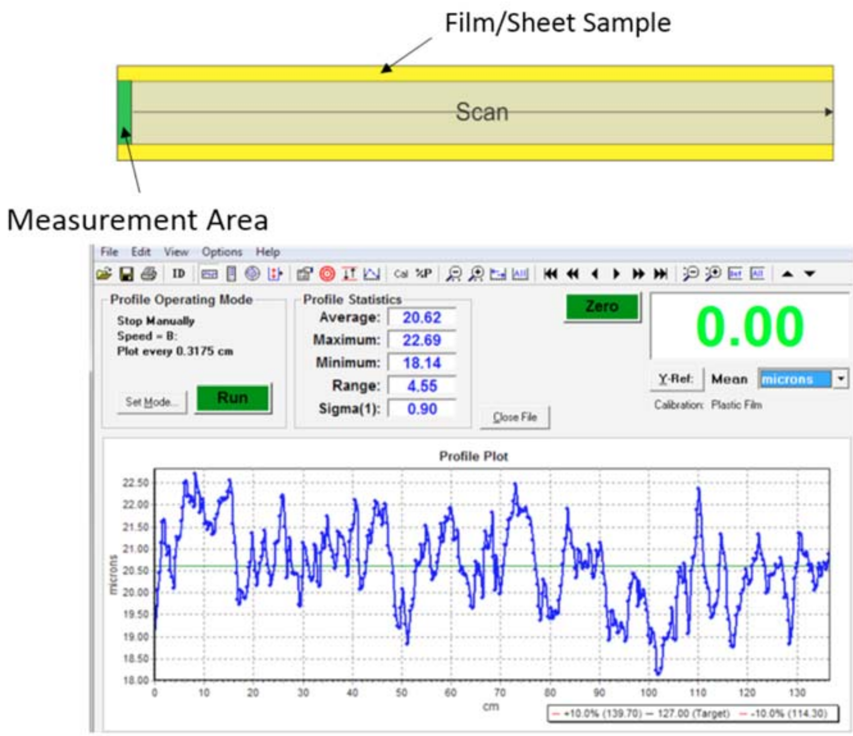


FIG. 3 Profiling a Film Specimen and the Resulting Graph and Data



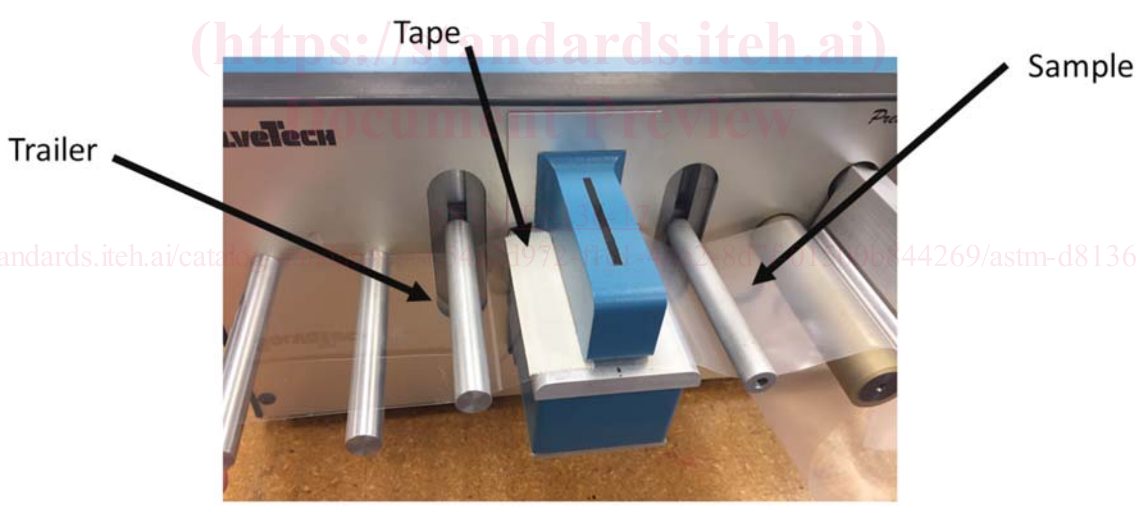


FIG. 4 Trailer Attached to the Specimen with Tape

3.2.13 *transverse direction, n*—direction perpendicular to the flow of the film out of the extrusion die.

3.2.13.1 *Discussion*—It is also commonly referred to as the “crossweb direction” (see Fig. 2).

3.2.14 *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 Test Method

4.1 This test method describes a non-contact method for measuring the thickness of plastic film using a capacitance-based gauging system and provides a guide for profiling film thickness variability in the transverse and machine directions.

4.2 This test method explains how to prepare and calibrate the instrument properly.

4.3 This test method explains how to prepare the specimens properly.

4.4 The first procedure option describes profiling a film specimen. A strip is cut from a film roll and thickness measurements are made along the strip to characterize the material’s thickness and pattern of thickness variability.

4.5 The second procedure option describes using the instrument to measure a single area on the film.

## 5. Significance and Use

5.1 This test method provides precise dimensions necessary for the calculation of properties expressed in physical units.

5.2 This test method provides a means to characterize the variability of the material thickness in the transverse and machine directions for quality control purposes, production process support and analysis, incoming product inspection and for defining variability for buying/selling film.

5.3 This test method provides a method for instrument calibration utilizing traceable standards available from the National Institute of Standards and Technology (NIST).

5.4 It is not intended to replace other thickness measurements based on commercial portable tools, nor is it implied that thickness measurements made by different procedures will exactly agree.

## 6. Apparatus

6.1 A non-contact capacitance gauge that is linear (±0.5 % over the thickness range of materials being measured as tested in accordance with Appendix X2) in its response and exhibits a precision of ±0.1 µm, or ±0.5 % of material thickness (whichever is larger) when used with standard reference materials.

NOTE 4—This can be verified using a ~25 µm specimen and verifying that it reads the same when measured twice to ±0.1 µm.



6.2 *Measurement Footprint:*

6.2.1 For profiling a specimen, the optimal measurement footprint is rectangular in area with an opposing direction length to an in-line length ratio of 5 to 1 or greater, such that the aspect ratio enhances the resolution of the measurement in the direction of the profile (transverse or machine) while averaging the variability in the perpendicular direction.

NOTE 5—When profiling a specimen, each measurement is the average of the entire measurement area. To define the variability in a specified direction, the variability is measured at higher resolution than the opposing direction. This averages a wider distance in the opposing direction while giving fine detail in the desired direction. This provides a line average with a high resolution in the direction of the profile and helps to isolate the variability in the desired direction (see Fig. 5).

6.2.2 In comparing this approach to previous standards that typically use a circular shape footprint, a data point using the rectangular footprint is similar to taking and averaging multiple single-point measurements perpendicular to the direction being profiled. A typical measurement area for a profiler is 3.2 mm wide by 57.2 mm long (see Fig. 6).

6.2.3 For a device designed for spot measurements, a circular or rectangular footprint is used.

6.3 A means is used to convey the film through the measurement head with an encoded data acquisition to automatically (preferred) or manually acquire and plot data points. It is recommended that this process be automated as this typically produces better repeatability and reproducibility results.

6.4 Provide proper shielding for the measurement sensor so that objects near or touching the device probe do not affect the reading.

6.5 The data collection software shall have the capability to calibrate the instrument, store calibration recipes, control the instrument, and record and present the data.

## 7. Hazards

7.1 In an automated film profiler, avoid pinch points where the two rollers come together to create friction on the drive roller. Do not place fingers between the rollers and keep loose clothing, hair, or other objects from entering the rollers.

## 8. Test Specimens

8.1 *Preparing a Specimen for a Profile Measurement:*

8.1.1 Prepare the specimen by cutting a strip to the width specified by the equipment manufacturer to ensure that the entire measurement surface is covered during the profiling operation. For a transverse direction specimen, it is recommended that the entire extruded width of the material be profiled to characterize the variability pattern across the entire width of the extrusion die. For a machine direction specimen, the user needs to select a specimen length based on their process conditions. Additional information on determining this machine direction specimen length is provided in Appendix X2 (see Figs. 7 and 8).

NOTE 6—It is recommended that the material be cut using a template so

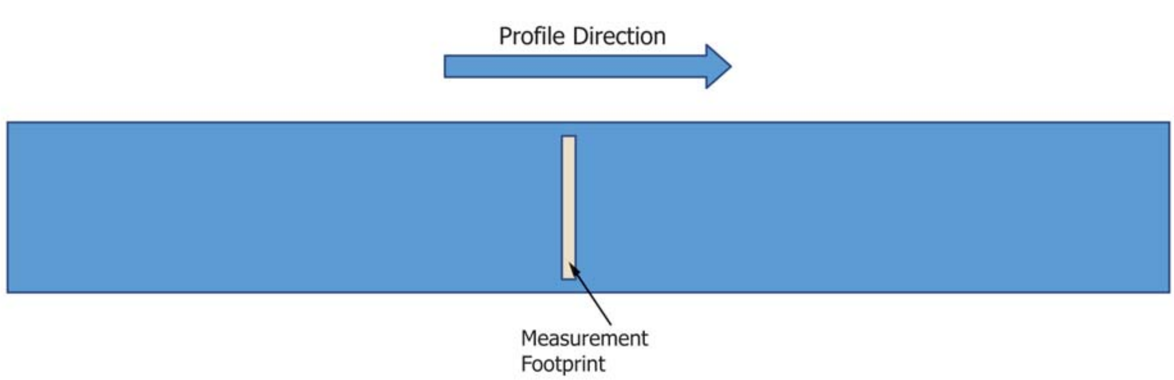


**FIG. 5 Measurement Footprint Orientation Relative to Profile Direction**

**FIG. 6 Typical Measurement Footprint in the Black Area Shown—3.2 by 57.2 mm**

that the length and width are easy to obtain and consistent across the specimen.

8.1.2 In some cases, the resulting specimen is a continuous loop of material. In other cases, a specimen will be a strip of material. To measure the ends of a specimen that is not a continuous loop, a leader and trailer (see Fig. 9) attached to the specimen with tape, can be used. For a proper characterization of variability, it is necessary to measure as much of the specimen as possible.

NOTE 7—When running strip with a leader and a trailer, typically missing 1 cm along the ends is acceptable because of the space required to attach the tape.

8.2 *Preparing a Specimen for a Spot Measurement:*

NOTE 8—Non-contact profilers are typically used for profiling a strip of material but can also be used to do spot measurements, similarly to a contact micrometer as discussed in Guide D6988.

8.2.1 The test specimens shall be prepared from plastic film that have been cut to the required dimensions consistent to the design requirements of the gauging system as recommended by the manufacturer.

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

NOTE 9—Avoid creasing the material as this can cause a reading error.

8.4 Allow specimens to equilibrate at 23 ± 2°C and 50 ± 10 % relative humidity in accordance with Procedure A of Practice D618 unless otherwise specified by agreement or the relevant ASTM International material specification.

8.5 Unless otherwise specified, make all dimension measurements at the same conditions used for equilibration.

## 9. Preparation of Apparatus

9.1 Turn on the instrument and allow it to stabilize for a time period as specified by the manufacturer.

NOTE 10—At least 1 h is typically required for the equipment to stabilize. It is common for users to leave the device on continuously to avoid this stabilization period.

9.2 Set the device to read zero with no specimen in the measurement area.

9.3 Verify proper operation of the gauge using a reference specimen (as specified in Annex A4) and the following procedure:

9.3.1 Load the calibration recipe for the reference specimen.

9.3.2 Insert the reference specimen into its specified position, and Confirm that it reads the correct value.

9.4 Choose the calibration recipe for the material composition being tested from the calibration table or calibrate the device using a method specified in Section 10.



## 10. Calibration and Standardization

10.1 Calibration is necessary for each material composition tested because material composition will determine the dielectric response.

NOTE 11—This is necessary as the device indirectly measures thickness by measuring the dielectric response of the material in an electric field.



10.2 The recommended calibration method, gauge by weight method, is described in Annex A1. Other calibration methods are found in Annex A2.

## 11. Procedure

11.1 *Profiling a Specimen:*

11.1.1 Prepare the specimen as noted in 8.1.

11.1.2 Prepare the apparatus as noted in Section 9.

11.1.3 Insert the specimen into the apparatus with the start of the specimen in the measurement area.

NOTE 12—If using a leader and trailer, be sure that the tape attaching the leader is not underneath the measurement footprint.

11.1.4 Apply a minimal amount of consistent tension to keep the film flat and stable as it moves through the apparatus.

11.1.5 Move the specimen automatically or manually through the apparatus and record the data until the entire specimen is measured, taking readings at least as frequently as the width of the footprint to provide a continuous profile of the material.

NOTE 13—For example, if the footprint is 3.2 mm wide, a reading needs to be taken every 3.2 mm or less.

11.1.6 Verify the run technique as specified in Annex A3.

NOTE 14—Once a run technique that demonstrates repeatable results has been established for a film, this procedure can be used without

FIG. 7 Cutting Template Placed over Film Specimen

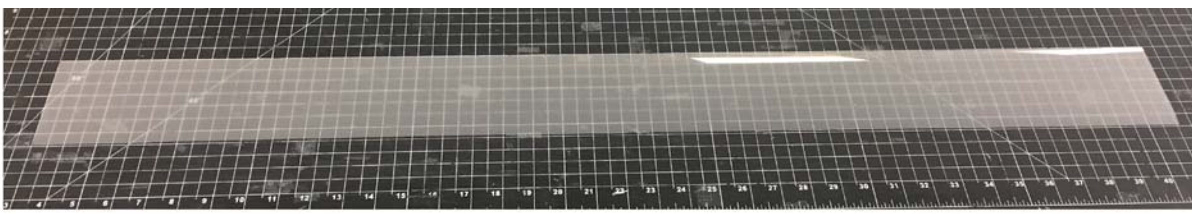

FIG. 8 Cut Film Specimen

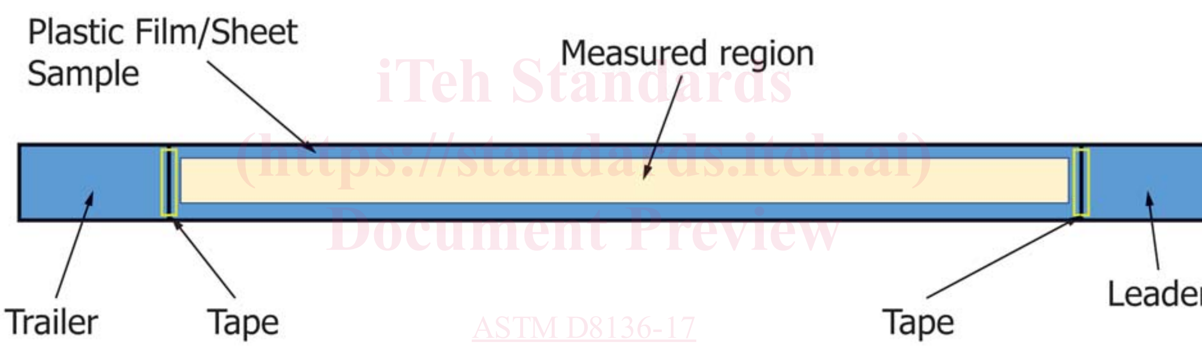


FIG. 9 Specimen with Leader and Trailer Attached



verifying the repeatability of every run. Different films will require different configurations for material handling, which can include guide posts, loop tensioners, a guide tray, or spooling.

11.2 *Measuring a Single Spot:*

11.2.1 Prepare the specimen as noted in 8.2.

11.2.2 Prepare the measurement apparatus as specified in Section 9.

11.2.3 Insert the specimen under the measurement area and apply a minimal amount of consistent tension to keep the film flat and stable as it moves through the apparatus.

NOTE 15—Wrinkled material will result in a higher value than the actual specimen since there is, physically, more material in the sensing region. The amount of tension applied needs to be sufficient to pull the material flat visually while avoiding stretching the material.

11.2.4 Verify that there is material under the entire measurement area and there is a buffer of additional material around the measurement area as specified by the manufacturer. The entire measurement area needs to be covered or the gauge will provide inaccurate readings.

NOTE 16—A typical buffer region is 6 mm or more of additional material around the edge of the measurement footprint.

11.2.5 Record the measurement.

## 12. Calculation or Interpretation of Results

12.1 The user will interpret the results to determine whether the material meets the desired criteria.

12.2 The software of the device will compute average thickness, minimum, maximum, range, and the standard deviation.

12.3 The apparatus software will display a graph for a visual analysis of the information.

NOTE 17—It is recommended that the apparatus software is able to export the data easily for further analysis and be able to exclude data that is invalid due to damage to the sample or poor material handling.

## 13. Report

13.1 Report the following information:

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

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