Designation: E252 – 06 (Reapproved 2021)$^{\varepsilon 1}$

Standard Test Method for Thickness of Foil, Thin Sheet, and Film by Mass Measurement[1]

This standard is issued under the fixed designation E252; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

ε^1 NOTE—The elements listed in Table A2.1 were re-ordered editorially in June 2021 to be consistent with registered alloys published by the Aluminum Association.

1. Scope

1.1 This test method covers the determination of the thickness of metallic foil and sheet 0.015 in. (0.38 mm) and less in thickness by measuring the mass of a specimen of known area and density. The test method is applicable to other sheet, foil, and film as indicated in Annex A3.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are mathematical conversions to SI units, which are provided for information only and are not considered 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *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 The following documents of the issue in effect on the date of material purchase, unless otherwise noted, form a part of this specification to the extent referenced herein:

2.2 *ASTM Standards:*[2]

D1505 Test Method for Density of Plastics by the Density-Gradient Technique

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

3. Apparatus

3.1 *Precision Blanking Press*—to cut foil or sheet circles that are 8.000 ± 0.008 in.^{2} (51.613 ± 0.051 cm^2) in area or 3.1915 ± 0.0015 in. (81.06 ± 0.04 mm) in diameter. Other size specimens may be used with the recognition that the accuracy stated in 6.1 is no longer applicable. See Annex A1 for the selection of other specimen sizes and the resulting change in accuracy of the test method.

3.2 *Balance*—capable of measuring to the nearest 0.1 mg of thickness for the 8.000-in.^{2} (51.613 cm^2) circle.

4. Procedure

4.1 Blank an 8.000 ± 0.008-in.^{2} (51.613 ± 0.051 cm^2) circle representative of the foil or sheet, swab with acetone or other suitable solvent to ensure a surface free of soil, and determine the mass of the clean, dry specimen to the nearest 0.1 mg. Use a suitable solvent to remove any coating known to exceed 0.005 mg/ft^2 (4.645 mg/cm^2) of surface area.

5. Calculation

5.1 Determine the thickness from the relationship:

$$T = \frac{M}{A \cdot D}$$

where:

T = thickness of the foil, sheet, or film, in. (or cm),
M = mass of the circle, g,
A = area of the circle, in.^{2} (or cm^2), and
D = density of the foil, sheet, or film, g/in.^{3} (or Mg/m^3).

5.2 *Densities of Aluminum Alloys:*

5.2.1 Calculate the density of aluminum foil or sheet from chemical composition limits of the alloy by the method

---

[1] This test method is under the jurisdiction of ASTM Committee B07 on Light Metals and Alloys and is the direct responsibility of Subcommittee B07.05 on Testing.

Current edition approved May 1, 2021. Published June 2021. Originally approved in 1964. Last previous edition approved in 2013 as E252 – 06 (2013). DOI: 10.1520/E0252-06R21E01.

[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.

described in Annex A2. The densities of foil or sheet alloys determined in this manner are accurate to within ± 0.3 %.

5.2.2 Calculated densities for some of the common foil or sheet alloys can be found in Table 1. A column headed "mils/g for 8.000-in.^{2} Area" is added for convenience in determining thickness of the 8.000-in.^{2} (51.613 cm^2) specimens. The mass of the specimen in grams multiplied by this factor is equal to the thickness of the foil or sheet in mils. One mil is equal to 0.001 in. (0.0254 mm).

6. Precision and Bias

6.1 Following the procedure outlined in this test method, repeated mass measurements of the same specimen on different balances should result in agreement within 1 mg. It is outside of the scope of this test method to describe maintenance and calibration procedures for balances, but disagreement larger than 1 mg warrants attention to maintenance or recalibration of the balance.

TABLE 1 Densities of Aluminum Foil or Sheet Alloys Applicable to Determination of Thickness by Mass Measurement Method

Alloy	Density		mils/g for 8.000-in.^{2} Area
	g/in.^{3}	Mg/m^{3A}	
1100	44.41	2.71	2.815
1145	44.24	2.700	2.826
1188	44.24	2.700	2.826
1199	44.24	2.700	2.826
1235	44.33	2.705	2.820
3003	44.74	2.73	2.794
5052	43.92	2.68	2.846
5056	43.26	2.64	2.890
8079	44.57	2.72	2.805
8111	44.41	2.71	2.815

^{A} *Registration Record of Aluminum Association Designations and Chemical Composition Limits for Wrought Aluminum and Wrought Aluminum Alloys*, Aluminum Assoc., Washington, DC.

ANNEXES

(Mandatory Information)

A1. SPECIMEN SIZE AND SHAPE AND ITS EFFECT ON ACCURACY

A1.1 General

A1.1.1 Specimens of sizes and shapes other than the 8.000-in.^{2} (51.613 cm^2) circle maybe used provided consideration is given to controllable factors affecting the accuracy of the method. Specifically, the area of the specimen shall be known and controlled to an accuracy of ±0.1 %, and the minimum mass of the specimen shall be 70 mg. Specimens ranging in size from 8 to 32 in.^{2} (52 to 206 cm^2) are convenient to handle and can be prepared to meet the aforementioned requirements.

A1.2 Source of Error

A1.2.1 Inherent errors in determining thickness by the mass measurement method result from the limits on the accuracy of the density value assigned to the alloy, the accuracy with which a specimen can be cut and its area determined, and the accuracy of the mass measurement. Much time could be devoted to a discussion of refinement of errors but it shall suffice here to draw on experience as a guide for determining the accuracy of the method.

A1.3 Error From Uncertainty of Densities of Specimen (E_D)

A1.3.1 The density of aluminum foil or sheet alloys shall be those listed in Table 1 or it shall be determined by the method described in Annex A2. Values so obtained are accurate to ± 0.3 % of the true density. The error imposed by uncertainty of the density then is $E_D = \pm\ 0.3$ % of the thickness determined.

A1.4 Error From Control of Area of Specimen (E_A)

A1.4.1 A precision blanking press can cut a specimen whose area is known and reproducible to an accuracy of ±0.1 %. If d is the specific diameter required to provide the area used in the thickness computation, then the error in area resulting from a small error, Δd, in the diameter is 200 $\Delta d/d$ %. It follows then that to maintain an area accurate to ±0.1 %, the tolerance on the diameter of the blanked circle shall be ±0.0005 times the circle diameter. The fact that the tolerance on diameter decreases in direct proportion to the diameter is a factor to consider in selecting the specimen size to use in the method. Compliance with this tolerance limits the area error to $E_A = \pm\ 0.1$ % of the thickness determined.

A1.5 Error From Measuring Mass of Specimen (E_M)

A1.5.1 The accuracy of measuring the mass of a foil or sheet specimen has been found to be 0.7 mg. This imposes a maximum error on the method of $\pm\ 0.07/(T \cdot A \cdot D)$ % of the thickness determined. Since D, density of the foil or sheet, is fixed, it is seen that the magnitude of the mass measurement error is a function of the thickness, T, of the foil or sheet and the area, A, of the specimen. The area, A, is a controllable factor in the method, and the importance of selecting a large area to minimize the overall percentage error in the method for thin foil or sheet is apparent from a few simple calculations. The product $T \cdot A \cdot D$ is the mass of the specimen in grams, so to prevent the mass measurement error from introducing errors in excess of ± 1.0 %, it is necessary that the mass of the specimen be larger than 70 mg. The maximum error in the method due to mass measurement then is $E_M = \pm\ 0.07/\ (T{\cdot}A{\cdot}D)\ \%$ of the thickness determined.

A1.6 Maximum Error of Method

A1.6.1 If E_D, E_A, and E_M represent the errors in percentage of thickness determined as imposed by the limits of accuracy of density, area, and mass measurement, respectively, then the maximum error of the method is $(E_D + E_A + E_M)$ percent of the thickness determined. Since these errors at a given test location are normally in the nature of a bias rather than random error, the accuracy of the method is best described in terms of this maximum error. The maximum error of the method in percent is as follows:

$$E_D + E_A + E_M = \left[0.4 + \frac{0.07}{(T{\cdot}A{\cdot}D)}\right]$$

where:

$T{\cdot}A{\cdot}D$ = is the mass of the specimen in grams.

A2. CALCULATING THE DENSITY OF ALUMINUM ALLOYS

A2.1 Calculation

A2.1.1 The following describes the procedures used to calculate nominal densities of aluminum and aluminum alloys.

A2.1.2 The form shown in Table A2.1 is convenient for making such calculations. A sample calculation is shown for 5052 alloy.

A2.1.2.1 For each alloying element, the arithmetic mean of its registered limits is determined. The mean is rounded to the number of places indicated in Table A2.2. Rounding, except when specified otherwise, shall be in accordance with the rounding method of Practice E29.

A2.1.2.2 For each impurity element or combination of impurity elements for which a maximum limit is registered, an arithmetic mean is determined using zero as the minimum limit. The mean is rounded to the number of places indicated in Table A2.1.

A2.1.2.3 For impurity elements having a combined limit (such as Si + Fe), each of the elements is considered to have an equal concentration. The concentrations are calculated by dividing the mean determined for the combined limit in A2.1.2.2 by the number of elements in the combined limit. Each element concentration is rounded to the number of places indicated in Table A2.1.

A2.1.2.4 The element concentrations in A2.1.2.1 – A2.1.2.3 are totaled and then subtracted from 100 to obtain the concentration of aluminum to be used in the calculation. The aluminum concentration is rounded to two decimal places. For 1XXX series aluminum, calculated aluminum content may be less than the specified minimum aluminum content. Nevertheless, the calculated aluminum content should be used for purposes of this calculation procedure.

A2.1.2.5 Each element concentration determined in A2.1.2.1 – A2.1.2.4 is multiplied by the value 1/Density given in Table A2.2. Each of these results is rounded to three decimal places.

A2.1.2.6 The values determined in A2.1.2.5 are added together and this sum is divided into the number 100. The result is the unrounded density in Mg/m^3.

A2.1.2.7 The final expression of density in metric units (Mg/m^3) is obtained by rounding the value determined in A2.1.2.6 as follows:

(1) For aluminum and aluminum alloys having a specified minimum aluminum content of 99.35 % or greater, the value obtained is rounded to the nearest multiple of .005 and expressed as X.XX0 or X.XX5.

(2) For aluminum and aluminum alloys having a specified minimum aluminum content less than 99.35 %, the value obtained is rounded to the nearest multiple of .01 and expressed as X.XX.

NOTE A2.1—Limiting the expression of density to the number of decimal places indicated above is based on the fact that composition variations are discernible from one cast to another for most alloys. The expression of density values to more decimal places than is outlined above infers a higher precision than is justified and should not be used.

A2.1.2.8 The density in $g/in.^3$ is calculated by multiplying the value obtained in A2.1.2.7 by 16.387 and rounding to two decimal places.

A2.2 Accuracy

A2.2.1 The accuracy of the density arrived at by this method is ±0.3 % of the determined value for the common foil or sheet alloys and ±0.5 % for highly alloyed compositions such as 2024.