Designation: B 618 – 03

Standard Specification for Aluminum-Alloy Investment Castings[1]

This standard is issued under the fixed designation B 618; 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 specification covers aluminum-alloy investment castings designated as shown in Table 1.

1.2 This specification is not intended for aluminum-alloy investment castings used in aerospace applications.

1.3 Alloy and temper designations are in accordance with ANSI H35.1. The equivalent Unified Numbering System alloy designations are in accordance with Practice E 527.

1.4 For acceptance criteria for inclusion of new aluminum and aluminum alloys and their properties in this specification, see Annex A1 and Annex A2.

1.5 *Units*—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.

1.6 *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 purchase form a part of this specification to the extent referenced herein:

2.2 *ASTM Standards:*

B 179 Specification for Aluminum Alloys in Ingot and Molten Forms for Castings from all Casting Processes[2]

B 275 Practice for Codification of Certain Nonferrous Metals and Alloys, Cast and Wrought[2]

B 557 Test Methods of Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products[2]

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

B 917/B 917M Practice for Heat Treatment of Aluminum-Alloy Castings from All Processes[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 88 Practice for Sampling Nonferrous Metals and Alloys in Cast Form for Determination of Chemical Composition[4]

E 94 Guide for Radiographic Testing[5]

E 155 Reference Radiographs for Inspection of Aluminum and Magnesium Castings[5]

E 165 Test Method for Liquid Penetrant Examination[5]

E 527 Practice for Numbering Metals and Alloys (UNS)[6]

E 607 Test Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique, Nitrogen Atmosphere[4]

E 716 Practices for Sampling Aluminum and Aluminum Alloys for Spectrochemical Analysis[4]

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[4]

IEEE/ASTM SI 10 Standard for Use of the International System of Units (SI): The Modern Metric System[3]

2.3 *ANSI Standard:*

H35.1 Alloy and Temper Designation Systems for Aluminum[2]

H35.1M Alloy and Temper Designation System for Aluminum [Metric][2]

2.4 *Military Standard:*

MIL-STD-129 Marking for Shipment and Storage[7]

2.5 *Federal Standard:*

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[7]

2.6 *AMS Standard:*

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[1] This specification is under the jurisdiction of ASTM Committee B07 on Light Metals and Alloys and is the direct responsibility of Subcommittee B07.01 on Aluminum Alloy Ingots and Castings.

Current edition approved Apr. 10, 2003. Published September 2003. Originally approved in 1977. Last previous edition approved in 2002 as B 618 – 02$^{\epsilon 1}$.

[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 03.03.

[6] *Annual Book of ASTM Standards*, Vol 01.01.

[7] Available from the Standardization Documents Order Desk, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094. Attn: NPODS.

***A Summary of Changes section appears at the end of this standard.**

TABLE 1 Chemical Composition Requirements

NOTE 1—When single units are shown, these indicate the maximum amounts permitted.
NOTE 2—Analysis shall be made for the elements for which limits are shown in this table.
NOTE 3—The following applies to all specified limits in this table: For purposes of acceptance and rejection, an observed value or a calculated value obtained from analysis should be rounded off to the nearest unit in the last right-hand place of figures used in expressing the specified limit (Practice E 29).

Alloy		Composition, %												
ANSI[A]	UNS	Aluminum	Silicon	Iron	Copper	Man-ganese	Mag-nesium	Chro-mium	Nickel	Zinc	Tin	Titan-ium	Other[B] Elements	
													Each	Total[C]
201.0	A02010	remainder	0.10	0.15	4.0–5.2	0.20–0.50	0.15–0.55	...	...	...	...	0.15–0.35	0.05[D]	0.10
204.0	A02040	remainder	0.20	0.35	4.2–5.0	0.10	0.15–0.35	...	0.05	0.10	0.05	0.15–0.30	0.05	0.15
242.0	A02420	remainder	0.7	1.0	3.5–4.5	0.35	1.2–1.8	0.25	1.7–2.3	0.35	...	0.25	0.05	0.15
295.0	A02950	remainder	0.7–1.5	1.0	4.0–5.0	0.35	0.03	...	...	0.35	...	0.25	0.05	0.15
319.0	A03190	remainder	5.5–6.5	1.0	3.0–4.0	0.50	0.10	...	0.35	1.0	...	0.25	...	0.50
328.0	A03280	remainder	7.5–8.5	1.0	1.0–2.0	0.20–0.6	0.20–0.6	0.35	0.25	1.5	...	0.25	...	0.50
355.0	A03550	remainder	4.5–5.5	0.6[E]	1.0–1.5	0.50[E]	0.40–0.6	0.25	...	0.35	...	0.25	0.05	0.15
C355.0	A33550	remainder	4.5–5.5	0.20	1.0–1.5	0.10	0.40–0.6	...	...	0.10	...	0.20	0.05	0.15
356.0	A03560	remainder	6.5–7.5	0.6[E]	0.25	0.35[E]	0.20–0.45	...	...	0.35	...	0.25	0.05	0.15
A356.0	A13560	remainder	6.5–7.6	0.20	0.20	0.10	0.25–0.45	...	...	0.10	...	0.20	0.05	0.15
443.0	A04430	remainder	4.5–6.0	0.8	0.6	0.50	0.05	0.25	...	0.50	...	0.25	...	0.35
B443.0	A24430	remainder	4.5–6.0	0.8	0.15	0.35	0.05	...	...	0.35	...	0.25	0.05	0.15
514.0	A05140	remainder	0.35	0.50	0.15	0.35	3.5–4.5	...	...	0.15	...	0.25	0.05	0.15
520.0	A05200	remainder	0.25	0.30	0.25	0.15	9.5–10.6	...	...	0.15	...	0.25	0.05	0.15
535.0	A05350	remainder	0.15	0.15	0.05	0.10–0.25	6.2–7.5	...	...	...	...	0.10–0.25	0.05[F]	0.15
705.0	A07050	remainder	0.20	0.8	0.20	0.40–0.6	1.4–1.8	0.20–0.40	...	2.7–3.3	...	0.25	0.05	0.15
707.0	A07070	remainder	0.20	0.8	0.20	0.40–0.6	1.8–2.4	0.20–0.40	...	4.0–4.5	...	0.25	0.05	0.15
710.0[G]	A07100	remainder	0.15	0.50	0.35–0.65	0.05	0.6–0.8	...	...	6.0–7.0	...	0.25	0.05	0.15
712.0[G]	A07120	remainder	0.30	0.50	0.25	0.10	0.50–0.65	0.40–0.6	...	5.0–6.5	...	0.15–0.25	0.05	0.20
713.0	A07130	remainder	0.25	1.1	0.40–1.0	0.6	0.20–0.50	0.35	0.15	7.0–8.0	...	0.25	0.10	0.25
771.0	A07710	remainder	0.15	0.15	0.10	0.10	0.8–1.0	0.06–0.20	...	6.5–7.5	...	0.10–0.20	0.05	0.15
850.0	A08500	remainder	0.7	0.7	0.7–1.3	0.10	0.10	...	0.7–1.3	...	5.5–7.0	0.20	...	0.30
851.0[G]	A08510	remainder	2.0–3.0	0.7	0.7–1.3	0.10	0.10	...	0.3–0.7	...	5.5–7.0	0.20	...	0.30
852.0[G]	A08520	remainder	0.40	0.7	1.7–2.3	0.10	0.6–0.9	...	0.9–1.5	...	5.5–7.0	0.20	...	0.30

[A] ASTM alloy designations are in Practice B 275.
[B] "Others" includes listed elements for which no specific limit is shown as well as 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.
[C] Other Elements—Total shall be the sum of unspecified metallic elements 0.010 % or more, rounded to the second decimal before determining the sum.
[D] Contains silver 0.40–1.0 %.
[E] If iron exceeds 0.45 %, manganese content shall not be less than one half of the iron content.
[F] Contains beryllium 0.003–0.007 %, boron 0.002 % max.
[G] 710.0 formerly A712.0, 712.0 formerly D712.0, 851.0 formerly A850.0, 852.0 formerly B850.0.

AMS 2771 Heat Treatment of Aluminum Alloy Castings [8]

3. Terminology

3.1 *Definition:*

3.1.1 *investment casting*—a metal object produced by surrounding (investing) an expendable pattern (usually wax or plastic) with a refractory slurry that sets at room temperature, after which the pattern is removed through the use of heat, and then filling the resulting cavity with molten metal and allowing it to solidify.

4. Ordering Information

4.1 Orders for material under 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 Alloy (Section 7 and Table 1),

4.1.3 Temper (Section 10 and Table 2),

4.1.4 Applicable drawing or part number,

4.1.5 The quantity in either pieces or pounds.

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

4.2.1 Whether castings or test specimens or both may be supplied in the artificially aged—T5 temper for alloys 705.0, 707.0, D712.0, and 713.0 (see 10.2),

4.2.2 Whether test specimens cut from castings are required in addition to or instead of separately cast specimens (see 10.3 and 11.2),

4.2.3 Whether repairs are permissible (see 17.1),

4.2.4 Whether inspection is required at the producer's works (see 18.1),

4.2.5 Whether surface requirements shall be checked against observational standards where such standards are established (see 18.2),

4.2.6 Whether liquid penetrant inspection is required (see 18.4),

4.2.7 Whether radiographic inspection is required (see 18.5),

4.2.8 Whether certification of chemical analysis and tensile properties is required (see 20.1),

[8] Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001.

TABLE 2 Tensile Requirements[A]

NOTE 1— For purposes of determining conformance with this specification, each value for tensile strength and yield strength shall be rounded to the nearest 0.1 ksi and each value for elongation shall be rounded to the nearest 0.5 %, both in accordance with the rounding method of Practice E 29.

Alloy		Temper[B]	Tensile Strength, min, ksi (MPa)[C]	Yield Strength (0.2 % offset) min, ksi (MPa)[C]	Elongation in 2 in. or 4× diameter, min, %	Typical Brinell Hardness,[D] 500 kgf, 10 mm
ANSI[E]	UNS					
201.0	A02010	T6	60.0 (414)	50.0 (345)	5.0	...
		T7	60.0 (414)	50.0 (345)	3.0	...
204.0	A02040	T4	45.0 (310)	28.0 (193)	6.0	...
		T6	30.0 (207)	[F]	[F]	115
242.0	A02420	O[G]	23.0 (159)	[F]	[F]	70
		T61	32.0 (221)	20.0 (138)	[F]	105
295.0	A02950	T4	29.0 (200)	13.0 (90)	6.0	60
		T6	32.0 (221)	20.0 (138)	3.0	75
		T62	36.0 (248)	28.0 (193)	[B]	95
		T7	29.0 (200)	16.0 (110)	3.0	70
319.0	A03190	F	23.0 (159)	13.0 (90)	1.5	70
		T6	31.0 (214)	20.0 (138)	1.5	80
328.0	A03280	F	25.0 (172)	14.0 (97)	1.0	60
		T6	34.0 (234)	21.0 (145)	1.0	80
355.0	A03550	T6	32.0 (221)	20.0 (138)	2.0	80
		T51	25.0 (172)	18.0 (124)	[F]	65
		T71	30.0 (207)	22.0 (152)	[F]	75
C355.0	A33550	T6	36.0 (248)	25.0 (172)	2.5	...
356.0	A03560	F	19.0 (131)	[F]	2.0	55
		T6	30.0 (207)	20.0 (138)	3.0	70
		T7	31.0 (214)	[F]	[F]	75
		T51	23.0 (159)	16.0 (110)	[F]	60
		T71	25.0 (172)	18.0 (124)	3.0	60
A356.0	A13560	T6	34.0 (234)	24.0 (166)	3.5	80
443.0	A04430	F	17.0 (117)	7.0 (48)	3.0	40
B443.0	A24430	F	17.0 (117)	6.0 (41)	3.0	40
514.0	A05140	F	22.0 (152)	9.0 (62)	6.0	50
520.0	A05200	T4	42.0 (290)	22.0 (152)	12.0	75
535.0	A05350	F	35.0 (241)	18.0 (124)	9.0	70
705.0	A07050	T1[H] and T5[I]	30.0 (207)	17.0 (117)[J]	5.0	65
707.0	A07070	T1[H]	33.0 (228)	22.0 (152)[J]	2.0	85
		T7	37.0 (255)	30.0 (207)[J]	1.0	80
710.0[K]	A07100	T1[H]	32.0 (221)	20.0 (138)	2.0	75
712.0[K]	A07120	T1[H] and T5[I]	34.0 (234)	25.0 (172)[J]	4.0	75
713.0	A07130	T1[H] and T5[I]	32.0 (221)	22.0 (152)	3.0	75
771.0	A07710	T5	42.0 (290)	38.0 (262)	1.5	100
		T51	32.0 (221)	27.0 (186)	3.0	85
		T52	36.0 (248)	30.0 (207)	1.5	85
		T6	42.0 (290)	35.0 (241)	5.0	90
		T71	48.0 (331)	45.0 (310)	2.0	120
850.0	A08500	T5	16.0 (110)	[F]	5.0	45
851.0[K]	A08510	T5	17.0 (117)	[F]	3.0	45
852.0[K]	A08520	T5	24.0 (166)	18.0 (124)	[F]	60

[A] If agreed upon by the producer and the purchaser, other mechanical properties may be obtained by other heat treatments such as annealing, aging, or stress relieving.
[B] Refer to ANSI H35.1 and/or H35.1M for description of tempers.
[C] SI units for information only. For explanation of the SI unit "MPa" see Appendix X2.
[D] For information only, not required for acceptance.
[E] ASTM alloy designations are in Practice B 275.
[F] Not required.
[G] Formerly designated 222.0-T2 and 242.0-T21.
[H] Aged 21 days at room temperature.
[I] Artificially aged in accordance with Practice B 917/B 917M.
[J] Yield strength to be determined only when specified in the contract or purchase order.
[K] 710.0 formerly A712.0, 712.0 formerly D712.0, 851.0, formerly A850.0, 852.0 formerly B850.0.

4.2.9 Whether the material shall be packaged or marked, or both, in accordance with Practices B 660, MIL-STD-129, and Fed. Std. No. 123 (see 22.3).

5. Responsibility for Quality Assurance

5.1 *Responsibility for Inspection and Tests*—Unless otherwise specified in the contract or purchase order, the producer shall be 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 confirm that material conforms to prescribed requirements.

6. Materials and Manufacture

6.1 The responsibility of furnishing castings that can be laid out and machined to the finished dimensions within the permissible variations specified, as shown on the blueprints or drawings, shall rest with the producer, except where pattern equipment is furnished by the purchaser.

6.1.1 Unless otherwise specified, only aluminum alloy conforming to the requirements of Specification B 179 or producer's foundry scrap (identified as being made from alloy conforming to Specification B 179) shall be used in the remelting furnace from which molten metal is taken for pouring directly into castings. Additions of small amounts of modifiers and grain refining elements or alloys are permitted.

6.1.2 Pure materials, recycled materials, and master alloys may be used to make alloys conforming to this specification, provided chemical analysis can be taken and adjusted to conform to Table 1 prior to pouring any castings.

7. Chemical Composition

7.1 The castings shall conform to the chemical composition limits prescribed in Table 1. Conformance shall be determined by the producer by analyzing samples taken at the time the castings are poured, or samples taken from castings or tension test specimens representative of castings. If the producer has determined the chemical composition of the material during the course of manufacture, he shall not be required to sample and analyze the finished product.

8. Sampling for Determination of Chemical Composition

8.1 A sample for the determination of chemical composition shall be taken to represent the following:

8.1.1 Not more than 500 lb (227 kg) of clean castings (gates and risers removed) or a single casting poured from one furnace and using only one melt charge.

8.1.2 Castings poured continuously from one furnace for not more than 8 consecutive hours from a single master heat. A master heat is defined as all the metal of a single furnace charge without subsequent additions after chemical composition has been determined.

8.2 Samples for determination of chemical composition shall be taken in accordance with one of the following methods.

8.2.1 *Samples for Chemical Analysis*— Samples for chemical analysis shall be taken by sawing, drilling, or milling the casting or test specimens in such a manner as to be representative of the material in accordance with Practice E 88. The weight of a prepared sample shall be not less than 75 g.

8.2.2 *Samples for Spectrochemical and Other Methods of Analysis*—Sampling for spectrochemical analysis shall be in accordance with Practices E 716. Samples for other methods of analysis shall be suitable for the form of material being analyzed and the type of analytical methods used.

9. Methods of Determination of Chemical Composition

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

10. Tensile Requirements

10.1 The separately cast tension test specimens representing the castings shall meet the mechanical properties prescribed in Table 2.

10.2 Although alloys 705.0, 707.0, D712.0, and 713.0 are most frequently used in the T1 naturally aged temper, by agreement of the producer and purchaser, the castings may be supplied in the T5 artificially aged temper. The producer and the purchaser may also agree to base the acceptance of castings on artificially aged test bars.

10.3 When specified, the tensile strength, yield strength, and elongation values of specimens cut from castings shall be not less than 75 % of the tensile and yield strength values and not less than 25 % of the elongation values specified in Table 2. The measurement of elongation is not required for test specimens cut from castings if 25 % of the specified minimum elongation value published in Table 2 is 0.5 % or less. If grade D quality castings as described in Table 3 are specified, no tensile tests shall be specified nor tensile requirements be met on specimens cut from castings.

11. Test Specimens

11.1 The tension test specimens shall be cast to size in refractory molds of the same material as used for the castings in accordance with the dimensions of the 0.250-in. diameter specimen shown in Fig. 8 of Test Methods B 557. They shall not be machined prior to test except to adapt the grip ends in such a manner as to assure axial loading.

11.2 When properties of castings are to be determined, tension test specimens shall be cut from the locations designated on the drawing unless otherwise negotiated. If no locations are designated, one or more specimens shall be taken to include locations having significant variation in cast thickness, except that specimens shall not be taken from areas directly under risers. The tension test specimens shall be the standard 0.500-in. diameter specimens shown in Fig. 8 of Test Methods B 557 or a round specimen of smaller size proportional to the standard specimen. In no case shall the dimensions of the smallest specimen be less than the following:

TABLE 3 Discontinuity-Level Requirements for Aluminum Investment Castings (Reference Radiographs E 155)

Discontinuity	Radiograph	Grade A		Grade B		Grade C		Grade D	
		Section Thickness, in.							
		1/4	3/4	1/4	3/4	1/4	3/4	1/4	3/4
Gas holes	1.1	none		1	1	2	2	5	5
Gas porosity (round)	1.21	none		1	1	3	3	7	7
Gas porosity (elongated)	1.22	none		1	1	3	4	5	5
Shrinkage cavity	2.1	none		1	1	2	[A]	3	[A]
Shrinkage porosity or sponge	2.2	none		1	1	2	2	4	3
Foreign material (less dense material)	3.11	none		1	1	2	2	4	4
Foreign material (more dense material)	3.12	none		1	1	2	1	4	3
Segregation	3.2	none		none		none		none	
Cracks	...	none		none		none		none	
Cold shuts	...	none		none		none		none	
Surface irregularity	...	not to exceed drawing tolerance							
Core shift	...	not to exceed drawing tolerance							

[A] Not available.

Diameter of reduced section, in.	0.250
Length of reduced section, in.	1¼
Radius of fillet, in.	3/16
Diameter of end section, in.	⅜
Overall length, in.:	
With shouldered ends	2⅜
With threaded ends	3
With plain cylindrical ends	4

When necessary, a rectangular specimen may be used proportional to that shown for the 0.500-in. (13-mm) wide specimen in Fig. 6 of Test Methods B 557, but in no case shall its dimensions be less than the following:

Width of reduced section, in.	0.250
Length of reduced section, in.	1¼
Radius of fillet, in.	¼
Overall length, in.	4

The specified elongation values shall not apply to tests of rectangular specimens.

11.3 If the castings are to be heat treated and separately cast specimens are to be used, the specimens representing such castings shall be heat treated with the castings they represent. If castings are to be heat treated and tests are to be made on the castings, the test specimens shall be taken from the castings after heat treatment.

12. Number of Tests

12.1 Unless otherwise agreed upon by the purchaser and producer, two tension test specimens shall be separately cast and tested to represent the following:

12.1.1 Not more than 500 lb (227 kg) of clean castings (gates and risers removed) or a single casting poured from the one furnace and using only one melt change.

12.1.2 The castings poured continuously from one furnace in not more than 8 consecutive hours from a single master heat.

12.2 When tensile properties of castings are to be determined, the number of castings to be tested shall be as shown on the drawing or as specified in the purchase order.

12.3 If any test specimen shows defective machining or flaws, it may be discarded; in which case the purchaser and the producer shall agree upon the selection of another specimen in its stead.

13. Test Methods

13.1 The tensile properties shall be determined in accordance with Test Methods B 557.

14. Retests

14.1 If the results of the tension tests do not conform to the requirements prescribed in Table 2, the castings may be retested not more than twice and the results of retests shall conform to the requirements of the specification.

15. Workmanship and Finish

15.1 The finished castings shall be uniform in composition and free of blowholes, cracks, shrinks, and other injurious defects except as designated and agreed upon as acceptable by the purchaser.

16. Heat Treatment

16.1 The heat treatment of castings shall be performed in accordance with Practice B 917/B 917M or AMS 2771.

17. Repair of Castings

17.1 Castings may be repaired only by processes approved and agreed upon by the producer and purchaser, that is, welding, impregnation, peening, blending, soldering, etc. Limitations on the extent and frequently of such repairs, and methods of inspection of repaired areas should also be agreed upon.

18. Inspection

18.1 If the purchaser desires to make an inspection of the casting at the producer's works, it shall be so stated in the contract or order.

18.2 Requirements such as surface finish, snagging projections where gates and risers were removed, etc., may be checked visually. It is advisable to have agreed upon observational standards representing both acceptable and unacceptable material.

18.3 If the purchaser elects to have inspection made at the producer's works, the producer shall afford the inspector all reasonable facilities to satisfy him that the material is being furnished in accordance with this specification. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

18.4 *Liquid Penetrant Inspection*:

18.4.1 When specified, liquid penetrant inspection shall be in accordance with Test Method E 165, and the required sensitivity shall be specified.

18.4.2 Acceptance standards for discontinuities shall be agreed upon, including size and frequency per unit area and location.

18.5 *Radiographic Inspection*:

18.5.1 When specified, radiographic inspection shall be in accordance with Guide E 94 and Reference Radiographs E 155.

18.5.2 Radiographic acceptance shall be in accordance with requirements selected from Table 3. Any modifications of this table and the frequency per unit area and location should also be agreed upon.

18.5.3 The number, film size, and orientation of radiographs and the number of castings radiographically inspected shall be agreed upon by the producer and purchaser.

19. Rejection

19.1 Castings that show unacceptable defects revealed by operations subsequent to acceptance and within an agreed time may be rejected, and shall be replaced by the producer.

20. Certification

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

21. Rehearing

21.1 In the case of dissatisfaction regarding rejections based on chemical composition and tensile property requirements specified in Sections 7 and 10, respectively, the producer may make claim for a rehearing as the basis of arbitration within a reasonable time after receipt by the producer of the rejection notification.

22. Packaging, Marking, and Shipping

22.1 The material shall be packaged to provide adequate protection during normal handling and transportation, and each package shall contain only castings of the same configuration unless otherwise agreed upon. The type of packaging and gross weight of containers shall, unless otherwise agreed upon, be at the producers discretion, provided they are such as to ensure acceptance by common or other carriers for safe transportation at the lowest rate to the delivery point.

22.2 Each package or container shall be marked with the purchase order number, drawing number, quantity, specification number, alloy and temper, gross and net weights, and the name of the producer.

22.3 When specified in the contract or purchase order, castings shall be preserved, packaged, and packed in accordance with the requirements of Practices B 660. The applicable levels shall be specified in the contract or order. Marking for shipment of such material shall be in accordance with Fed. Std. No. 123 for civil agencies and MIL-STD-129 for military agencies.

23. Keywords

23.1 aluminum; investment casting

ANNEXES

(Mandatory Information)

A1. BASIS FOR INCLUSION OF PROPERTY LIMITS

A1.1 Limits are established at a level at which a statistical evaluation of the data indicates that 99 % of the population obtained from all standard material meets the limit with 95 % confidence. For the products described, mechanical property limits for the respective size ranges are based on the analyses of at least 100 data from standard production material with no more than ten data from a given lot. All tests are performed in accordance with the appropriate ASTM test methods. For informational purposes, refer to “Statistical Aspects of Mechanical Property Assurance” in the Related Material section of the *Annual Book of ASTM Standards*, Vol 02.02.

A2. ACCEPTANCE CRITERIA FOR INCLUSION OF NEW ALUMINUM AND ALUMINUM ALLOYS IN THIS SPECIFICATION

A2.1 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[9] holds the Secretariat of ANSI H35 Committee and administers the criteria and procedures for registration.

A2.2 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:

A2.2.1 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.

A2.2.2 The aluminum or aluminum alloy has been offered for sale in commercial quantities within the prior twelve months to at least three identifiable users.

[9] The Aluminum Association, 900 19th Street, NW, Washington, DC 20006.

A2.2.3 The complete chemical composition limits are submitted.

A2.2.4 The composition is, in the judgment of the responsible subcommittee, significantly different from that of any other aluminum or aluminum alloy already in this specification.

A2.2.5 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 specified. Unalloyed aluminum contains a minimum of 99.00 % aluminum.

A2.2.6 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)	

A2.2.7 Standard limits for alloying elements and impurities are expressed in the following sequence: Silicon; Iron; Copper; Manganese; Magnesium; Chromium; Nickel; Zinc (Note A2.1); Titanium; Other Elements, Each; Other Elements, Total; Aluminum (Note A2.2).

NOTE A2.1—Additional specified elements having limits are inserted in alphabetical order of their chemical symbols between zinc and titanium, or are specified in footnotes.

NOTE A2.2—Aluminum is specified as *minimum* for unalloyed aluminum and as a *remainder* for aluminum alloys.

APPENDIXES

(Nonmandatory Information)

X1. ALLOY PROPERTIES AND CHARACTERISTICS

X1.1 The data in Table X1.1 are approximate and are supplied for general information only.

TABLE X1.1 Properties and Characteristics

NOTE 1— 1 indicates best of group, 5 indicates poorest of group.

Alloy		Pattern Shrinkage Allowance, in. ft[A] [mm/m]	Approximate Melting Range, ° F[B] [°C]	Resistance to Hot Cracking[C]	Pressure Tightness	Fluidity[D]	Solidification Shrinkage Tendency[E]	Normally Heat Treated	Resistance to Corrosion[F]	Machining[G]	Polishing[H]	Electroplating[I]	Anodizing (Appearance)[J]	Chemical Oxide Coating (Protection)[K]	Strength at Elevated Temperature[L]	Suitability for Welding[M]	Suitability for Brazing[N]
ANSI[O]	UNS																
201.0	A02010	5/32 [13]	1050–1200 [566-649]	4	3	3	4	yes	4	1	1	1	2	2	1	4	no
204.0	A02040	5/32 [13]	985–1200 [529-649]	4	3	3	4	yes	4	1	2	1	3	4	1	4	no
242.0	A02420	5/32 [13]	990–1175 [532-635]	4	3	3	4	yes	4	2	2	1	3	4	1	4	no
295.0	A02950	5/32 [13]	970–1190 [521-643]	4	4	3	3	yes	3	2	2	1	2	3	3	3	no
319.0	A03190	5/32 [13]	950–1125 [510-607]	2	2	2	2	yes	3	3	4	2	4	3	3	2	no
328.0	A03280	5/32 [13]	960–1135 [516-613]	1	1	1	1	yes	3	4	5	2	4	2	2	2	no
355.0	A03550	5/32 [13]	1015–1150 [546–621]	1	1	1	1	yes	3	3	3	1	4	2	2	2	no
C355.0	A33550	5/32 [13]	1015–1150 [546–621]	1	1	1	1	yes	3	3	3	1	4	2	2	2	no
356.0	A33560	5/32 [13]	1035–1135 [557-613]	1	1	1	1	yes	2	4	5	2	4	2	3	2	no
A356.0	A13560	5/32 [13]	1035–1135 [557-621]	1	1	1	1	yes	2	4	5	2	4	2	3	2	no
443.0	A04430	5/32 [13]	1065–1170 [574-632]	1	1	1	1	no	3	5	5	2	5	2	4	1	ltd
		5/32 [13]	1065–1170 [574-632]	1	1	1	1	no	3	5	5	2	5	2	4	1	ltd
B443.0	A24430	5/32 [13]	1065–1170 [574-632]	1	1	1	1	no	2	5	5	2	5	2	4	1	ltd
514.0	A05140	5/32 [13]	1110–1185 [599-640]	4	5	5	5	no	1	1	1	5	1	1	2	4	no

TABLE X1.1 *Continued*

Alloy		Pattern Shrinkage Allowance, in. ft[A] [mm/m]	Approximate Melting Range, ° F[B] [°C]	Resistance to Hot Cracking[C]	Pressure Tightness	Fluidity[D]	Solidification Shrinkage Tendency[E]	Normally Heat Treated	Resistance to Corrosion[F]	Machining[G]	Polishing[H]	Electroplating[I]	Anodizing (Appearance)[J]	Chemical Oxide Coating (Protection)[K]	Strength at Elevated Temperature[L]	Suitability for Welding[M]	Suitability for Brazing[N]
ANSI[O]	UNS																
520.0	A05200	5/32 [13]	840-1120 [449-604]	3	4	3	4	no	1	2	2	4	2	1	3	4	no
535.0	A05350	1/10 [8]	1020-1165 [549-629]	2	5	4	5	yes	1	1	1	4	1	1	[P]	5	no
705.0	A07050	5/32 [13]	1105-1180 [596-638]	3	5	5	5	no	1	1	1	5	1	1	3	4	no
707.0	A7070	3/16 [16]	1085-1165 [585-629]	5	3	4	4	aged only	2	1	1	3	2	2	5	4	yes
710.0[Q]	A07100	3/16	1105-1195	5	3	4	4	yes	2	1	1	3	2	2	5	4	yes
712.0[Q]	A07120	[16] 3/16 [16]	[596-646] 1110-1185 [599-641]	5	3	4	4	aged only	2	1	1	2	2	3	5	4	yes
713.0	A07130	3/16 [16]	1100–1185 [593-641]	5	3	4	4	aged only	2	1	1	2	2	3	5	4	yes
771.0	A07710	3/16	1120–1190	5	3	4	4	yes	2	1	1	3	2	2	5	4	yes
850.0	A08500	[16] 5/32 [13]	[604-643] 435–1200 [224-649]	5	5	5	5	aged only	3	1	1	5	4	5	[P]	5	no
851.0[Q]	A08510	5/32 [13]	440–1165 [227-629]	4	4	5	4	aged only	3	1	1	5	4	5	[P]	5	no
852.0[Q]	A08520	5/32 [13]	400–1175 [204-635]	5	5	5	5	aged only	3	1	1	5	4	5	[P]	5	no

[A] Allowances for average castings. Shrinkage requirements will vary with intricacy of design and dimensions.

[B] Temperatures of solidus and liquidus are indicated; pouring temperatures will be higher.

[C] Ability of alloy to withstand contraction stresses while cooling through hot-short or brittle-temperature range.

[D] Ability of liquid alloy to flow readily in mold and fill thin sections.

[E] Decrease in volume accompanying freezing of alloy and measure of amount of compensating feed metal required in form of risers.

[F] Based on alloy resistance in standard-type salt-spray test.

[G] Composite rating based on ease of cutting, chip characteristics, quality of finish, and tool life. Ratings in the case of heat-treatable alloys, based on − T6 Temper. Other tempers, particularly the annealed temper, may have lower rating.

[H] Composite rating based on ease and speed of polishing and quality of finish provided by typical polishing procedure.

[I] Ability of casting to take and hold an electroplate applied by present standard methods.

[J] Rated on lightness of color, brightness, and uniformity of clear anodized coating applied in sulfuric acid electrolyte.

[K] Rated on combined resistance of coating and base alloy to corrosion.

[L] Rating based on tensile and yield strengths at temperatures up to 500°F (260°C), after prolonged heating at testing temperature.

[M] Based on ability of material to be fusion welded with filler rod of same alloy.

[N] Refers to suitability of alloy to withstand brazing temperatures without excessive distortion or melting.

[O] ASTM alloy designations are in Practice B 275.

[P] Not recommended for service at elevated temperatures.

[Q] 710.0 formerly A712.0, 712.0 formerly D712.0, 851.0 formerly A850.0, 852.0 formerly B850.0.

X2. METRIC EQUIVALENTS

X2.1 The SI unit for strength properties now shown is in accordance with the International System of Units (SI) (IEEE/ASTM SI 10). The derived SI unit for force is the newton (N), which is defined as that force which when applied to a body having a mass of 1 kg gives it an acceleration of 1 m/s^2($N = kg \cdot m/s^2$). The derived SI unit for pressure or stress is the newton per square metre (N/m^2), which has been named the pascal (Pa) by the General Conference on Weights and Measures. Since 1 ksi = 6 894 757 Pa, the metric equivalents are expressed as megapascal (MPa), which is the same as MN/m^2 and N/mm^2.

X3. INACTIVE ALLOYS

X3.1 Alloys listed as inactive by the Aluminum Association—208.0 and 222.0. Listing the composition limits, mechanical properties, and characteristics of the alloys is a method of preserving this data should it be needed at some future date.

TABLE X3.1 Chemical Composition Requirements–Inactive Alloys

NOTE 1—All applicable notes and footnotes can be found in Table 1

Alloy		Aluminum	Composition, (Values in Weight Percent)										Others	
ANSI	UNS		Silicon	Iron	Copper	Manganese	Magnesium	Chromium	Nickel	Zinc	Tin	Titanium	Each	Total
208.0	A02080	remainder	2.5-3.5	1.2	3.5-4.5	0.50	0.10	...	0.35	1.0	...	0.25	...	0.50
222.0	A02220	remainder	2.0	1.5	9.2-10.7	0.50	0.15-0.35	...	0.50	0.8	...	0.25	...	0.35

TABLE X3.2 Tensile Requirements–Inactive Alloys

NOTE 1—All applicable notes and footnotes can be found in Table 2.

Alloy		Temper	Tensile Strength, min, ksi	Yield Strength (0.2 % offset), min, ksi	Elongation in 2 in. or 4 x diameter, min, %	Typical Brinell Hardness, 500 kgf, 10 mm
ANSI	UNS					
208.0	A02080	F	19.0 (131)	120 (83)	1.5	55
222.0	A02220	O	23.0 (159)			80
		T6	30.0 (207)			115

TABLE X3.3 Properties and Characteristics–Inactive Alloys

NOTE 1—1 indicates best of group, 5 indicates poorest of group.
NOTE 2—All applicable notes and footnotes can be found in Table X1.1.

Alloy		Pattern Shrinkage Allowance,[A] in./ft [mm/m]	Approximate Melting Range,[B] °F [°C]	Resistance to Hot Cracking[C]	Pressure Tightness	Fluidity[D]	Solidification Shrinkage Tendency[E]	Normally Heat Treated	Resistance to Corrosion[F]	Machining[G]	Polishing[H]	Electroplating[I]	Anodizing (Appearance)[J]	Chemical Oxide Coating (Protection)[K]	Strength at Elevated Temperature[L]	Suitability for Welding[M]	Suitability for Brazing[N]
ANSI[O]	UNS																
208.0	A02080	5⁄32 [13]	970-1160 [521-627]	2	2	2	2	yes	4	3	3	2	3	3	3	2	no
222.0	A02220	5⁄32 [13]	965-1155 [518-624]	3	3	3	3	yes	4	1	2	1	3	4	1	4	no

SUMMARY OF CHANGES

Committee B07 has identified the location of selected changes to this standard since the last issue (B 26/B 26M – 02$^{\epsilon 1}$) that may impact the use of this standard. (Approved Apr. 10, 2003.)

(*1*) Added Section 2.6, *AMS Standard*, and AMS 2271 to Referenced Documents.
(*2*) Added paragraph 1.2.
(*3*) Revised paragraph 16.1.
(*4*) Deleted Test Method E 227 from Referenced Documents, and deleted citations of Test Method E 227 from the specification.
(*5*) Added Appendix X3.
(*6*) Deleted Alloys 208.0 and 222.0 from Table 1, Table 2, and Table X1.1 and placed them in "Inactive Alloys" Tables in X3.1.
(*7*) Editorially revised Section 1.