Designation: E 252 – 84 (Reapproved 1999)

Standard Test Method for Thickness of Thin Foil and Film by Weighing[1]

This standard is issued under the fixed designation E 252; 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 Department of Defense.

1. Scope

1.1 This test method covers the determination of the thickness of metallic foils 0.002 in. (0.05 mm) and less in thickness by weighing a specimen of known area and density. The test method is applicable to other foils and films as indicated in Annex A3.

1.2 The values stated in inch-pound 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.*

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:*

D 1505 Test Method for Density of Plastics by the Density-Gradient Technique[2]

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[3]

3. Apparatus

3.1 *Precision Blanking Press*—to cut foil 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 Other size specimens may be used with the recognition that the accuracy stated in 6.1 is no longer applicable.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 swab with acetone or other suitable solvent to ensure a surface free of soil, and weigh 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:

$$T = W/AD$$

where:

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

5.2 *Densities of Aluminum Alloys*:

5.2.1 Calculate the density of aluminum foil from chemical composition limits of the alloy by the method described in Annex A2. The densities of foil alloys determined in this manner are accurate to within ± 0.3 %.

5.2.2 Table 1 lists densities computed for some of the common foil alloys. 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 weight of the specimen in grams multiplied by this factor is equal to the thickness of the foil in mils.

6. Precision and Bias

6.1 Following the procedure outlined in this test method, repeated weighings 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.

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[1] This test method is under the jurisdiction of ASTM Committee B-7 on Light Metals and Alloys and is the direct responsibility of Subcommittee B07.05 on Testing.

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

[3] *Annual Book of ASTM Standards*, Vol 14.02.

TABLE 1 Densities of Aluminum Foil Alloys Applicable to the Determination of Foil Thickness by the Weight Method

Alloy	Density		mils/g for 8.000-in.^{2} Area
	g/in.^{3}	Mg/m^3[A]	
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 weight of 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 weight 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 weighing. 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 the Densities of the Specimen (E_D)

A1.3.1 The density of aluminum foil alloys shall be those listed in Table 1 or 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 the Area of the 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 loosens 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 Weighing the Specimen (E_W)

A1.5.1 The accuracy of weighing a foil specimen has been found to be 0.7 mg. This imposes a maximum error on the method of ± 0.07/*TAD*% of the thickness determined. Since *D*, density of the foil, is fixed, it is seen that the magnitude of the weighing error is a function of the thickness, *T*, of the foil 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 is apparent from a few simple calculations. The product *TAD* is the weight of the specimen in grams, so to prevent the weighing error from introducing errors in excess of ±1.0 %, it is necessary that the weight of the minimum thickness specimen be larger than 70 mg. The maximum error in the method due to weighing then is $E_W = \pm$ 0.07/*TAD* % of the thickness determined.

A1.6 Maximum Error of the Method

A1.6.1 If E_D, E_A, and $E_W$represent the errors in percentage of thickness determined as imposed by the limits of accuracy of density, area, and weighing, respectively, then the maximum error of the method is *ED + EA + EW* 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:

$$E_D + E_A + E_W = [0.4 + (0.07/TAD)]$$

where *TAD* is the weight 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 in italics 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 E 29.

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's concentration is rounded to the number of places indicated in Table A2.1.

TABLE A2.1 Density Calculations of Aluminum and Aluminum Alloys at 20°C

Alloy *5052*

Element	1/Density[A] (m^3/Mg)	Weight Percent Present	1/Density × Weight Percent Present
Cu	0.1116	*(0.05)*	*(0.006)*
Fe	0.1271	*(0.20)*	*(0.025)*
Si	0.4292	*(0.12)*	*(0.052)*
Mn	0.1346	*(0.05)*	*(0.007)*
Mg	0.5522[B]	*(2.50)*	*(1.380)*
Zn	0.1401	*(0.05)*	*(0.007)*
Ni	0.1123		
Cr	0.1391	*(0.25)*	*(0.035)*
Ti	0.2219		
Pb	0.0882		
V	0.1639		
B	0.4274		
Be	0.5411		
Zr	0.1541		
Ga	0.1693		
Bi	0.1020		
Sn	0.1371		
Cd	0.1156[C]		
Co	0.1130[C]		
Li	1.8727[C]		
		(3.22)	*(1.512)*
A1	0.3705	*(96.83)*	*(35.857)*
			(37.369)

[A] Calculated Density
= 100/37.369 = *(2.68)* Mg/m^3
Mg/m^3 × 16.387 = *(43.92)* g/$in.^3$
Kunkle, D. E., and Willey, L. A., "Densities of Wrought Aluminum Alloys," *Journal of Materials*, ASTM, Vol 1, No. 1, March 1966.

[B] The magnesium density used in this calculation is 4.2 % greater than the density of pure magnesium. This corrects for metallurgical formations that normally occur in alloys containing magnesium.

[C] Metals Handbook, Amer. Soc. for Metals, Vol 1, 8th Edition.

TABLE A2.2 Precision for Standard Limits for Alloy Elements and Impurities

Less than 1/1000 %	0.000×
1/1000 to 1/100 %	0.00×
1/100 to 1/10 %	
Unalloyed aluminum made by a refining process	0.0××
Alloys and unalloyed aluminum not made by a refining process	0.0×
	0.0×
1/10 through 1/2 %	0.××
Over 1/2 %	0.×, × .×, etc.

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 1 XXX 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 answer is rounded to three decimal places.

A2.1.2.6 The values determined in A2.1.2.5 are added together and the number 100 is divided by the total.

A2.1.2.7 The final expression of density in metric units (Mg/m3) 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 alloys and ±0.5 % for highly alloyed compositions such as 2024.

A3. USE OF METHOD FOR POLYETHYLENE FILM

A3.1 Scope

A3.1.1 This method is applicable to a wide range of films and foils. As an example of the slight modifications required for adaptation to other materials the procedure recommended for polyethylene film of 0.002 in. (0.05 mm) and less in thickness is described.

A3.2 Apparatus

A3.2.1 A hand striking die is a convenient way to cut the specimen. The precision blanking press with the polyethylene film on a piece of paper will also produce good results, but any other method capable of the desired precision may be used.

A3.3 Test Specimen

A3.3.1 Because of the lower density of polyethylene film, a minimum specimen of 16.000 ± 0.016 $in.^2$ (103.23 ± 0.10 cm^2) is recommended; other specimen sizes may be used as discussed in Annex A1. If there is evidence of surface contamination, the specimen may be wiped clean with a dry cloth or tissue, but no solvent should be used.

A3.4 Calculations

A3.4.1 The density of polyethylene film may be determined directly by Test Method D 1505. In many cases the film density will be known within the accuracy needed for this method (about 0.5 %) from specifications or previous experience. Polyethylene density is usually reported in grams per cubic centimetre. To convert this to grams per cubic inch as needed in this calculation, multiply by 16.39.