



Designation: ~~B618/B618M-11~~ Designation: **B618/B618M – 11a**

Standard Specification for Aluminum-Alloy Investment Castings¹

This standard is issued under the fixed designation B618/B618M; 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~~ 1.2 This specification is for aluminum-alloy investment castings used in general purpose applications. It may not address the mechanical properties integrity testing and verification required for highly loaded or safety critical applications.

1.3 Alloy and temper designations are in accordance with ANSI H35.1/H35.1 (M). The equivalent Unified Numbering System alloy designations are in accordance with Practice E527.

1.4 Unless the order specifies the “M” specification designation, the material shall be furnished to the inch-pound units.

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

1.6 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

1.7 *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:*²

B179 Specification for Aluminum Alloys in Ingot and Molten Forms for Castings from All Casting Processes

B275 Practice for Codification of Certain Nonferrous Metals and Alloys, Cast and Wrought

B557 Test Methods for Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products

B557M Test Methods for Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products (Metric)

B660 Practices for Packaging/Packing of Aluminum and Magnesium Products

B881 Terminology Relating to Aluminum- and Magnesium-Alloy Products

B917/B917M Practice for Heat Treatment of Aluminum-Alloy Castings from All Processes

D3951 Practice for Commercial Packaging

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

E34 Test Methods for Chemical Analysis of Aluminum and Aluminum-Base Alloys

E94 Guide for Radiographic Examination

E155 Reference Radiographs for Inspection of Aluminum and Magnesium Castings

E165 Practice for Liquid Penetrant Examination for General Industry

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

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.

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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.

*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 E29).

ANSI ^A	UNS	Composition, %											Other ^B Elements		Aluminum	
		Alloy	Silicon	Iron	Copper	Manganese	Magnesium	Chromium	Nickel	Zinc	Titanium	Tin		Each		Total ^C
201.0	A02010	0.10	0.15	4.0–5.2	0.20–0.50	0.15–0.55	...	...	...	...	...	...	...	0.05	0.10	remainder
240.0	A02040	0.20	0.35	4.2–5.0	0.10	0.15–0.35	0.25	0.05	0.10	0.15–0.30	...	0.05	0.15	0.05	0.15	remainder
242.0	A02420	0.7	1.0	3.5–4.5	0.35	1.2–1.8	...	1.7–2.3	0.35	0.25	...	...	0.15	0.05	0.15	remainder
295.0	A02950	0.7–1.5	1.0	4.0–5.0	0.35	0.03	...	...	0.35	0.25	...	...	0.15	0.05	0.15	remainder
319.0	A03190	5.5–6.5	1.0	3.0–4.0	0.50	0.10	...	0.35	1.0	0.25	...	...	0.50	...	0.50	remainder
328.0	A03280	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	...	...	0.15	0.05	0.15	remainder
355.0	A03550	4.5–5.5	0.6 ^F	1.0–1.5	0.50 ^F	0.40–0.6	0.25	...	0.35	0.20	...	...	0.15	0.05	0.15	remainder
C355.0	A3550	4.5–5.5	0.20	1.0–1.5	0.10	0.40–0.6	...	...	0.10	0.20	...	...	0.15	0.05	0.15	remainder
356.0	A03560	6.5–7.5	0.6 ^F	0.25	0.35 ^F	0.20–0.45	...	...	0.10	0.20	...	...	0.15	0.05	0.15	remainder
A356.0	A13560	6.5–7.6	0.20	0.20	0.10	0.25–0.45	...	...	0.10	0.20	...	...	0.15	0.05	0.15	remainder
443.0	A04430	4.5–6.0	0.8	0.6	0.50	0.05	0.25	...	0.50	0.20	...	...	0.35	...	0.35	remainder
B443.0	A24430	4.5–6.0	0.8	0.15	0.35	0.05	...	...	0.35	0.25	...	...	0.15	0.05	0.15	remainder
514.0	A05140	0.35	0.50	0.15	0.35	3.5–4.5	...	...	0.15	0.25	...	...	0.15	0.05	0.15	remainder
520.0	A05200	0.25	0.30	0.25	0.15	9.5–10.6	...	...	0.15	0.25	...	...	0.15	0.05	0.15	remainder
535.0	A05350	0.15	0.15	0.05	0.10–0.25	6.2–7.5	...	...	0.15	0.10–0.25	...	...	0.15	0.05	0.15	remainder
705.0	A07050	0.20	0.8	0.20	0.40–0.6	1.4–1.8	0.20–0.40	...	...	2.7–3.3	...	...	0.15	0.05	0.15	remainder
707.0	A07070	0.20	0.8	0.20	0.40–0.6	1.8–2.4	0.20–0.40	...	...	4.0–4.5	...	...	0.15	0.05	0.15	remainder
710.0 ^G	A07100	0.15	0.50	0.35–0.65	0.05	0.6–0.8	...	...	0.10	0.25	...	...	0.15	0.05	0.15	remainder
712.0 ^G	A07120	0.30	0.50	0.25	0.10	1.8–2.4	...	...	0.10	0.15–0.25	...	...	0.15	0.05	0.15	remainder
713.0	A07130	0.25	1.1	0.40–1.0	0.6	0.50–0.65	0.40–0.6	0.15	5.0–6.5	0.15–0.25	...	...	0.20	0.10	0.25	remainder
771.0	A07710	0.15	0.15	0.10	0.10	0.20–0.50	0.35	...	7.0–8.0	0.25	...	...	0.15	0.05	0.15	remainder
850.0	A08500	0.7	0.7	0.7–1.3	0.10	0.8–1.0	0.06–0.20	0.7–1.3	6.5–7.5	0.10–0.20	...	...	0.30	...	0.30	remainder
851.0 ^G	A08510	2.0–3.0	0.7	0.7–1.3	0.10	0.10	...	0.3–0.7	...	0.20	5.5–7.0	...	0.30	...	0.30	remainder
852.0 ^G	A08520	0.40	0.7	1.7–2.3	0.10	0.6–0.9	...	0.9–1.5	...	0.20	5.5–7.0	...	0.30	...	0.30	remainder

^A ASTM alloy designations are in Practice B275.

^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.

E716 Practices for Sampling and Sample Preparation of Aluminum and Aluminum Alloys for Determination of Chemical Composition by Spectrochemical Analysis

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

E2422 Digital Reference Images for Inspection of Aluminum Castings

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

2.3 *ANSI Standard:*³

H35.1/H35.1 (M) - 2006 American National Standard Alloy and Temper Designation Systems for Aluminum

2.4 *Military Standards:*⁴

MIL-STD-129 Marking for Shipment and Storage

MIL-STD-276 Impregnation of Porous Nonferrous Metal Castings

2.5 *Federal Standard:*

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)⁴

2.6 *AMS Standard:*⁵

AMS 2771 Heat Treatment of Aluminum Alloy Castings

2.7 *NAVSEA Standard:*⁶

S9074-AR-GIB-010/278 Requirements for Fabrication Welding and Inspection, and Casting Inspection and Repair for Machinery, Piping, and Pressure Vessels

2.8 *Other Standards:*⁷

CEN EN 14242 Aluminum and Aluminum Alloys, Chemical Analysis, Inductively Coupled Plasma Optical Emission Spectral Analysis

3. Terminology

3.1 *Definitions:* Refer to Terminology B881 for definitions of product terms used in this specification.

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 (Sections 1.4 and 1.6):

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

NOTE 1—For inch-pound application, specify Specification B618 and for metric application specify Specification B618M. Do not mix units.

4.1.2 Alloy (Section 7 and Table 1),

4.1.3 Temper (Section 11 and Table 2 [Table 3]),

4.1.4 Applicable drawing or part number,

4.1.5 The quantity in either pieces or pounds [kilograms].

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

4.2.1 Whether chemical analysis and tensile property reports are required (Table 1, Table 2 [Table 3]),

4.2.2 Whether castings or test specimens or both may be supplied in the artificially aged—T5 temper for alloys 705.0, 707.0, 712.0, and 713.0 (see 11.2),

4.2.3 Whether test specimens cut from castings are required in addition to or instead of separately cast specimens (see 11.3 and 12.2),

4.2.4 Whether heat treatment is to be performed in accordance with AMS 2771 (see 16)

4.2.5 Whether repairs are permissible (see 17.1),

4.2.6 Whether inspection is required at the producer's works (see 19.1),

4.2.7 Whether surface requirements shall be checked against observational standards where such standards are established (see 20.1),

4.2.8 Whether liquid penetrant inspection is required (see 20.3),

~~4.2.9 Whether radiographic inspection is required (see~~

4.2.9 Whether radiographic inspection is required and if so the radiographic grade of casting required (see 20.4, Table 4),

4.2.10 Whether certification is required (see 22.1),

4.2.11 Whether foundry control is required (10),

³ Available from Aluminum Association, Inc., 1525 Wilson Blvd., Suite 600, Arlington, VA 22209, <http://www.aluminum.org>.

⁴ Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, <http://www.dodssp.daps.mil>.

⁵ Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, <http://www.sae.org>.

⁶ Available from Naval Sea Systems Command (NAVSEA), 1333 Isaac Hull Ave., SE, Washington, DC 20376, <http://www.navsea.navy.mil>.

⁷ Available from European Committee for Standardization (CEN), 36 rue de Stassart, B-1050, Brussels, Belgium, <http://www.cenorm.be>.

TABLE 2 Tensile Requirements^A (Inch-Pound Units)

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 E29.

Alloy		Temper ^B	Tensile Strength, min, ksi	Yield Strength (0.2 % offset) min, ksi	Elongation in 2 in. or 4× diameter, min, %	Typical Brinell Hardness, ^C 500 kgf, 10 mm
ANSI ^D	UNS					
201.0	A02010	T6	60.0	50.0	5.0	...
		T7	60.0	50.0	3.0	...
204.0	A02040	T4	45.0	28.0	6.0	...
		T6	30.0	^E	^E	115
242.0	A02420	O ^F	23.0	^E	^E	70
		T61	32.0	20.0	^E	105
295.0	A02950	T4	29.0	13.0	6.0	60
		T6	32.0	20.0	3.0	75
		T62	36.0	28.0	^B	95
		T7	29.0	16.0	3.0	70
319.0	A03190	F	23.0	13.0	1.5	70
		T6	31.0	20.0	1.5	80
328.0	A03280	F	25.0	14.0	1.0	60
		T6	34.0	21.0	1.0	80
355.0	A03550	T6	32.0	20.0	2.0	80
		T51	25.0	18.0	^E	65
		T71	30.0	22.0	^E	75
C355.0	A33550	T6	36.0	25.0	2.5	...
356.0	A03560	F	19.0	^E	2.0	55
		T6	30.0	20.0	3.0	70
		T7	31.0	^E	^E	75
		T51	23.0	16.0	^E	60
		T71	25.0	18.0	3.0	60
A356.0	A13560	T6	34.0	24.0	3.5	80
443.0	A04430	F	17.0	7.0	3.0	40
B443.0	A24430	F	17.0	6.0	3.0	40
514.0	A05140	F	22.0	9.0	6.0	50
520.0	A05200	T4	42.0	22.0	12.0	75
535.0	A05350	F	35.0	18.0	9.0	70
705.0	A07050	T1 ^G and T5 ^H	30.0	17.0 ^I	5.0	65
707.0	A07070	T1 ^G	33.0	22.0 ^I	2.0	85
		T7	37.0	30.0 ^I	1.0	80
710.0 ^J	A07100	T1 ^G	32.0	20.0	2.0	75
712.0 ^J	A07120	T1 ^G and T5 ^H	34.0	25.0 ^I	4.0	75
713.0	A07130	T1 ^G and T5 ^H	32.0	22.0	3.0	75
771.0	A07710	T5	42.0	38.0	1.5	100
		T51	32.0	27.0	3.0	85
		T52	36.0	30.0	1.5	85
		T6	42.0	35.0	5.0	90
		T71	48.0	45.0	2.0	120
850.0	A08500	T5	16.0	^E	5.0	45
851.0 ^J	A08510	T5	17.0	^E	3.0	45
852.0 ^J	A08520	T5	24.0	18.0	^E	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/H35.1(M) for description of tempers.

^C For information only, not required for acceptance.

^D ASTM alloy designations are in Practice B275.

^E Not required.

^F Formerly designated 222.0-T2 and 242.0-T21.

^G Aged 21 days at room temperature.

^H Artificially aged in accordance with Practice B917/B917M.

^I Yield strength to be determined only when specified in the contract or purchase order.

^J 710.0 formerly A712.0, 712.0 formerly D712.0, 851.0, formerly A850.0, 852.0 formerly B850.0.

TABLE 3 Tensile Requirements (SI Units)—[Metric]^{A, B}

NOTE 1—For purposes of determining conformance with this specification, each value for tensile strength and yield strength shall be rounded to the nearest 1 MPa and each value for elongation shall be rounded to the nearest 0.5 %, both in accordance with the rounding method of Practice E29.

Alloy		Temper ^C	Tensile Strength, min, MPa ^D	Yield Strength (0.2 % offset) min, MPa	Elongation in 5D, min, %	Typical Brinell Hard- ness, ^E 500 kgf, 10 mm
ANSI ^F	UNS					
201.0	A02010	T6	415	345	4.0	...
		T7	415	345	3.0	...
204.0	A02040	T4	310	195	5.0	...
		T6	205	^G	^G	115
242.0	A02420	O ^H	160	^G	^G	70
		T61	220	140	^G	105
295.0	A02950	T4	200	90	5.0	60
		T6	220	140	3.0	75
		T62	250	195	^G	95
		T7	200	110	3.0	70
319.0	A03190	F	160	90	1.5	70
		T6	215	140	1.5	80
328.0	A03280	F	170	95	1.0	60
		T6	235	145	1.0	80
355.0	A03550	T6	220	140	2.0	80
		T51	170	125	^G	65
		T71	205	150	^G	75
C355.0	A33550	T6	250	170	2.5	...
356.0	A03560	F	130	^G	2.0	55
		T6	205	140	3.0	70
		T7	215	^G	^G	75
		T51	160	110	^G	60
		T71	170	125	3.0	60
A356.0	A13560	T6	235	165	3.5	80
443.0	A04430	F	115	50	3.0	40
B443.0	A24430	F	115	40	3.0	40
514.0	A05140	F	150	60	5.0	50
520.0	A05200	T4	290	150	10.0	75
535.0	A05350	F	240	125	8.0	70
705.0	A07050	T1 ^I and T5 ^J	205	115 ^K	4.0	65
707.0	A07070	T1 ^I	230	150 ^K	2.0	85
		T7	255	205 ^K	1.0	80
710.0 ^L	A07100	T1 ^I	220	140	2.0	75
712.0 ^L	A07120	T1 ^I and T5 ^J	235	170 ^K	4.0	75
713.0	A07130	T1 ^I and T5 ^J	220	150	3.0	75
771.0	A07710	T5	290	260	1.5	100
		T51	220	185	3.0	85
		T52	250	205	1.5	85
		T6	290	240	5.0	90
		T71	330	310	2.0	120
850.0	A08500	T5	110	^G	4.0	45
851.0 ^L	A08510	T5	115	^G	3.0	45
852.0 ^L	A08520	T5	165	125	^G	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 Guidelines for metric conversion from the "Temperatures for Aluminum and Aluminum Alloys, Metric Edition" (Tan Sheets) Appendix A, were used to convert the tensile and yield values to SI units.³

^C Refer to H35.1/H35.1 (M) - 2006 for description of tempers.

^D For explanation of SI unit "Mpa" see Appendix X2.

^E For information only, not required for acceptance.

^F ASTM alloy designations are in Practice B275.

^G Not required.

^H Formerly designated 222.0-T2 and 242.0-T21.

^I Aged 21 days at room temperature.

^J Artificially aged in accordance with Practice B917/B917M.

^K Yield strength to be determined only when specified in the contract or purchase order.

^L 710.0 formerly A712.0, 712.0 formerly D712.0, 851.0, formerly A850.0, 852.0 formerly B850.0.

4.2.12 Whether Practices B660 applies and, if so, the levels of preservation, packaging and packing required (24.3),

4.2.13 Whether marking in accordance with Fed. Std. 123 or D3951 or MIL-STD 129 applies (24.3).

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

TABLE 4 Discontinuity-Level Requirements for Aluminum Investment Castings (in Accordance with Film Reference Radiographs E155) or Digital Reference Radiographs E2422

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. Use 1/4-in. [6-mm] for all section thicknesses.

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 B179 or producer's foundry scrap (identified as being made from alloy conforming to Specification B179) 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 product shall conform to the chemical composition limits prescribed in Table 1. Conformance shall be determined by the producer by taking samples at the time castings are poured in accordance with E716 and analyzed in accordance with E607, E1251, E34 or EN 14242. If the producer has determined the composition of the material during casting, they shall not be required to sample and analyze the finished product.

7.2 If it becomes necessary to analyze castings for conformance to chemical composition limits, the method used to sample castings for the determination of chemical composition shall be by agreement between the producer and the purchaser. Analysis shall be performed in accordance with E716, E607, E1251, E34 or EN 14242 (ICP method).

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

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 [225 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.

9. Material Requirements—Castings Produced for Governmental and Military Agencies

9.1 Unless otherwise specified, only aluminum alloy conforming to the requirements of Specification B179 or producer's foundry scrap (identified as being made from alloy conforming to Specification B179) 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.

9.1.1 Pure materials, recycled materials, and master alloys may be used to make alloys conforming to this specification, provided chemical analysis can be performed and the composition of the melt adjusted to conform to Table 1 prior to pouring any castings.

10. Foundry Control—Castings Produced for Governmental or Military Agencies, or Both

10.1 When specified, castings shall be produced under foundry control approved by the purchaser. Foundry control shall consist