Designation: B373 – 19

Standard Specification for Aluminum Foil for Capacitors[1]

This standard is issued under the fixed designation B373; 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 nine thicknesses (0.00017 to 0.00050 in. (0.0043 to 0.0127 mm)) of annealed aluminum foil used in the manufacture of capacitors.

1.2 Foil to be used as anodes in electrolytic capacitors is beyond the scope of this specification.

1.3 Alloy designations are in accordance with ANSI H35.11/H35.1(M). The equivalent Unified Numbering System alloy designations are those of Table 1 preceded by A9, for example, A91145 for Aluminum 1145 in accordance with Practice E527.

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

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

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

2.2 *ASTM Standards:*[2]

B193 Test Method for Resistivity of Electrical Conductor Materials

B666/B666M Practice for Identification Marking of Aluminum and Magnesium Products

B881 Terminology Relating to Aluminum- and Magnesium-Alloy Products

B985 Practice for Sampling Aluminum Ingots, Billets, Castings and Finished or Semi-Finished Wrought Aluminum Products for Compositional Analysis

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

E252 Test Method for Thickness of Foil, Thin Sheet, and Film by Mass Measurement

E345 Test Methods of Tension Testing of Metallic Foil

E527 Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)

E607 Test Method for Atomic Emission Spectrometric Analysis Aluminum Alloys by the Point to Plane Technique Nitrogen Atmosphere (Withdrawn 2011)[3]

E716 Practices for Sampling and Sample Preparation of Aluminum and Aluminum Alloys for Determination of Chemical Composition by Spark Atomic Emission Spectrometry

E1251 Test Method for Analysis of Aluminum and Aluminum Alloys by Spark Atomic Emission Spectrometry

E3061 Test Method for Analysis of Aluminum and Aluminum Alloys by Inductively Coupled Plasma Atomic Emission Spectrometry (Performance Based Method)

2.3 *ANSI Standard:*

H35.1/H35.1(M) Alloy and Temper Designation Systems for Aluminum[4]

2.4 *Other Standards:*

CEN EN 14242 Aluminum and aluminum alloys. Chemical analysis. Inductively coupled plasma optical emission spectral analysis[5]

3. Terminology

3.1 *Definitions:*

3.1.1 Refer to Terminology B881 for definitions of product terms used in this specification.

3.2 *Definitions of Terms Specific to This Standard:*

[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.

Current edition approved July 1, 2019. Published July 2019. Originally approved in 1961. Last previous edition approved in 2006 as B373 – 00 (2006) which was withdrawn January 2015 and reinstated in July 2019. DOI: 10.1520/B0373-19.

[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 Aluminum Association, Inc., 1400 Crystal Drive Suite 430, Arlington, VA 22202. http://www.aluminum.org.

[5] Available from European Committee for Standardization, Central Secretariat (CEN), rue de Stassart 36, B1050 Brussels, Belgium. www.cen.eu.

TABLE 1 Chemical Requirements[A,B,C,F]

Aluminum Designation	Silicon plus Iron	Copper	Manganese	Magnesium	Zinc	Vanadium	Titanium	Other Elements[D]		Aluminum
								Each	Total	
1235	0.65	0.05	0.05	0.05	0.10	0.05	0.06	0.03	...	99.35 min[E]
1145	0.55	0.05	0.05	0.05	0.05	0.05	0.03	0.03	...	99.45 min[E]

[A] Limits are in percent maximum unless stated otherwise.
[B] Analysis shall be made for the elements for which limits are shown in this table, except Aluminum.
[C] For purposes of determining the conformance to these limits, an observed value or a calculated value attained from analysis shall be rounded to the nearest unit in the last right-hand place of figures used in expressing the specified limit, in accordance with the rounding method of Practice E29.
[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 nonconforming.
[E] The minimum 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 second decimal before determining the sum.
[F] In case there is a discrepancy in the values listed in Table 1 with those listed in the "International Alloy Designations and Chemical Composition Limits for Wrought Aluminum and Wrought Aluminum Alloys" (known as the "Teal Sheets"), the composition limits registered with the Aluminum Association and published in the "Teal Sheets" shall be considered the controlling composition. The "Teal Sheets" are available at www.aluminum.org.

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.

3.2.2 *dry annealed A*—having a test dryness of 100/0, free from residual rolling oil, as determined by the water test (10.2.1).

3.2.3 *dry annealed B*—having a test dryness of 90/10, a slight film of residual rolling oil, as determined by the wateralcohol test (10.2.2).

3.2.4 *dry annealed C*—having a test dryness of 80/20, a slight film of residual rolling oil, as determined by the wateralcohol test (10.2.3).

3.2.5 *slick annealed*—having a uniform film of residual rolling oil or applied oil as determined by the water test (10.2.4).

3.2.6 *producer*—the primary manufacturer of the material.

3.2.7 *supplier*—includes only the category of jobbers and distributors as distinct from producers.

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 pounds,

4.1.3 Aluminum designation (Section 7),

4.1.4 Nominal thickness and width (Section 11),

4.1.5 Surface condition (Section 10),

4.1.6 Outside diameter of rolls (Section 13),

4.1.7 Inside diameter of cores (Section 13);

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

4.2.1 Whether inspection or witness of inspection and tests by the purchaser's representative is required prior to material shipment (Section 16),

4.2.2 Whether certification is required (Section 18), and

4.2.3 Whether marking for identification is required (see 19.1).

5. Manufacturing Process Changes

5.1 No process changes shall be made in the manufacture of this material after initially approved by the purchaser, except by prior agreement between the purchaser and the producer.

6. Responsibility for Quality Assurance

6.1 *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. 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.

6.2 *Lot Definition*—An inspection lot shall consist of an identifiable quantity of material of the same alloy, temper, and nominal dimensions subjected to inspection at one time.

7. Chemical Composition

7.1 *Limits*—The foil shall conform to the chemical composition limits prescribed in Table 1. Conformance shall be determined by the producer by taking samples in accordance with Practices E716 when the ingots are poured and analyzing those samples in accordance with Test Methods E607, E1251, E3061, or EN14242. At least one sample shall be taken for each group of ingots poured simultaneously from the same source of molten metal. If the producer of the foil or the producer of the material from which the foil is produced has determined the chemical composition of the material during pouring of the ingots, they shall not be required to sample and analyze the finished product.

NOTE 1—It is standard practice in the United States aluminum industry to determine conformance to the chemical composition limits prior to further processing of ingots 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.

7.2 If it becomes necessary to analyze foil for conformance to chemical composition limits, the methods of sampling and methods of analysis shall be as provided in the following:

7.2.1 *Methods of Sampling*—Samples for chemical analysis shall be taken in accordance with Practice B985.

7.2.2 *Methods of Analysis*—Analysis shall be performed in accordance with E607, E1251, E3061, or EN 14242.

7.3 Other methods of analysis or in the case of dispute may be by agreement between the producer and the purchaser.

8. Mechanical Properties

8.1 *Tensile Breaking Load*—The foil shall be capable of conforming to the tensile breaking load requirements prescribed in Table 2. Splices shall be capable of developing 80 % of the breaking load specified for unspliced foil.

8.2 *Number of Specimens*—When tensile breaking load is determined, tests shall be made on samples from each 1000 lb (454 kg), or fraction thereof, of each thickness and width of coil in a lot. Not less than two samples shall be selected with each sample from a different roll of foil except that if the lot consists of only one roll of foil, one sample shall be selected. Each sample shall consist of either a single-thickness or multiple-thickness specimen from one roll of foil.

8.3 *Test Method*—For determination of tensile breaking load, tests shall be made in accordance with Test Methods E345. If breaking load tests of a sample are made by both single-thickness specimens (Type B) and by multiplethickness specimens (Type A) and the results do not agree with each other, the results of the tests of the single-thickness specimens shall be the basis for acceptance or rejection of the material.

8.4 *Retests*—If any test specimen for tensile breaking load fails to conform to the requirements prescribed in Table 2, two additional specimens shall be selected from other representative rolls in the inspection lot, or from the same roll if the lot consists of only one roll, and tested. If either of these specimens fails to conform to the applicable requirements, the material may be rejected. If, however, the failure of the foil to conform to the requirements is the result of an inadequate thermal treatment, the material may be reannealed and resampled in accordance with 8.2. Only one such reworking of material shall be permitted.

NOTE 2—Experience of testing of foil has demonstrated that failures are more likely due to faulty test specimens, or to misalignment of the specimen in the testing machine, than is the case with material having a greater section thickness. Care must be exercised to discard test results where the evidence indicates that the specimen failure may be related to testing conditions.

9. Electrical Properties

9.1 *Electrical Resistance*—The foil shall be capable of conforming to the direct current electrical resistance requirements prescribed in Table 3 when measured at a temperature between 60 and 80 °F (15 and 25 °C).

NOTE 3—Direct-current electrical resistance values listed in Table 3 are based on a minimum electrical conductivity of 58.5 % IACS and the minimum permissible foil thickness corresponding with each nominal thickness.

9.2 *Number of Specimens*—When electrical resistance is determined, tests shall be made on samples from each 1000 lb (454 kg), or fraction thereof, of each thickness and width of coil in a lot. Not less than two samples shall be selected with each sample from a different roll of foil except that if the lot consists of only one roll of foil, one sample shall be selected.

9.3 *Method of Test*—When electrical resistance is determined, this determination shall be made by any method having an accuracy of ±0.001 Ω, provided that in the case of dispute, the results obtained by Test Method B193 shall be the basis for acceptance.

10. Surface Condition

10.1 The foil shall be supplied with the finish bright on one side and matte on the other.

10.2 The foil shall be supplied in the dry or slick condition, as specified on the purchase order. The 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. To ensure an acceptable water-alcohol mixture, the alcohol denaturant shall be methanol (Formula 30—ten parts ethyl alcohol and one part methanol by volume) or equivalent. Foil dryness is categorized by the water or water-alcohol test in which the foil will support a continuous unbroken line across the web for 2 s. (The unbroken line is the top of the band of water or mixture across the web.)

10.2.1 *Dry Annealed A (test dryness 100/0)*—Foil shall support a continuous unbroken line using 100 % distilled

TABLE 2 Tensile Breaking Load

Nominal Thickness, in. (mm)	Breaking Load, min, lbf/in. of Width (N/m of Width)
0.00017 (0.0043)	1.1 (192)
0.00020 (0.0051)	1.3 (228)
0.00023 (0.0058)	1.5 (262)
0.00025 (0.0064)	1.6 (280)
0.00030 (0.0076)	1.9 (332)
0.00035 (0.0089)	2.3 (402)
0.00040 (0.0102)	2.6 (455)
0.00045 (0.0114)	2.9 (508)
0.00050 (0.0127)	3.2 (560)

TABLE 3 Direct Current Electrical Resistance

Nominal Thickness in. (mm)	Ohms per Foot of Length for 1-in. Width max	*(Ohms per Meter of Length for 10-mm Width, max)*
0.00017 (0.0043)	0.090	(0.75)
0.00020 (0.0051)	0.077	(0.64)
0.00023 (0.0058)	0.066	(0.55)
0.00025 (0.0064)	0.061	(0.51)
0.00030 (0.0076)	0.051	(0.43)
0.00035 (0.0089)	0.044	(0.36)
0.00040 (0.0102)	0.038	(0.32)
0.00045 (0.0114)	0.034	(0.28)
0.00050 (0.0127)	0.031	(0.25)