



**Designation: B618/B618M-10** ~~Designation: B618/B618M - 11~~

## Standard Specification for Aluminum-Alloy Investment Castings<sup>1</sup>

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 ( $\epsilon$ ) 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.~~

1.2 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:*<sup>2</sup>

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

<sup>1</sup> 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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<sup>2</sup> 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 <sup>A</sup>	UNS	Composition, %											Other <sup>B</sup> Elements		Aluminum		
		Silicon	Iron	Copper	Manganese	Magnesium	Chromium	Nickel	Zinc	Titanium	Tin		Each	Total <sup>C</sup>			
201.0	A02010	0.10	0.15	4.0–5.2	0.20–0.50	0.15–0.55	...	...	...	...	...	...	...	...	0.05	0.10	remainder
204.0	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	0.15–0.30	0.05	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	...	...	0.25	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	...	...	0.25	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	...	...	0.25	...	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	...	...	0.25	...	0.50	remainder	
355.0	A03550	4.5–5.5	0.6 <sup>F</sup>	1.0–1.5	0.50 <sup>F</sup>	0.40–0.6	0.25	...	0.35	0.20	...	...	0.20	0.05	0.15	remainder	
355.0	A03550	4.5–5.5	0.20	1.0–1.5	0.10	0.40–0.6	...	...	0.10	0.20	...	...	0.20	0.05	0.15	remainder	
356.0	A03560	6.5–7.5	0.6 <sup>F</sup>	0.25	0.35 <sup>F</sup>	0.20–0.45	...	...	0.10	0.20	...	...	0.20	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	...	...	0.20	0.05	0.15	remainder	
443.0	A04430	4.5–6.0	0.8	0.6	0.50	0.05	0.25	...	0.50	0.25	...	...	0.25	...	0.35	remainder	
B443.0	A24430	4.5–6.0	0.8	0.15	0.35	0.05	...	...	0.35	0.25	...	...	0.25	0.05	0.15	remainder	
514.0	A05140	0.35	0.50	0.15	0.35	3.5–4.5	...	...	0.15	0.25	...	...	0.25	0.05	0.15	remainder	
520.0	A05200	0.25	0.30	0.25	0.15	9.5–10.6	...	...	0.15	0.25	...	...	0.25	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	...	...	0.10–0.25	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	...	...	0.25	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	...	...	0.25	0.05	0.15	remainder	
710.0 <sup>G</sup>	A07100	0.15	0.50	0.35–0.65	0.05	0.6–0.8	...	...	0.6–0.8	6.0–7.0	...	...	0.25	0.05	0.15	remainder	
712.0 <sup>G</sup>	A07120	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	remainder	
713.0	A07130	0.25	1.1	0.40–1.0	0.6	0.20–0.50	0.35	0.15	7.0–8.0	0.25	...	...	0.25	0.10	0.25	remainder	
771.0	A07710	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	remainder	
850.0	A08500	0.7	0.7	0.7–1.3	0.10	0.10	...	...	0.7–1.3	0.20	...	...	0.20	...	0.30	remainder	
851.0 <sup>G</sup>	A08510	2.0–3.0	0.7	0.7–1.3	0.10	0.10	...	...	0.3–0.7	0.20	...	...	0.20	...	0.30	remainder	
852.0 <sup>G</sup>	A08520	0.40	0.7	1.7–2.3	0.10	0.6–0.9	...	...	0.9–1.5	0.20	...	...	0.20	...	0.30	remainder	

<sup>A</sup> ASTM alloy designations are in Practice B275.

<sup>B</sup> "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.

<sup>C</sup> Other Elements—Total shall be the sum of unspecified metallic elements 0.010 % or more, rounded to the second decimal before determining the sum.

<sup>D</sup> Contains silver 0.40–1.0 %.

<sup>E</sup> If iron exceeds 0.45 %, manganese content shall not be less than one half of the iron content.

<sup>F</sup> Contains beryllium 0.003–0.007 %, boron 0.002 % max.

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

2.3 *ANSI Standard:*<sup>3</sup>

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

2.4 *Military Standards:*<sup>4</sup>

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)<sup>4</sup>

2.6 *AMS Standard:*<sup>5</sup>

AMS 2771 Heat Treatment of Aluminum Alloy Castings

2.7 *NAVSEA Standard:*<sup>6</sup>

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:*<sup>7</sup>

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 20.4),

4.2.10 Whether certification is required (see 22.1),

4.2.11 Whether foundry control is required (10),

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).

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

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

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

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

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

**TABLE 2 Tensile Requirements<sup>A</sup> (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 <sup>B</sup>	Tensile Strength, min, ksi	Yield Strength (0.2 % offset) min, ksi	Elongation in 2 in. or 4× diameter, min, %	Typical Brinell Hardness, <sup>C</sup> 500 kgf, 10 mm
ANSI <sup>D</sup>	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	<sup>E</sup>	<sup>E</sup>	115
242.0	A02420	O <sup>F</sup>	23.0	<sup>E</sup>	<sup>E</sup>	70
		T61	32.0	20.0	<sup>E</sup>	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	<sup>B</sup>	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	<sup>E</sup>	65
		T71	30.0	22.0	<sup>E</sup>	75
C355.0	A33550	T6	36.0	25.0	2.5	...
356.0	A03560	F	19.0	<sup>E</sup>	2.0	55
		T6	30.0	20.0	3.0	70
		T7	31.0	<sup>E</sup>	<sup>E</sup>	75
		T51	23.0	16.0	<sup>E</sup>	60
		T71	25.0	18.0	3.0	60
		T6	34.0	24.0	3.5	80
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 <sup>G</sup> and T5 <sup>H</sup>	30.0	17.0 <sup>I</sup>	5.0	65
707.0	A07070	T1 <sup>G</sup>	33.0	22.0 <sup>J</sup>	2.0	85
		T7	37.0	30.0 <sup>J</sup>	1.0	80
		T1 <sup>G</sup>	32.0	20.0	2.0	75
710.0 <sup>J</sup>	A07100	T1 <sup>G</sup> and T5 <sup>H</sup>	34.0	25.0 <sup>I</sup>	4.0	75
712.0 <sup>J</sup>	A07120	T1 <sup>G</sup> and T5 <sup>H</sup>	32.0	22.0	3.0	75
713.0	A07130	T5	42.0	38.0	1.5	100
771.0	A07710	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
		T5	16.0	<sup>E</sup>	5.0	45
		T5	17.0	<sup>E</sup>	3.0	45
850.0	A08500	T5	16.0	<sup>E</sup>	5.0	45
851.0 <sup>J</sup>	A08510	T5	17.0	<sup>E</sup>	3.0	45
852.0 <sup>J</sup>	A08520	T5	24.0	18.0	<sup>E</sup>	60

<sup>A</sup> 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.

<sup>B</sup> Refer to ANSI H35.1/H35.1(M) for description of tempers.

<sup>C</sup> For information only, not required for acceptance.

<sup>D</sup> ASTM alloy designations are in Practice B275.

<sup>E</sup> Not required.

<sup>F</sup> Formerly designated 222.0-T2 and 242.0-T21.

<sup>G</sup> Aged 21 days at room temperature.

<sup>H</sup> Artificially aged in accordance with Practice B917/B917M.

<sup>I</sup> Yield strength to be determined only when specified in the contract or purchase order.

<sup>J</sup> 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]<sup>A,B</sup>

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.

Table with 7 columns: Alloy (ANSI, UNS), Temper, Tensile Strength (min, MPa), Yield Strength (0.2 % offset, min, MPa), Elongation in 5D, min, %, and Typical Brinell Hardness (500 kgf, 10 mm). Rows list various aluminum alloys and their mechanical properties.

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 "Tempers for Aluminum and Aluminum Alloys, Metric Edition" (Tan Sheets) Appendix A, were used to convert the tensile and yield values to SI units. 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.

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 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 of examination of castings by radiographic or other approved methods for determining internal discontinuities until the gating, pouring, and other foundry practices have been established to produce castings meeting the quality standards furnished by the purchaser or agreed upon between the purchaser and the producer. When foundry practices have been so established, the production method shall not be significantly changed without demonstrating to the satisfaction of the purchaser that the change does not adversely affect the quality of the castings. Minor changes in pouring temperature of  $\pm 50^\circ\text{F}$  ( $\pm 28^\circ\text{C}$ ) from the established nominal temperature are permissible.

## 11. Tensile Requirements

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

11.2 Although alloys 705.0, 707.0, 712.0, 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. The conditions of artificial aging shown in Practice B917/B917M shall be employed unless other conditions are accepted by mutual consent.

11.3 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 [Table 3]. 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 4 are specified, no tensile tests shall be specified nor tensile requirements be met on specimens cut from castings.