Designation: B 479 – 00

Standard Specification for Annealed Aluminum and Aluminum-Alloy Foil for Flexible Barrier, Food Contact, and Other Applications[1]

This standard is issued under the fixed designation B 479; 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 specification covers annealed aluminum and aluminum-alloy foil containing 98.00 % minimum aluminum and in thicknesses 0.00025 in. (0.0064 mm) to, but not including, 0.006 in. (0.15 mm). Alloys (see Note 1) covered by this specification include, but are not limited to 1100, 1145, 1235, 8079, and 8111, which conform to the requirements of 6.1 and Table 1. Unless otherwise specified by the purchaser, the alloy to be supplied shall be left to the discretion of the producer.

1.2 The foil is for use in packaging, which includes food handling and processing applications, requiring flexible barrier materials, and other general applications. The foil may be used as supplied or laminated to other materials, such as paper or plastic films.

1.3 For acceptance criteria for inclusion of new aluminum and aluminum alloys in this specification, see Annex A1.

1.4 The values stated in inch-pound units are to be regarded as the standard. The SI values in parentheses are for information only.

1.5 The following precautionary caveat pertains only to the test method portion of this specification: *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—Throughout this specification, use of the term *alloy* in the general sense includes aluminum as well as aluminum alloy.

NOTE 2—If the alloy is specified by the purchaser, its designation shall be in accordance with ANSI H35.1. The equivalent Unified Numbering System alloy designations are those shown in Section 1.1 preceded by A9, for example, A91100 for aluminum 1100 in accordance with Practice E 527.

2. Referenced Documents

2.1 The following documents of the date of issue in effect on date of material procurement form a part of this specification to the extent referenced herein.

TABLE 1 Chemical Composition Limits[A,B,C]

Si + Fe	1.8	Ti	0.08
Cu	0.20	Others—each[D]	0.05[E,F]
Mn	0.10	Others—total[D]	0.15
Mg	0.05	Al, min.	98.00[G]
Zn	0.10		

[A] Limits are in percent maximum unless otherwise noted.

[B] Analysis shall be made for the elements for which limits are shown in this table.

[C] For purposes of determining conformance to these limits, an observed value or a calculated value obtained from analysis shall be rounded to the nearest unit in the last right-hand place or figures used in expressing the specified limit, in accordance with the rounding method of Practice E 29.

[D] *Others* includes all unlisted metallic elements. The producer may analyze samples for trace elements not specified in the specification. However, such analysis is not required and may not cover all metallic *Others* elements. Should any analysis by the producer or the purchaser establish that an *Others* element exceeds the limit of *Each* or that the aggregate of several *Others* elements exceeds the limit of *Total*, the material shall be considered non-conforming.

[E] For food applications, lead, arsenic, and cadmium shall be less than 0.01 % each. For purposes of determining conformance to the limits of these three elements, an observed value or a calculated value obtained from analysis shall be considered significant, in accordance with the absolute method of Practice E 29.

[F] Food packaging, in accordance with CONEG Model Legislation, shall have a maximum total of less than 100 ppm for the combined total of lead, mercury, cadmium, and hexavalent-chrome (Pb, Hg, Cd, and Cr^{tb}).

[G] The aluminum content shall be calculated by subtracting from 100.00 % the sum of all metallic elements present in amounts of 0.010 % or more each, rounded to the nearest 0.01 % prior to determining the sum.

2.2 *ASTM Standards:*

B 660 Practices for Packaging/Packing of Aluminum and Magnesium Products[2]

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

E 34 Test Methods for Chemical Analysis of Aluminum and Aluminum Base Alloys[4]

E 55 Practice for Sampling Wrought Nonferrous Metals and Alloys for Determination of Chemical Compo sition[5]

E 96 Test Methods for Water Vapor Transmission of Materials[6]

E 227 Test Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique[4]

E 252 Test Method for Thickness of Thin Foil and Film by Weighing[2]

[1] This specification is under the jurisdiction of ASTM Committee B07 on Light Metals and Alloys and is the direct responsibility of Subcommittee B07.03 on Aluminum Alloy Wrought Products.

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[2] *Annual Book of ASTM Standards*, Vol 02.02.

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

[4] *Annual Book of ASTM Standards*, Vol 03.05.

[5] *Annual Book of ASTM Standards*, Vol 03.06.

[6] *Annual Book of ASTM Standards*, Vol 04.06.

E 345 Test Methods of Tension Testing of Metallic Foil[7]
E 607 Test Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique, Nitrogen Atmosphere[5]
E 716 Practices for Sampling of Aluminum and Aluminum Alloys for Spectrochemical Analysis[5]
E 1251 Test Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Argon Atmosphere, Point-to-Plane, Unipolar Self-Initiating Capacitor Discharge[5]

2.3 *American National Standard:*

H35.1 Alloy and Temper Designation Systems for Wrought Aluminum[8]
Z1.4 Sampling Procedures and Tables for Inspection by Attributes[8]

3. Terminology

3.1 *Definitions:*

3.1.1 *foil*—a rolled product rectangular in cross section of thickness less than 0.006 in. (0.15 mm).

3.1.2 *matte one-side foil (MIS*)—foil with a diffuse reflecting finish (matte) on one side and a bright specular finish on the other side.

3.1.3 *bright two-sides foil (B2S*)—foil having a uniform bright specular finish on both sides.

3.1.4 *dry annealed, A*—having a test dryness 100/0, free from residual rolling oil as determined by the water test.

3.1.5 *dry annealed, B*—having a test dryness 90/10, having a slight film of residual rolling oil as determined by the water-alcohol test.

3.1.6 *dry annealed, C*—having a test dryness 80/20, having a slight film of residual rolling oil as determined by the water-alcohol test.

3.1.7 *slick annealed*—having a uniform film of residual rolling or applied oil as determined by the drop of water test.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *capable of*—The term *capable of* as used in this specification means that the test need not be performed by the producer of the material. However, should subsequent testing by the purchaser establish that the material does not meet these requirements, the material shall be subject to rejection.

4. Ordering Information

4.1 Orders for material to this specification shall include the following information:

4.1.1 This specification designation (which includes the number, the year, and the revision letter, if applicable),

4.1.2 Quantity in pieces or lbs (kg),

4.1.3 Nominal thickness and (a) sheet size, or (b) maximum roll diameter, nominal roll width, and core size (Section 9),

4.1.4 Surface condition (see 3.1.2 and 3.1.3),

4.1.5 Type of splice (for rolls only), (see 10.2),

4.2 Additionally, orders for material to this specification shall include the following information when required by the purchaser:

4.2.1 Whether supply of a specific alloy is required (see 1.1),

4.2.2 Whether inspection or witness of inspection and tests by the purchaser's representative is required prior to shipment (see 11.1),

4.2.3 Whether the intended use involves food processing, food packaging, or food preservation (see 6.1 and 15.2), and if so, what government regulations are applicable.

4.2.4 Whether certification is required (Section 13).

4.2.5 Whether Mullen test is required (see Section 11).

4.2.6 Whether special statistical methods are to be used for visual and dimensional inspection. If so, these methods shall be listed.

5. Responsibility for Quality Assurance

5.1 *Responsibility for Inspection and Tests*—Unless otherwise specified in the contract or purchase order, the producer is responsible for the performance of all inspection and test requirements specified herein. Except as otherwise specified in the contract or order, the producer may use his own or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless disapproved by the purchaser at the time the order is placed. The purchaser shall have the right to perform any of the inspections and tests set forth in this specification where such inspections are deemed necessary to assure that the material conforms to prescribed requirements.

6. Chemical Composition

6.1 *Limits*—The foil shall conform to the chemical composition limits in Table 1. For applications involving food packaging, handling, or preservation the absolute amounts of lead, arsenic, and cadmium shall be less than 0.01 % each (see footnote E of Table 1). The producer shall determine conformance by analyzing samples taken when the ingots are poured, or when continuous sheet or plate is cast, or by analyzing samples taken from the finished or semifinished product. If the producer has determined the chemical composition during the course of manufacture, he shall not be required to sample and analyze the finished product.

NOTE 3—It is standard practice in the United States aluminum industry to determine conformance to the chemical composition limits prior to further processing of ingots or continuously cast plate or sheet into wrought products. Due to the continuous nature of the process, it is not practical to keep a specific ingot analysis identified with a specific quantity of finished material.

6.2 *Number of Samples*—The number of samples taken for determination of chemical composition shall be as follows:

6.2.1 When samples are taken at the time the ingots are poured, at least one sample shall be taken for each group of ingots poured simultaneously from the same source of molten metal.

6.2.2 When samples are taken at the time a coil is cast, at least one sample shall be taken for each coil cast from the same source of molten metal.

6.2.3 When samples are taken from the finished or semifinished product, a sample shall be taken to represent each 4000 lb (1814 kg), or fraction thereof, in the shipment.

6.3 *Methods of Sampling*—Samples for determination of

[7] *Annual Book of ASTM Standards*, Vol 03.01.
[8] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

chemical composition shall be taken in accordance with one of the following methods:

6.3.1 Samples for chemical analysis shall be taken from the material by clipping a representative piece or pieces to obtain a prepared sample of not less than 75 g. Sampling shall be in accordance with Practice E 55.

6.3.2 Sampling for spectrochemical analysis shall be in accordance with Practices E 716. Samples for other methods of analysis shall be taken by means suitable for the form of material being analyzed and the type of analytical method used.

6.4 *Methods of Analysis*—The determination of chemical composition shall be made in accordance with suitable chemical (Test Methods E 34), or spectrochemical (Test Method E 227, E 607, and E 1251), methods. Other methods may be used only when no published ASTM method is available. In case of dispute, the methods of analysis shall be agreed between the producer and purchaser.

7. Tensile Properties

7.1 *Limits*—The foil shall be capable of conforming to the tensile breaking loads in Table 2. Splices shall be capable of developing 80 % of the breaking load specified for unspliced foil.

NOTE 4—Tensile breaking loads define the strength properties good quality foil is capable of meeting.

7.2 *Number of Tests*—When the tensile breaking load is to be determined not less than two samples shall be selected from a shipment with each sample from a different roll of foil.

7.3 *Test Specimens*—All the test specimens shall be taken parallel to the direction of rolling and they shall be in accordance with Type A or Type B specimens as covered by Test Methods E 345.

7.4 *Test Method*—The tensile breaking load tests shall be made in accordance with Test Methods E 345.

8. Covering Area

8.1 *Limits*—The covering area per pound shall be in accordance with the limits in Table 3.

TABLE 2 Tensile Breaking Load

Nominal Thickness		Breaking Load	
in.	(mm)	Pounds per Inch of Width, min	(Kilograms per centimetre of Width, min)
0.00025	(0.0064)	1.6	(0.29)
0.00030	(0.0076)	1.9	(0.34)
0.00035	(0.0089)	2.2	(0.39)
0.00040	(0.0102)	2.6	(0.46)
0.00045	(0.0114)	2.9	(0.52)
0.00050	(0.0127)	3.2	(0.57)
0.00055	(0.0140)	3.5	(0.63)
0.00060	(0.0152)	3.8	(0.68)
0.00065	(0.0165)	4.1	(0.73)
0.00070	(0.0178)	4.4	(0.79)
0.00080	(0.0203)	5.2	(0.93)
0.00090	(0.0229)	5.7	(1.02)
0.001	(0.0254)	6.4	(1.14)
0.0015	(0.0381)	9.6	(1.71)
0.002	(0.0508)	12.8	(2.28)
0.003	(0.0762)	19.2	(3.42)
0.004	(0.1016)	25.6	(4.56)
0.005	(0.127)	32.0	(5.7)

8.2 *Number of Tests*—Specimens consisting of at least 16 $in.^2$ (103 cm^2) of unspliced foil shall be taken to represent each 1000 lb (454 kg) or fraction thereof in a shipment. Not less than two specimens shall be taken when the shipment consists of more than one roll, or 50 sheets.

8.3 *Test Methods*—The covering area per pound shall be determined in accordance with Test Method E 252. The covering area may also be determined by means of a direct-reading basis-weight scale, but in case of dispute, the covering area shall be determined by weighing to the nearest 1 mg a piece of unspliced foil not less than 10 ft (3 m) long and calculating the average area per pound by use of the following equation:

$$\text{Covering area, in.}^2\text{/lb} = 453.6 \times \text{area of sample (in.}^2\text{)/weight of sample (g)} \quad (1)$$

NOTE 5—The covering area in Table 3 is based on a nominal density of 0.0975 $lb/in.^3$ (2.700 g/cm^3) for a composition containing 99.35 % or greater aluminum. For a composition having less than 99.35 % aluminum, a nominal density of 0.098 $lb/in.^3$ (2.71 g/cm^3) shall be used and the covering areas in Table 3 shall be adjusted accordingly.

9. Dimensional Tolerances

9.1 *Rolls*—Rolls shall be wound on metal cores having an inside diameter of 1 5⁄16 ± 0.012 in. (33.3 ± 0.3 mm), 3 ± 0.015 in. (76.2 ± 0.4 mm) or 6 ± 0.030 in. (152.4 ± 0.8 mm), as specified by the purchaser. For specified foil widths up through 12 in. (305 mm) the dimensional tolerance shall be ± 1⁄64 in. (0.4 mm), and for widths over 12 in. it shall be ± 1⁄32 in. (0.8 mm). The maximum outside roll diameter shall be as specified by the purchaser.

9.2 *Flat Sheets*—The nominal width (perpendicular to rolling direction) and length (parallel to rolling direction) of flat sheets shall be as specified by the purchaser and the permissible deviations from specified width and length shall be ± 1⁄16 in. (1.6 mm).

10. General Quality

10.1 The foil shall be free from splits, slivers, wrinkles, ragged edges, and excessive pinholes.

NOTE 6—Foil in thickness about 0.002 in. (0.05 mm) and heavier is virtually free of pinholes. With decrease in thickness, the number of pinholes and variability in their number increases. Present test methods for determining pinholes do not permit the establishment of quantitative limits in thin foil.

10.2 Rolls shall be wound firmly on the cores so as to prevent slipping or telescoping and to permit free unwinding without sticking or tearing. The permissible number of splices shall be in accordance with Table 4. Necessary splices shall be foil tape, electric weld, ultrasonic, plastic tape, or mechanically knurled.

10.3 Foil shall be tested for surface condition by spraying, as from a squeeze bottle, a continuous line of distilled water or distilled water-alcohol mixture across the web of foil inclined 30° from horizontal. Foil dryness is categorized by the distilled water or water-alcohol mixture that will support a continuous unbroken line of water or mixture across the web of the foil for 2 seconds (the unbroken line is the top of the band of water or

TABLE 3 Minimum, Maximum, and Nominal Covering Areas[A]

Nominal Thickness		Nominal Covering Area		Permissible Range of Covering Area[B]			
				min		max	
in.	(mm)	$in.^2/lb$ (10^3)	(m^2/kg)	$in.^2/lb$ (10^3)	(m^2/kg)	$in.^2/lb$ (10^3)	(m^2/kg)
0.00020	(0.0051)	51.3	(72.9)	46.6	(66.3)	57.0	(81.1)
0.00025	(0.0064)	41.0	(58.3)	37.3	(53.0)	45.6	(64.8)
0.00030	(0.0076)	34.2	(48.6)	31.1	(44.2)	38.0	(54.0)
0.00035	(0.0089)	29.3	(41.7)	26.6	(37.8)	32.6	(46.4)
0.00040	(0.0102)	25.6	(36.4)	23.3	(33.1)	28.5	(40.5)
0.00045	(0.0114)	22.8	(32.4)	20.7	(29.4)	25.3	(36.0)
0.00050	(0.0127)	20.5	(29.1)	18.6	(26.4)	22.8	(32.4)
0.00055	(0.0140)	18.6	(26.4)	17.0	(24.2)	20.7	(29.4)
0.00060	(0.0152)	17.1	(24.3)	15.5	(22.0)	19.0	(27.0)
0.00065	(0.0165)	15.8	(22.5)	14.3	(20.3)	17.5	(24.9)
0.00070	(0.0178)	14.6	(20.8)	13.3	(18.9)	16.3	(23.1)
0.00075	(0.0190)	13.7	(19.5)	12.4	(17.6)	15.2	(21.6)
0.00080	(0.0203)	12.8	(18.2)	11.7	(16.6)	14.2	(20.2)
0.00085	(0.0216)	12.1	(17.2)	11.0	(15.6)	13.4	(19.1)
0.00090	(0.0229)	11.4	(16.2)	10.4	(14.8)	12.7	(18.1)
0.00095	(0.0241)	10.8	(15.4)	9.81	(13.9)	12.0	(17.1)
0.0010	(0.0254)	10.3	(14.6)	9.32	(13.2)	11.4	(16.2)
0.0015	(0.0381)	6.83	(9.71)	6.22	(8.84)	7.60	(10.8)
0.0020	(0.0508)	5.13	(7.29)	4.66	(6.63)	5.70	(8.11)
0.0030	(0.0762)	3.42	(4.86)	3.11	(4.42)	3.80	(5.40)
0.0040	(0.1016)	2.56	(3.64)	2.33	(3.31)	2.85	(4.05)
0.005	(0.127)	2.05	(2.91)	1.86	(2.64)	2.28	(3.24)

[A] Covering area is based on a density of 0.0975 lb/cu in. for 1145 and 1235 aluminum. To obtain values for aluminum and aluminum alloys 1100, 8079, and 8111, divide by the density factor 1.005.

[B] Range of covering area based on the standard thickness tolerance of plus and minus 10 % per roll or shipment.

TABLE 4 Number of Permissible Splices

Roll Diameter, in. (mm)	Foil Thickness, in. (mm)			
	0.00035 through 0.001 (0.0089 through 0.025)		Over 0.001 (over 0.025)	
	Foil Width, in. (mm)			
	Up through 52½[A] (1330)	Over 52½ (1330)	Up through 52½[A] (1330)	Over 51½ (1330)
	Maximum Splices per Individual Roll			
Up through 9½ (240)	3	4	1	1
Over 9½ through 13½ (340)	5	7	2	3
Over 13½ through 18 (460)	8	11	4	5
Over 18 through 22 (560)	10	13	6	7
	Maximum Average Splices per Roll in Total Shipment			
Up through 9½ (240)	2	3	½	½
Over 9½ through 13½ (340)	3	5	1	1
Over 13½ through 18 (460)	5	8	2	2
Over 18 through 22 (560)	7	10	3	4

[A] Maximum for 90 % of shipment; remainder shall not exceed the maximum listed for widths over 52½ in. (1330 mm).

mixture across the web). To ensure an acceptable water-alcohol mixture the alcohol denaturant shall be methanol (Formula 30—10 parts of ethyl alcohol and one part methanol by volume) or equivalent.

10.3.1 *Dry Annealed A*—Test dryness 100/0 foil shall support a continuous unbroken line using 100 % distilled water. Alternatively, dry annealed (100/0) foil may be tested by a distilled water drop test in which case the drops shall spread evenly into a thin film.

10.3.2 *Dry Annealed, B*—Test dryness 90/10 foil shall support a continuous unbroken line using 90 % distilled water-10 % alcohol mixture.

10.3.3 *Dry Annealed, C*—Test dryness 80/20 foil shall support a continuous unbroken line using 80 % distilled water-20 % alcohol mixture.

10.3.4 *Slick Annealed* foil shall exhibit no areas wettable by a distilled water drop test, that is, the drops will remain as spherical drops.

10.4 Foils with an intended end use in food processing, food packaging, and food preservation, shall be produced with rolling lubricants which meet FDA[9] and religious dietary requirements for such applications.

10.5 If special statistical methods are to be used for visual or dimensional inspection, or both, the lot size shall be expressed by the number of sheets or rolls of the same size ordered. Samples for rolls shall be taken from the end of each roll selected for inspection. Samples used for dimensional inspection also may be used for visual inspection. The sampling procedures found in ANSI/ASQC Z1.4 shall be used.

11. Mullen Test

11.1 Mullen bursting strength of foil 0.0008 in. (0.02 mm) and over in thickness shall be as specified in Table 5.

[9] FDA requirements.

TABLE 5 Mullen Bursting Strength

Nominal Thickness (in.)	Bursting Strength (psi)	
	Min	Max
0.0008	8	23
0.0010	11	31
0.0015	22	55
0.0020	40	90
0.0030	75	150
0.0040	110	220
0.0050	140	280

12. Source Inspection

12.1 If the purchaser desires that his representative inspect or witness the inspection and testing of the material prior to shipment, such agreement shall be made by the purchaser and producer as part of the purchase contract.

12.2 When such inspection or witness of inspection and testing is to be made, the producer shall afford the purchaser's representative all reasonable facilities to satisfy him that the material meets the requirements of this specification. Inspection and tests shall be conducted so there is no unnecessary interference with the producer's operations.

13. Rejection and Retest

13.1 When tensile breaking load tests are performed and any specimen fails to conform to the requirements of this specification, it shall be cause for rejection of the material represented by the specimen. When no sampling plan is provided or approved by the purchaser, and when there is evidence that indicates that a failed specimen was not representative of the lot of material, and when the contract or purchase order does not specify otherwise, at least two specimens shall be selected to replace each test specimen that failed. All specimens so selected for retest shall meet the requirements of the specification or the lot shall be subject to rejection.

13.2 Material failing to conform to other requirements of this specification, or in which defects are discovered during subsequent manufacturing operations, may be rejected. If rejected, the producer shall be responsible only for replacement of material to the purchaser. As much as possible of the rejected material shall be returned to the producer.

14. Certification

14.1 The producer or supplier shall, on request, furnish to the purchaser a certificate stating that the material has been sampled, tested and inspected in accordance with this specification, and has met the requirements.

15. Packaging and Package Marking

15.1 The material shall be packaged to provide adequate protection during normal handling and transportation and each package shall contain only one size of material unless otherwise agreed. Each roll shall be banded with a layer of paper or other suitable material that is free from contaminants harmful to the foil. The type of packaging and gross weight of containers shall, unless otherwise agreed, be at the producer's discretion, provided that they are such as to ensure acceptance by common or other carriers for safe transportation at the lowest rate to the delivery point.

15.2 Each shipping container shall be marked with the purchase order number, material size, specification number, material description, gross and net weights, and the producer's name or trademark. If food packaging or preservation is specified on the purchase order, the words "for food application" shall also be included in the marking.

16. Keywords

16.1 aluminum alloy; foil

ANNEX

(Mandatory Information)

A1. ACCEPTANCE CRITERIA FOR INCLUSION OF NEW ALUMINUM AND ALUMINUM ALLOYS IN THIS SPECIFICATION

A1.1 Prior to acceptance for inclusion in this specification, the composition of wrought or cast aluminum or aluminum alloy shall be registered in accordance with ANSI H35.1. The Aluminum Association[10] holds the Secretariat of ANSI H35 Committee and administers the criteria and procedures for registration.

A1.2 If it is documented that the Aluminum Association could not or would not register a given composition, an alternative procedure and the criteria for acceptance shall be as follows:

A1.2.1 The designation submitted for inclusion does not utilize the same designation system as described in ANSI H35.1. A designation not in conflict with other designation systems or a trade name is acceptable.

A1.2.2 The aluminum or aluminum alloy has been offered for sale in commercial quantities within the prior twelve months to at least three identifiable users.

A1.2.3 The complete chemical composition limits are submitted.

A1.2.4 The composition is, in the judgment of the responsible subcommittee, significantly different from that of any other aluminum or aluminum alloy already in the specification.

A1.2.5 For codification purposes, an alloying element is any element intentionally added for any purpose other than grain refinement and for which minimum and maximum limits are

[10] The Aluminum Association, 900 19th St., NW, Washington, DC 20006.

specified. Unalloyed aluminum contains a minimum of 99.00 % aluminum.

A1.2.6 Standard limits for alloying elements and impurities are expressed to the following decimal places:

Less than 0.001 %	0.000X
0.001 to but less than 0.01 %	0.00X
0.01 to but less than 0.10 %	
Unalloyed aluminum made by a refining process	0.0XX
Alloys and unalloyed aluminum not made by a refining process	0.0X
0.10 through 0.55 %	0.XX
(It is customary to express limits of 0.30 through 0.55 % as 0.X0 or 0.X5.)	
Over 0.55 %	0.X, X.X, etc.
(except that combined Si + Fe limits for 99.00 % minimum aluminum must be expressed as 0.XX or 1.XX)	

A1.2.7 Standard limits for alloying elements and impurities are expressed in the following sequence: Silicon; Iron; Copper; Manganese; Magnesium; Chromium; Nickel; Zinc (Note A1.1); Titanium; Other Elements, Each; Other Elements, Total; Aluminum (Note A1.2).

NOTE A1.1—Additional specified elements having limits are inserted in alphabetical order of their chemical symbols between zinc and titanium, or are specified in footnotes.

NOTE A1.2—Aluminum is specified as *minimum* for unalloyed aluminum and as a *remainder* for aluminum alloys.

APPENDIX

(Nonmandatory Information)

X1. TYPICAL WATER VAPOR TRANSMISSION RATES FOR ALUMINUM FOIL

X1.1 Water vapor transmission (WVT) rates obtained by any of the procedures covered by Test Methods E 96, on several specimens from the same sample may vary 10 % or more. Because of difficulty in obtaining consistent test results and because such test requires an elapsed time of 4 to 5 days or more, water vapor transmission limits are not considered practical as a specification requirement.

X1.1.1 When aluminum foil is used as a flexible barrier material it is usually combined with, or laminated to other materials such as paper, plastics, etc. These composite materials exhibit WVT rates considerably less than the plain foil.

X1.2 It has been found that the WVT rates of laminated structures, especially those containing aluminum foil, ordinarily cannot be determined from that of the individual components. This is especially true of creased laminates. Therefore to ensure accuracy the actual gain or loss of moisture through the entire laminated structure must be determined.

X1.3 However, as general information, Fig. X1.1 presents values which may be considered as typical for the various foil thicknesses.

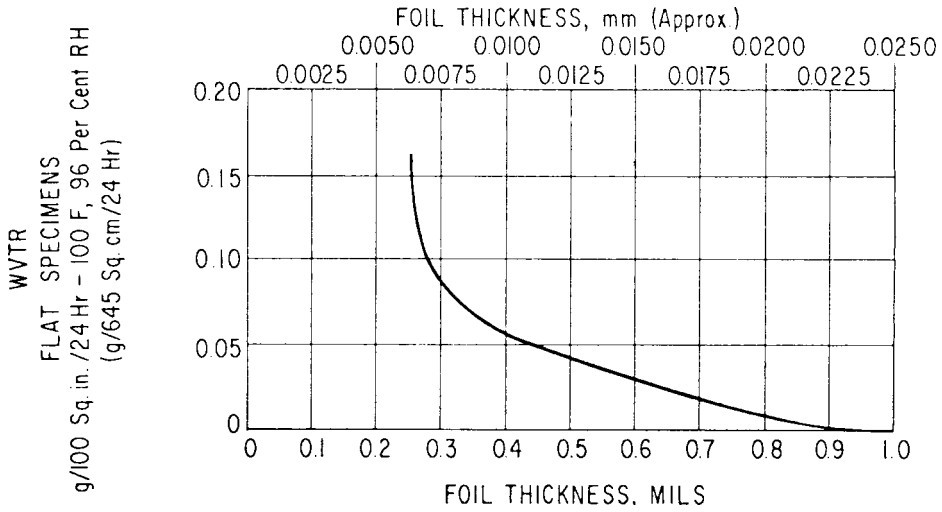

FIG. X1.1 Typical Water Vapor Transmission Rates for 1145 Plain Aluminum Foil at 100°F and 96 % Relative Humidity