Designation: B969/B969M – 14

Standard Specification for Aluminum-Alloy Castings Produced by Squeeze Casting, Thixocast and Rheocast Semi-Solid Casting Processes[1]

This standard is issued under the fixed designation B969/B969M; 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 aluminum-alloy castings, produced by the thixocast, rheocast, semi-solid, and squeeze casting processes, shown in Table 1.

1.2 This specification is not intended for castings used in aerospace 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 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 non-conformance 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 *ASTM Standards:*[2]

NOTE 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.

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

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

D3951 Practice for Commercial Packaging

E8/E8M Test Methods for Tension Testing of Metallic Materials

E23 Test Methods for Notched Bar Impact Testing of Metallic Materials

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

E505 Reference Radiographs for Inspection of Aluminum and Magnesium Die Castings

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]

[1] This test method 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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

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

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

Alloy		Composition,%													
ANSI[D]	UNS	Silicon	Iron	Copper	Manganese	Magnesium	Chromium	Nickel	Zinc	Titanium	Tin	Other Elements[E]			Aluminum
												Each	Total[F]		
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	Remainder
355.0	A03550	4.5–5.5	0.6[G]	1.0–1.5	0.50[G]	0.40–0.6	0.25	...	0.35	0.25	...	...	0.05	0.15	Remainder
356.0	A03560	6.5–7.5	0.6[G]	0.25	0.35[G]	0.20–0.45			0.35	0.25			0.05	0.15	Remainder
A356.0	A13560	6.5–7.5	0.20	0.20	0.10	0.25–0.45			0.10	0.20			0.05	0.15	Remainder
357.0	A03570	6.5–7.5	0.15	0.05	0.03	0.45–0.6	...	...	0.05	0.20	...	...	0.05	0.15	Remainder
366.0		6.5–7.5	0.15	0.05	0.03	0.5–1.2			0.05	0.20			0.05	0.15	Remainder
380.0	A03800	7.5–9.5	2.0	3.0–4.0	0.50	0.10	...	0.50	3.0	...	0.35	...	...	0.50	Remainder
A390.0	A13900	16.0–18.0	0.50	4.0–5.0	0.10	0.45–0.65[H]	...	...	0.10	0.20	...	...	0.10	0.20	Remainder

[A]When single units are shown, these indicate the maximum amounts permitted.
[B]Analysis shall be made for the elements for which limits are shown in this table.
[C]The following applies to all specified limits in this table: For purposes of determining conformance to these limits, an observed value or a calculated value obtained from analysis shall be rounded to the nearest unit in the last right-hand place of figures used in expressing the specified limit in accordance with the rounding method of Practice E29.
[D]ASTM alloy designations are defined in ANSI H35.1/H35.1 (M).
[E]*Other* 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 *Other Elements*. Should any analysis by the producer or the purchaser establish that an *Other Elements* exceeds the limit of *Each* or that the aggregate of several *Other Elements* exceeds the limit of *Total*, the material shall be considered nonconforming.
[F]*Other Elements*—Total shall be the sum of unspecified metallic elements 0.010 % or more, rounded to the second decimal before determining the sum.
[G]If the iron content exceeds 0.45 %, manganese content shall not be less than one half of the iron.
[H]The Aluminum Association ruling on the number of decimal places to which Mg percent is expressed is exempted for some long standing alloys. (See A2.2.6.)

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

2.2 *ANSI Standard:*[4]
H35.1/H35.1 (M)-2006 American National Standard Alloy and Temper Designation Systems for Aluminum

2.3 *NADCA Standards:*[5]
#403 Product Specification Standards for Die Castings Produced by the Semi-Solid and Squeeze Casting Processes

2.4 *NADCA Product Specification Standards for Die Castings:*
Engineering and Design: Coordinate Dimensioning
S-4A-1-09 Linear Dimensions: Standard Tolerances
S-4A-2-09 Parting Line: Standard Tolerances
S-4A-3-09 Moving Die Components (MDC): Standard Tolerances
S-4A-4-09 Draft Requirements: Standard Tolerances
S-4A-5-09 Flatness Requirements: Standard Tolerances
S-4A-6-09 Cored Holes for Cut Threads: Standard Tolerances
S-4A-8-09 Cored Holes for Pipe Threads: Standard Tolerances
P-4A-1-09 Linear Dimensions: Precision Tolerances
P-4A-2-09 Parting Line: Precision Tolerances
P-4A-3-09 Moving Die Components (MDC): Precision Tolerances
P-4A-4-09 Draft Requirements: Precision Tolerances
P-4A-5-09 Flatness Requirements: Precision Tolerances
P-4A-6-09 Cored Holes for Cut Threads: Precision Tolerances
P-4A-7-09 Cored Holes for Formed Threads: Precision Tolerances
S/P-4-9-09 Machining Stock Allowances (Standard and Precision) Engineering and Design: Additional Specification Guidelines
G-6-1-09 Pressure Tightness in Die Cast Parts
G-6-2-09 Fillets, Ribs and Corners in Die Cast Parts (1 of 2)
G-6-3-09 Fillets, Ribs and Corners in Die Cast Parts (2 of 2)
G-6-4-09 Ejector Pins, Pin Marks and Pin Flash
G-6-5-09 Casting Flash removal
G-6-6-09 Surface Finish, As Cast
G-6-7-09 Die Cast Lettering and Ornamentation

2.5 *Federal Standard:*[6]
Fed. Std. No. 123 Marking for Shipment (Civil Agencies)

2.6 *Military Standard:*[6]
MIL-STD-129 Marking for Shipment and Storage (Military Agencies)
MIL-STD-276 Impregnation of Porous Nonferrous Metal Castings

2.7 *SAE Standard:*
AMS-STD-184 Identification Marking of Aluminum, Magnesium, and Titanium
AMS 2771 Heat Treatment of Aluminum Alloy Castings

2.8 *Naval Standard:*
NAVSEA Technical Publication S9074-AR-GIB-010/278

2.9 *Other Standards:*[7]
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.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *die casting, n*—a casting produced by introducing molten metal under substantial pressure into a metal die and characterized by a high degree of fidelity to the die cavity.

3.2.2 *rheocasting, n*—semi-solid casting process in which the thixotropic aluminum alloy feed-stock is produced at the die cast machine and injected whilst in its thixotropic state into a metal die cavity without an intermediate solidification stage.

3.2.3 *semi-solid casting (SSM), n*—a casting process wherein a partially solidified metal slurry is injected into a die cavity to form cast components.

3.2.4 *semi-solid slurry, n*—a mixture of solid spherical or globular primary phase dispersed in liquid, and which exhibits thixotropic behavior.

3.2.5 *slurry, n*—a thick suspension of solids in a liquid.

3.2.6 *squeeze casting, n*—a process whereby a metal product is produced by injecting molten metal at a relatively slow speed through a large ingate into a metal die and held under high pressure until solidification is complete.

3.2.7 *thixocasting, n*—semi-solid casting process wherein the feed-stock is a pre-cast slug of aluminum alloy capable of acting in a thixotropic manner, that has been heated to its thixotropic state and injected into a metal die cavity and allowed to solidify.

3.2.8 *thixotropic, adj*—a property of some materials to flow like a high viscosity liquid when a force is applied and maintain form when the force is removed.

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),

NOTE 2—For inch-pound application, specify Specification B969 and for metric application specify Specification B969M. Do not mix units.

4.1.2 Alloy (Section 7 and Table 1),

[4] Available from Aluminum Association, Inc., 1525 Wilson Blvd., Suite 600, Arlington, VA 22209, http://www.aluminum.org.
[5] Available from North American Die Casting Association, (NADCA,) 241 Holbrook Drive, Wheeling, IL 60090 (www.diecasting.org).
[6] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://dodssp.daps.dla.mil.
[7] Available from European Committee for Standardization (CEN), 36 Rue de Stassart, B-1050, Brussels, Belgium, http://www.cenorm.be.

4.1.3 Temper (Section 11, Table X2.1 [Table X2.2], Table X2.3 [Table X2.4], and Table X2.5 [Table X2.6]),

4.1.4 Applicable drawing or part number, and

4.1.4.1 Drawing of casting, when required, giving all necessary dimensions and showing latest revisions and allowances for linear dimensions (12.2), parting lines (see 12.3), moving die components (12.4), draft (12.5), flatness (12.6), cored hole threads (12.7 – 12.9), and machining stock (12.10). Location of ejector pin marks or parting lines shall be at the option of the producer, unless specifically designated on the drawing.

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

4.2 Additional tests, options, and special inspection requirements as provided below should be justified only on the basis of need. These shall be specified in the contract or purchase order, as additional procedures and extended delivery time may be involved,

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

4.3.1 Whether squeeze casting process or the semi-solid thixocast or rheocast process is to be used to produce the parts,

4.3.2 Whether chemical analysis and tensile property reports are required (see Sections 7.3 and 22, Table 1, Table X2.1 [Table X2.2], Table X2.3 [Table X2.4], and Table X2.5 [Table X2.6]),

4.3.3 Whether foundry control is required (Section 9),

4.3.4 Whether mechanical property tests are required (Sections 10, 11, 14, Table X2.1 [Table X2.2], Table X2.3 [Table X2.4], and Table X2.5 [Table X2.6]),

4.3.5 Whether yield strength tests are required (Footnote D in Table X2.1 [Table X2.2], Table X2.3 [Table X2.4], and Table X2.5 [Table X2.6]),

4.3.6 Whether heat treatment is to be performed in accordance with AMS 2771 or other practices (Section 16),

4.3.7 Whether repairs are permissible (Section 18),

4.3.8 Whether inspection is required at the producer's works (Section 19),

4.3.9 Whether surface requirements will be checked visually or by observational standards where such standards are established (20.1),

4.3.10 Whether liquid penetrant inspection is required (20.2),

4.3.11 Whether radiographic inspection is required and, if so, the radiographic grade of casting required (20.3 and Table 2),

4.3.12 Whether certification is required (Section 22),

4.3.13 Whether the standard AMS-STD-184 applies to the marking of castings, (24.1),

4.3.14 Whether Practices B660 apply and, if so, the levels of preservation, packaging and packing required (25.3),

4.3.15 Whether marking in accordance with Fed. Std. No. 123, Practice D3951, or MIL-STD-129 apply (25.2 and 25.3).

5. Manufacture

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

6. Quality Assurance

6.1 *Responsibility for Inspection*—When specified in the contract or purchase order, the producer or supplier is responsible for the performance of all inspection and test requirements specified herein. Except as otherwise specified in the contract or order, the producer or supplier 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. Quality assurance standards shall be agreed upon between the producer or supplier and purchaser at the time a contract or order is placed.

6.2 *Lot Definition*—An inspection lot shall be defined as follows:

6.2.1 An inspection lot shall consist of the production from each die or compound die on each machine for each 24 h during the first week (or five calendar days) of continuous normal operation and the production for each 48 h thereafter of

TABLE 2 Discontinuity-Level Requirements for Aluminum Castings in Accordance with Reference Radiographs E155 or Digital Reference Radiographs E2422

Discontinuity	Grade A[A]	Grade B		Grade C		Grade D	
	Section Thickness, in. (mm)						
	¼ to ¾ [6 to 19-mm]	¼ [6-mm]	¾ [19-mm]	¼ [6-mm]	¾ [19-mm]	¼ [6-mm]	¾ [19-mm]
Gas holes	none	1	1	2	2	5	5
Gas porosity (round)	none	1	1	3	3	7	7
Gas porosity (elongated)	none	1	1	3	4	5	5
Shrinkage cavity	none	1	[B]	2	[B]	3	[B]
Shrinkage porosity or sponge	none	1	1	2	2	4	3
Foreign material (less dense material)	none	1	1	2	2	4	4
Foreign material (more dense material)	none	1	1	2	1	4	3
Segregation	none	none		none		none	
Cracks	none	none		none		none	
Cold shuts	none	none		none		none	
Surface irregularity	not to exceed drawing tolerance						
Core shaft	not to exceed drawing tolerance						

[A] Caution should be exercised in requesting Grade A because of the difficulty in obtaining this level.
[B] No radiographs available. Use ¼-in [6-mm] for all thicknesses.

continuous normal operation. (Normal operations are those without occurrences such as, but not limited to, equipment breakdowns, unscheduled work stoppages, out of control situations, and so forth.) Castings inspected by this method shall be so marked or handled during the finishing operations as not to lose their identity.

6.2.2 Normal operation shall be considered production in the absence of any significant change in the machine, alloy composition, die, or continuity of operation. Should significant changes occur they shall be considered as the start of a new lot.

6.2.3 Each casting of a randomly selected sample shall be examined to determine conformance to the requirements with respect to general quality, dimensions, and identification marking. The producer or supplier may use a system of statistical quality control for such examinations.

6.3 All testing shall be performed in accordance with applicable ASTM test methods.

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 Practices E716 and analyzed in accordance with Test Methods E34, E607, or E1251, 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.

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

7.1.1.1 For production runs of less than 8 h, one sample from each die or compound die on each machine.

7.1.1.2 For production runs of more than 8 h, one sample from each die or compound die on each machine every 8 h.

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 in accordance with Practice B985. Analysis shall be performed in accordance with Practices E716, Test Methods E34, E607, or E1251, or EN 14242 (ICP method).

7.3 When a chemical analysis is required with a shipment, it shall be called for in the contract or purchase order.

7.4 If the producer's or supplier's method of composition control is acceptable, sampling for chemical analysis may be waived at the discretion of the purchaser.

8. Material Requirements (Castings Produced for Governmental and Military Agencies)

8.1 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.

8.1.1 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.

9. Foundry Control (Castings Produced for Governmental or Military Agencies, or Both)

9.1 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 ±50°F [±25°C] from the established nominal temperature are permissible.

10. Mechanical Properties

10.1 Unless specified in the contract or purchase order or specifically guaranteed by the manufacturer, acceptance of die castings under these specifications shall not depend on mechanical properties determined by tension or impact tests.

10.2 When specified in the contract or purchase order, the castings shall withstand proof tests without failure as defined by agreement between the purchaser and the producer or supplier.

11. Tensile Properties

11.1 The tensile properties shall be determined in accordance with Test Methods B557 [B557M].

11.2 If Grade D quality castings as described in Table 2 are specified, no tensile tests shall be specified nor tensile requirements be met on specimens cut from castings.

12. Dimensions, Mass, and Permissible Variations

12.1 Permissible variations in dimensions shall be within the limits specified on the drawings or in the contract or purchase order.

12.2 *Linear Dimensions*—Unless otherwise specified on the drawing or in the contract or purchase order, linear dimension tolerances shall conform to NADCA Product Specification Standard S-4A-1-09, Standard Tolerances, or by agreement between the producer and the supplier, P-4A-1-09, Precision Tolerances.

12.3 *Parting Lines*—Unless otherwise specified on the drawing or in the contract or purchase order, parting line dimension tolerances shall conform to NADCA Product Specification Standard S-4A-2-09, Standard Tolerances, or by agreement between the producer and the supplier, P-4A-2-09, Precision Tolerances.

12.4 *Moving Die Components*—Unless otherwise specified on the drawing or in the contract or purchase order, moving die component dimension tolerances shall conform to NADCA

Product Specification Standard S-4A-3-09, Standard Tolerances, or by agreement between the producer and the supplier, P-4A-3-09, Precision Tolerances.

12.5 *Draft*—Unless otherwise specified on the drawing or in the contract or purchase order, draft tolerance dimensions shall conform to NADCA Product Specification Standard S-4A-4-09, Standard Tolerances, or by agreement between the producer and the supplier, P-4A-4-09, Precision Tolerances.

12.6 *Flatness*—Unless otherwise specified on the drawing or in the contract or purchase order, flatness dimensional tolerances shall conform to NADCA Product Specification Standard S-4A-5-09, Standard Tolerances, or by agreement between the producer and the supplier, P-4A-5-09, Precision Tolerances.

12.7 *Cored Holes for Cut Threads*—Unless otherwise specified on the drawing or in the contract or purchase order, the dimensional tolerances for cored holes for cut threads shall conform to NADCA Product Specification Standard S-4A-6-09, Standard Tolerances, or by agreement between the producer and the supplier, P-4A-6-09, Precision Tolerances.

12.8 *Cored Holes for Pipe Threads*—Unless otherwise specified on the drawing or in the contract or purchase order, the dimensional tolerances for cored holes for cut threads shall conform to NADCA Product Specification Standard S-4A-8-09.

12.9 *Cored Holes for Formed Threads*—Unless otherwise specified on the drawing or in the contract or purchase order, the dimensional tolerances for cored holes for cut threads shall conform to NADCA Product Specification Standard P-4A-7-09.

12.10 *Machining Stock*—Unless otherwise specified on the drawing or in the contract or purchase order, allowances for machining stock shall conform to the standard tolerances detailed in NADCA Product Specification Standard S/P-4-9-09, or by agreement between the producer and the supplier, the precision tolerances shown in S/P-4-9-09.

12.11 Dimensional tolerance deviations waived by the purchaser shall be confirmed in writing to the producer or supplier.

13. General Quality

13.1 Imperfections inherent in the castings shall not be cause for rejection provided it is demonstrated that the castings are in accordance with the requirements and standards agreed upon.

13.2 *Internal Soundness*—When specified, the soundness of the castings shall conform to standards or requirements agreed upon between the producer or supplier and the purchaser. The number and extent of imperfections shall not exceed those specified by the purchaser. The standards or requirements may consist of radiographs in accordance with Reference Radiographs E505, photographs or sectioned castings.

13.3 *Pressure Tightness*—When specified in the contract or purchase order, the pressure tightness of the castings shall conform to standards agreed upon between the purchaser and the producer or supplier, or as prescribed in NADCA Product Specification Standards for Die Castings G-6-1-09.

13.4 *Fillets, Ribs and Corners*—Unless otherwise specified in the contract or purchase order fillets, ribs and corners shall conform to NADCA Product Specification Standards for Die Castings G-6-2-09 and G-6-3-09.

13.5 *Ejector Pins, Pin Marks, Pin Flash, and Flash Removal*—Unless otherwise specified in the contract or purchase order ejector pins, pin marks, pin flash, and flash removal shall conform to NADCA Product Specification Standards for Die Castings G-6-4-09 and G-6-5-09.

13.6 *Casting Flash Removal*—Unless otherwise specified in the contract or purchase order casting flash removal shall conform to NADCA Product Specification Standards for Die Castings G-6-5-09.

13.7 *Surface Finish*—When specified in the contract or purchase order the as-cast surface finish required shall conform to standards agreed upon between the purchaser and the producer or supplier, or as prescribed in NADCA Product Specification Standards for Die Castings G-6-6-09.

13.8 *Die Cast Lettering and Ornamentation*—Unless otherwise specified in the contract or purchase order, cast lettering and ornamentation shall conform to NADCA Product Specification Standards for Die Castings G-6-7-09.

13.9 *Machining Stock Allowances*—Unless otherwise specified in the contract or purchase order, cast machining stock allowances shall conform to NADCA Product Specification Standards for Die Castings standard allowances shown in S/P-4-9-09.

13.10 *Workmanship*—Die castings shall be of uniform quality, free of injurious discontinuities that will adversely affect their serviceability.

14. Number of Tests and Retests

14.1 Unless otherwise agreed upon between the purchaser and producer, a minimum of two tension test specimens shall be tested to represent the following:

14.1.1 For production runs of less than 8 h, one sample from each die or compound die on each machine.

14.1.2 For production runs of more than 8 h, but less than 24 h, one sample from each die or compound die on each machine every 8 h.

14.1.3 For production runs longer than 24 h, an inspection lot as defined in 6.2.1.

14.1.4 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.

14.1.5 If the results of the tension tests do not conform to the requirements prescribed in Table X2.1 [Table X2.2], Table X2.3 [Table X2.4], and Table X2.5 [Table X2.6]; the test bars representative of the castings may be retested in accordance with the replacement tests and retest provisions of Test Methods B557 [B557M], and the results of retests shall conform to the requirements as to mechanical properties

specified in Table X2.1 [Table X2.2], Table X2.3 [Table X2.4], and Table X2.5 [Table X2.6].

15. Specimen Preparation

15.1 When properties of castings are to be determined, tension test specimens shall be cut from the locations designated on the drawing, in accordance with Test Methods B557 or B557M (6.3.3), unless otherwise negotiated. If no locations are designated, one or more specimens shall be taken to included locations having significant variation in casting thickness, except that specimens shall not be taken from areas directly under risers.

15.2 If castings are to be heat treated and tests are to be obtained on the castings, the test specimens shall be taken from the castings after heat treatment.

16. Heat Treatment

16.1 The temper of the castings shall be specified in the purchase order.

16.2 *Squeeze Castings:*

16.2.1 Heat treatment of castings shall be performed in accordance with Practice B917/B917M.

16.2.2 When specified, heat treatment shall be in accordance with AMS 2771.

16.3 *Semi-Solid Thixocast and Rheocast Castings*

16.3.1 Unless other practices are agreed upon between the purchaser and the producer, heat treatment, when required shall be performed in accordance with Practice B917/B917M.

17. Repair of Castings

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

18. Repairing of Castings (Produced for Governmental and Military Agencies)

18.1 *Welding:*

18.1.1 When welding is permitted, it shall be done by methods suitable for the particular alloy. Welding methods shall be in accordance with such specifications as are referenced on the applicable drawings, or as are required by the contract or order.

18.1.2 All welding shall be done by qualified welders approved by the purchaser.

18.1.3 When castings are to be supplied in the heat-treated condition, they shall be heat treated to the required temper after welding, except that small arc welds may be performed without subsequent heat treatment upon approval of the purchaser.

18.1.4 Unless otherwise specified, castings that have been repaired by welding shall have the welded areas examined radiographically after all reworking and heat treatment have been completed.

18.1.5 All welds shall be free of cracks, excess gas, porosity, lack of fusion and meet the same quality requirements as the parent material.

18.1.6 Welded castings shall be marked with a symbol of three concentric circles with a letter or number designating the welder adjacent to the symbol. The outer circle of the symbol shall be not larger than ¼ in. [6 mm] in outside diameter. All welded areas shall be encircled with a ring of white paint prior to submission for final inspection.

18.1.7 *Naval Shipboard Applications*—Repair welding of castings used in Naval shipboard pressure vessels, piping systems and machinery shall be performed in accordance with requirements for repair of castings specified in NAVSEA Technical Publication S9074-AR-GIB-010/278.

18.2 *Impregnation*—When impregnation is permitted, it shall be to correct general seepage leaks only and shall not be used to correct poor foundry technique or significant porosity. It shall be accomplished in accordance with MIL-STD-276. Unless otherwise authorized by the purchaser, castings which have been impregnated shall be marked “IMP.”

18.3 *Peening*—When peening is permitted, it shall be to correct localized minor seepage leaks and small surface imperfections only, or to disclose subsurface voids for purpose of inspection. Peening will not be permitted to repair cracks, cold shuts, shrinks, misruns, defects due to careless handling, or other similar major defects. Peening may be accomplished either hot or cold and shall be performed by methods which are acceptable to the purchaser. Peened castings shall be marked with Maltese cross approximately ¼ in. [6 mm] high.

18.4 *Blending*—Blending with suitable grinders or other tools will be permitted for the removal of surface imperfections only, and shall not result in dimensions outside the tolerances shown on the applicable drawing.

19. Source Inspection

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

19.2 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.

20. Foundry Inspection

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

20.2 *Liquid Penetrant Inspection:*

20.2.1 When specified, liquid penetrant inspection shall be in accordance with Test Method E165 and the required sensitivity shall be specified.

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

20.3 *Radiographic Inspection:*

20.3.1 Radiographic inspection shall be in accordance with Guide E94 and Reference Radiographs E155.

20.3.2 When agreed upon between the manufacturer and purchaser digital radiographic inspection shall be in accordance with Guide E94 and Digital Reference Radiographs E2422.

20.3.3 Radiographic acceptance shall be in accordance with requirements selected from Table 2. Any modifications of this table and the frequency per unit area and location should also be agreed upon.

20.3.4 The number, film size, and orientation of radiographs and the number of castings radiographically inspected shall be agreed upon between the manufacturer and purchaser.

21. Rejection and Rehearing

21.1 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. As much of the rejected original material as possible shall be returned to the producer or supplier.

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

22. Certification

22.1 The producer or supplier shall, when called for in the contract or purchase order, furnish to the purchaser a certificate of inspection stating that each lot has been sampled, tested, and inspected in accordance with this specification, and has been found to meet the requirements specified.

23. Identification and Repair Marking—Castings Produced for Government and Military Agencies

23.1 *Identification*—Unless otherwise specified, each casting shall be marked with the applicable drawing or part number. The marking shall consist of raised Arabic numerals, and when applicable capital letters, cast integral. The location of the identification marking shall be as specified on the applicable drawing. When the location is not specified on the drawing, the drawing/part number shall be placed in a location mutually agreeable to the purchaser and producer.

23.1.1 *Lot Identification*—When practicable, each casting shall also be marked with the melt or inspection lot number.

23.2 *Lot*—A lot shall consist of all of the cleaned castings poured from the same heat or melt when subsequent heat treatment is not required.

23.2.1 When the castings consist of alloys which require heat treatment, the lot shall consist of all castings from the same melt or heat which have been heat treated in the same furnace charge, or if heat treated in a continuous furnace, all castings from the same melt or heat that are discharged from the furnace during a 4-h period.

23.3 *Repair Markings*—All identification markings indicating repairs as specified in 18.1.6, 18.2, and 18.3, shall be made with a waterproof marking fluid.

24. Product Marking

24.1 Unless otherwise specified, each casting shall be marked with the applicable drawing or part number. The marking shall consist of raised Arabic numerals, and when applicable capital letters, cast integral. The location of the identification marking shall be as specified on the applicable drawing. When the location is not specified on the drawing, the drawing/part number shall be placed in a location mutually agreeable to the purchaser and producer. Government applications shall be marked in accordance with AMS-STD-184.

25. Packaging, Marking, and Shipping

25.1 *Packaging*—The material shall be packaged in such a manner as to prevent damage in ordinary handling and transportation. The type of packaging and gross weight of individual containers shall be left to the discretion of the producer unless otherwise agreed upon. Packaging methods and containers shall be so selected as to permit maximum utility of mechanical equipment in unloading and subsequent handling. Each package or container shall contain only one size, alloy, and temper of material when packaged for shipment unless otherwise agreed upon.

25.1.1 Packages or containers shall be such as to ensure acceptance by common or other carriers for safe transportation at the lowest rate to the point of delivery.

25.2 *Marking*—Each shipping container shall be legibly marked with the purchase order number, gross and net weights, and the supplier's name or trademark. Marking for shipment shall be in accordance with Fed. Std. No. 123 or Practice D3951 for civil agencies and MIL-STD-129 for military agencies.

25.3 *Preservation*—When specified in the contract or purchase order, material shall be preserved, packaged, and packed in accordance with the requirements of Practices B660. The applicable levels shall be as specified in the contract or order. Marking for shipment of such material shall be in accordance with Fed. Std. No. 123 or Practice D3951 for civil agencies and MIL-STD-129 for military agencies.

26. Keywords

26.1 aluminum; die casting; rheocasting; semi-solid; squeeze; thixocasting

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 cast aluminum or aluminum alloy shall be registered in accordance with ANSI H35.1/H35.1 (M). The Aluminum Association[4] 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/H35.1 (M). 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.

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 % (It is customary to express limits of 0.30 through 0.55 % as 0.X0 or 0.X5)	0.XX
Over 0.55 % (Except that combined Si + Fe limits for 99.00 % minimum aluminum must be expressed as 0.XX or 1.XX)	0.X, X.X, and so forth

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

X1.1 Table X1.1 shows certain casting and other outstanding characteristics, which are usually considered in selecting a casting alloy for a specific application. The characteristics are rated from (*1*) to (*5*), (*1*) being the best and (*5*) being the least desirable for that attribute. In considering these ratings, it should be noted that all the alloys have sufficiently good characteristics to be accepted by users and producers of squeeze castings, semi-solid castings, or both. Hence the rating for each characteristic is a relative measure of that attribute compared to the same attribute in another alloy.

TABLE X1.1 Squeeze and Semi-Solid Casting and Other Characteristics (Inch-Pound Units) (SI Units) [Metric]

NOTE 1—*Rating System*: The various alloys are rated 1 to 5 according to the positive to negative qualities in the listed categories. A rating of 1 gives the best performance, 5 the poorest performance. No one alloy is best in all categories. A rating of 5 in any one or more categories does not rule an alloy out of commercial usefulness if its other attributes are especially favorable. However, ratings of 5 may present manufacturing difficulties.

Designation			Casting Characteristics				Other Characteristics[A]						
AA No. (ANSI)[B]	UNS[B]	Approximate Melting Temperature Range, ° F [°C]	Resistance to Hot Cracking[C]	Pressure Tightness	Die Filling Capacity[D]	Anti-Soldering to the Die[E]	Resistance to Corrosion[F]	Machining[G]	Polishing[H]	Electro - plating[I]	Anodizing (Appearance)[J]	Chemical Oxide Coating (Protection)[K]	Strength at Elevated Temperatures[L]
319.0	A03190	950-1125 [510-607]	2	2	3	3	3	3	3	2	3	3	3
355.0	A03550	1015-1150 [546-621]	1	1	3	3	3	3	3	2	3	2	2
356.0	A3056	1035-1135 (557-613)	2	2	3	5	1	3	3	1	3	2	3
A356.0	A135600	1035-1135 [557-613]	2	2	3	5	1	3	3	1	3	2	3
357.0	A03570	1035-1135 [557-613]	2	2	3	5	1	3	3	1	3	2	3
366.0		1035-1135 [557-613]	2	2	2	1	4	3	3	1	4	4	3
380.0	A03800	1000-1100 [537-593]	2	2	2	1	4	3	3	1	4	4	3
A390.0	A13900	945-1200 [507-649]	4	4	1	2	3	5	5	3	5	5	3

[A] Squeeze and Semi-solid castings are usually heat treated. Both solution heat treatment and low temperature aging may be applied to obtain specific mechanical properties.
[B] ASTM designations were established in accordance with Practice B275. ANSI designations were established in accordance with ANSI H35.1/H35.1 (M). UNS designations were established in accordance with Practice E527.
[C] Ability of alloy to withstand stresses from contraction while cooling through hot-short or brittle temperature range.
[D] Ability of molten alloy to flow readily in die and fill thin sections.
[E] Ability of molten alloy to flow without sticking to the die surfaces. Ratings given for antisoldering are based on nominal iron compositions of approximately 1.0.
[F] Based on resistance of alloy in standard type salt spray test.
[G] Composite rating based on ease of cutting, chip characteristics, quality of finish and tool life.
[H] Composite rating based on ease and speed of polishing and quality of finish provided by typical polishing procedure.
[I] Ability of the alloy 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 sulphuric acid electrolyte. Generally aluminum die castings are unsuitable for light color anodizing where pleasing appearance is required.
[K] Rated on combined resistance of coating and base alloy to corrosion.
[L] Rating based on tensile and yield strengths at temperature up to 500°F [260°C], after prolonged heating at testing temperature.

X2. TYPICAL MECHANICAL PROPERTIES

X2.1 Table X2.1 [Table X2.2], Table X2.3 [Table X2.4], and Table X2.5 [Table X2.6] show typical or mid range mechanical properties that may be expected of test specimens cut from castings and that conform to the chemical composition specified. When tension or impact tests are made, the tension test specimen shown in Fig. 18 of Test Methods E8/E8M or Fig. 13 of Test Methods B557 [B557M], and the type 'A' Charpy impact test specimen with V notch cast into the specimen as shown in Fig. 1 of Test Methods E23 shall be used.

TABLE X2.1 Squeeze Cast Mechanical Properties (Inch-Pound Units)[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 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[C]	Tensile Strength, ksi	Yield Strength (0.2 % offset), ksi[D]	Elongation in 2 in. or 4 × Diameter, %	Typical Brinell Hardness[E] 500-kgf load, 10-mm ball
ANSI[F]	UNS[F]					
A356.0	A13560	T6	44	33	12	...
357.0	A03570	T6	48	36	9	...
380.0	A03800	F	38	23	2	...
A390.0	A13900	T6	54	N/A	<1	140

[A] Properties copied with permission from NADCA publication #403.
[B] If agreed upon by manufacturer and the purchaser, other mechanical properties may be obtained by other heat treatments such as annealing, aging, or stress relieving.
[C] Temper designations are based on those found in ANSI H35.1/H35.1 (M). The heat treatment practices for Squeeze Castings are shown in Practice B917/B917M.
[D] Yield strength to be evaluated only when specified in contract or purchase order.
[E] Hardness values given for information only, not required for acceptance.
[F] ASTM designations were established in accordance with Practice B275. ANSI designations were established in accordance with ANSI H35.1/H35.1 (M). UNS designations were established in accordance with Practice E527.

TABLE X2.2 Squeeze Cast Mechanical Properties (SI Units) [Metric][A,B,C]

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[D]	Tensile Strength, (MPa)	Yield Strength[E] (0.2 % offset), (MPa)	Elongation in 5D, %	Typical Brinell Hardness[F] 500-kgf load, 10-mm ball
ANSI[G]	UNS[G]					
A356.0	A13560	T6	305	230	10	...
357.0	A03570	T6	330	250	8	...
380.0	A03800	F	260	160	1	...
A390.0	A13900	T6	370	N/A	<1	140

[A] Properties copied with permission from NADCA publication #403.
[B] If agreed upon by manufacturer and the purchaser, other mechanical properties may be obtained by other heat treatments such as annealing, aging, or stress relieving.
[C] 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.[4]
[D] Temper designations are based on those found in ANSI H35.1/H35.1 (M). The heat treatment practices for Squeeze Castings are shown in Practice B917/B917M.
[E] Yield strength to be evaluated only when specified in contract or purchase order.
[F] Hardness values given for information only, not required for acceptance.
[G] ASTM designations were established in accordance with Practice B275. ANSI designations were established in accordance with ANSI H35.1/H35.1 (M). UNS designations were established in accordance with Practice E527.

TABLE X2.3 Thixocast–Semi-Solid Casting Mechanical Properties (Inch-Pound Units)[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 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[C]	Tensile Strength, ksi	Yield Strength[D] (0.2 % offset), ksi	Elongation in 2 in. %	Typical Brinell Hardness[E] 500-kgf load, 10-mm ball
ANSI[F]	UNS[F]					
355.0	A03550	T5	46	33	7	...
A356.0	A13560	T5	36	26	10	89
A356.0	A13560	T6	44	33	12	...
357.0	A03570	T5	41	29	8	90
357.0	A03570	T6	50	41	9	...
366.0		T5	46	35	4	...
		T6	52	47	4	...
A390.0	A13900	T6	50	N/A	<.2	...

[A] Properties copied with permission from NADCA publication #403 .
[B] If agreed upon by manufacturer and the purchaser, other mechanical properties may be obtained by other heat treatments such as annealing, aging, or stress relieving.
[C] Temper designations are based on those found in ANSI H35.1/H35.1 (M), but the heat treatment practices are non-standard. For typical heat treatment practices for semi-solid castings see Practice B917/B917M.
[D] Yield strength to be evaluated only when specified in contract or purchase order.
[E] Hardness values given for information only, not required for acceptance.
[F] ASTM designations were established in accordance with Practice B275. ANSI designations were established in accordance with ANSI H35.1/H35.1 (M). UNS designations were established in accordance with Practice E527.

TABLE X2.4 Thixocast–Semi-Solid Casting Mechanical Properties (SI Units) [Metric][A,B,C]

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[D]	Tensile Strength, (MPa)	Yield Strength[E] (0.2 % offset), (MPa)	Elongation in 5D, %	Typical Brinell Hardness[F] 500-kgf load, 10-mm ball
ANSI[G]	UNS[G]					
355.0	A03550	T5	315	230	6	...
A356.0	A13560	T5	250	180	9	89
A356.0	A13560	T6	305	230	10	...
357.0	A03570	T5	285	200	7	90
357.0	A03570	T6	345	285	8	...
366.0		T5	320	240	4	...
		T6	360	325	4	...
A390.0	A13900	T6	345	N/A	<0.2	...

[A] Properties copied with permission from NADCA publication #403.
[B] If agreed upon by manufacturer and the purchaser, other mechanical properties may be obtained by other heat treatments such as annealing, aging, or stress relieving.
[C] 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.[4]
[D] Temper designations are based on those found in ANSI H35.1/H35.1 (M), but the heat treatment practices are non-standard. For typical heat treatment practices for semi-solid castings see Practice B917/B917M.
[E] Yield strength to be evaluated only when specified in contract or purchase order.
[F] Hardness values given for information only, not required for acceptance.
[G] ASTM designations were established in accordance with Practice B275. ANSI designations were established in accordance with ANSI H35.1/H35.1 (M). UNS designations were established in accordance with Practice E527.

TABLE X2.5 Rheocast–Semi-Solid Casting Mechanical Properties (Inch-Pound Units)[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 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[C]	Tensile Strength, ksi	Yield Strength[D] (0.2 % offset), ksi	Elongation in 2 in. or 4 × Diameter, %	Typical Brinell Hardness[E] 500-kgf load, 10-mm ball
ANSI[F]	UNS[F]					
319.0	A03190	F	34	19	4	...
319.0	A03190	T6	37	22	6	...
356.0	A03560	F	26	18	6	...
		T51	27	20	3	...
		T61	44	34	6	...
		T71	32	24	7	...
A356.0	A13560	F	35	16	13	...
A356.0	A13560	T5	39	26	7	...
A356.0	A13560	T6	45	34	13	...
357.0	A03570	T6	50	42	7	...

[A] Properties copied with permission from NADCA publication #403.
[B] If agreed upon by manufacturer and the purchaser, other mechanical properties may be obtained by other heat treatments such as annealing, aging, or stress relieving.
[C] Temper designations are based on those found in ANSI H35.1/H35.1 (M), but the heat treatment practices are non-standard. For typical heat treatment practices for semi-solid castings are shown in see Practice B917/B917M.
[D] Yield strength to be evaluated only when specified in contract or purchase order.
[E] Hardness values given for information only, not required for acceptance.
[F] ASTM designations were established in accordance with Practice B275. ANSI designations were established in accordance with ANSI H35.1/H35.1 (M). UNS designations were established in accordance with Practice E527.

TABLE X2.6 Rheocast–Semi-Solid Casting Mechanical Properties (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, (MPa)	Yield Strength[D] (0.2 % offset), (MPa)	Elongation in 5D, %	Typical Brinell Hardness[E] 500–kgf load, 10-mm ball
ANSI[F]	UNS[F]					
319.0	A03190	F	235	130	3	...
319.0	A03190	T6	255	150	5	...
356.0	A03560	F	180	125	5	...
		T51	185	140	2	...
		T61	305	235	5	...
		T71	220	165	6	...
A356.0	A13560	F	240	110	11	...
A356.0	A13560	T5	270	180	6	...
A356.0	A13560	T6	310	235	11	...
357.0	A03570	T6	345	290	6	...

[A] Properties copied with permission from NADCA publication #403.
[B] If agreed upon by manufacturer and the purchaser, other mechanical properties may be obtained by other heat treatments such as annealing, aging, or stress relieving.
[C] Temper designations are based on those found in ANSI H35.1/H35.1 (M), but the heat treatment practices are non-standard. For typical heat treatment practices for semi-solid castings see Practice B917/B917M.
[D] Yield strength to be evaluated only when specified in contract or purchase order.
[E] Hardness values given for information only, not required for acceptance.
[F] ASTM designations were established in accordance with Practice B275. ANSI designations were established in accordance with ANSI H35.1/H35.1 (M). UNS designations were established in accordance with Practice E527.

X3. METRIC EQUIVALENTS

X3.1 The SI unit for strength properties (MPa) 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 one kilogram gives it an acceleration of one metre per second squared ($N = kg \cdot m/s^2$). 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.

SUMMARY OF CHANGES

Committee B07 has identified the location of selected changes to this standard since the last issue (B969/B969M – 11) that may impact the use of this standard. (Approved Oct. 1, 2014.)

(1) Reference to Practice B985 was added to Subsections 2.1 and 6.2.
(2) Section 7.3 was deleted.
(3) Section 7.4, and Subsections 7.4.1 and 7.4.2, were moved into Section 7.1.