



Standard Specification for Zinc and Zinc-Aluminum (ZA) Alloy Foundry and Die Castings¹

This standard is issued under the fixed designation B86; 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 commercial zinc, zinc-aluminum castings and continuous cast bar stock, as designated and specified in **Table 1**. Seven alloy compositions are specified and designated as follows:

Common	Traditional	ASTM ^A	UNS
Alloy 3	Zamak 3	AG 40A ^B	Z33525
Alloy 7	Zamak 7	AG 40B	Z33527
Alloy 5	Zamak 5	AC 41A ^B	Z35533
Alloy 2	Zamak 2	AC 43A	Z35545
ZA-8	ZA-8	...	Z35638
ZA-12	ZA-12	...	Z35633
ZA-27	ZA-27	...	Z35841

^A See **Table 1**, Footnote C.

^B SAE Specification, Nos. 903 and 925 conform to the requirements for alloys AG40A and AC41A, respectively.

1.2 Zinc Alloys Z33525, Z33527, Z35533, and Z35545 are used primarily in the manufacture of pressure die castings. Zinc-Aluminum Alloys Z35638, Z35633, and Z35841 are used in the manufacture of both foundry and pressure die castings. These alloys are also fabricated into continuous cast bar stock used for prototyping and screw machine stock.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.4 Systems of nomenclature used to designate zinc and zinc-aluminum (ZA) alloys used for casting are described in **Appendix X1**.

1.5 *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 become familiar with all hazards including those identified in the appropriate Material Safety Data Sheet (MSDS) for this product/material*

¹ This specification is under the jurisdiction of ASTM Committee B02 on Nonferrous Metals and Alloys and is the direct responsibility of Subcommittee B02.04 on Zinc and Cadmium.

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as provided by the manufacturer, 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 date of order acceptance form a part of this specification to the extent referenced herein:

2.2 ASTM Standards:²

- B240** Specification for Zinc and Zinc-Aluminum (ZA) Alloys in Ingot Form for Foundry and Die Castings
 - 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
 - B899** Terminology Relating to Non-ferrous Metals and Alloys
 - B949** Specification for General Requirements for Zinc and Zinc Alloy Products
 - E8** 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
 - E88** Practice for Sampling Nonferrous Metals and Alloys in Cast Form for Determination of Chemical Composition
 - E527** Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)
 - E536** Test Methods for Chemical Analysis of Zinc and Zinc Alloys
 - E634** Practice for Sampling of Zinc and Zinc Alloys by Spark Atomic Emission Spectrometry
- 2.3 *North American Die Casting Association (NADCA):³*
NADCA Product Specification Standards for Die Castings

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 Available from North American Die Casting, Assn., 2000 5th Ave., River Grove, IL 60171, http://www.diecasting.org.

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

TABLE 1 Chemical Requirements

Element	Alloy 3 ^{A,B,C,D} Zamak 3 (AG40A) (Z33525)	Alloy 7 ^{A,B,C,D,E} Zamak 7 (AG40B) (Z33527)	Alloy 5 ^{A,B,C,D} Zamak 5 (AC41A) (Z35533)	Alloy 2 ^{A,C,D} Zamak 2 (AC43A) (Z35545)	ZA-8 ^{A,C,F} ZA-8 (Z35638)	ZA-12 ^{A,C,F} ZA-12 (Z35633)	ZA-27 ^{A,C,F} ZA-27 (Z35841)
Aluminum	3.7-4.3	3.7-4.3	3.7-4.3	3.7-4.3	8.0-8.8	10.5-11.5	25.0-28.0
Magnesium	0.02-0.06 ^G	0.005-0.020	0.02-0.06 ^G	0.02-0.06	0.01-0.03	0.01-0.03	0.01-0.02
Copper	0.1 max ^H	0.1 max ^E	0.7-1.2	2.6-3.3	0.8-1.3	0.5-1.2	2.0-2.5
Iron, max	0.05	0.05	0.05	0.05	0.075	0.075	0.075
Lead, max	0.005	0.003	0.005	0.005	0.006	0.006	0.006
Cadmium, max	0.004	0.002	0.004	0.004	0.006	0.006	0.006
Tin, max	0.002	0.001	0.002	0.002	0.003	0.003	0.003
Nickel	...	0.005-0.020
Zinc ^I	remainder	remainder	remainder	remainder	remainder	remainder	remainder

^A For purposes of acceptance and rejection, the observed value or calculated value obtained from analysis should 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 procedure prescribed in Practice E29.

^B Zinc alloy castings may contain nickel, chromium, silicon, and manganese in amounts of 0.02, 0.02, 0.035, and 0.06 %, respectively. No harmful effects have ever been noted due to the presence of these elements in these concentrations and, therefore, analyses are not required for these elements, with the exception of nickel analysis for Z33527.

^C ASTM alloy designations were established in accordance with Practice B275. The UNS designations were established in accordance with Practice E527. The last digit of a UNS number differentiates between alloys of similar composition. The UNS designations for ingot and casting versions of an alloy were not assigned in the same sequence for all alloys.

^D When this material is required to conform to ISO 301, the chemical limits for thallium and indium each shall not exceed 0.001 %.

^E For the majority of commercial applications, a copper content up to 0.25 % will not adversely affect the serviceability of these die castings and should not serve as a basis for rejection, unless otherwise specified in the contract or purchase order between the producer and user.

^F Zinc-aluminum ingot for foundry and pressure die casting may contain chrome, manganese, or nickel in amounts of up to 0.01 % each or 0.03 % total. No harmful effects have ever been noted due to the presence of these elements in up to these concentrations and, therefore, analyses are not required for these elements.

^G Magnesium may be as low as 0.015 % provided that the lead, cadmium, and tin do not exceed 0.003, 0.003, and 0.001 %, respectively.

^H For the majority of commercial applications, a copper content of up to 0.7 % will not adversely affect the serviceability of die castings and should not serve as a basis for rejection, unless otherwise specified in the contract or purchase order between the producer and user, such as to meet the requirements of ISO 15201.

^I Determined arithmetically by difference.

2.4 Federal Standard:⁴

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

2.5 Military Standard:⁴

MIL-STD-129 Marking for Shipment and Storage (Military Agencies)

2.6 Military Specification:⁴

MIL-P-116 Methods of Preservation

2.7 ISO Standards:⁵

ISO 301 Zinc Alloy Ingots Intended for Casting

ISO 15201 Zinc and Zinc alloys—Castings—Specifications

ISO 3815-1 Zinc and zinc alloys—Part 1: Analysis of solid samples by optical emission spectrometry

ISO 3815-2 Zinc and zinc alloys—Part 2: Analysis by inductively coupled plasma optical emission spectrometry

3. Terminology

3.1 Terms shall be defined in accordance with Terminology B899.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *continuous casting, n*—a casting technique in which a cast is continuously withdrawn through the bottom of the mold as it solidifies, so that its length is not determined by mold dimensions; used chiefly to produce semifinished mill products such as billets, blooms, ingots, slabs, and tubes; also known as concast.

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 American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

3.2.2 *die casting, n*—a casting process in which molten metal is injected under high velocity and pressure into a metal die and solidified, also a product produced by such a process. Alternately known as pressure die casting.

3.2.3 *foundry casting, n*—metal object produced by introducing molten metal by gravity into a mold of any type and allowing it to solidify.

3.2.4 *permanent mold casting, n*—metal object produced by introducing molten metal by gravity or low pressure into a mold constructed of durable material, usually iron or steel, and allowing it to solidify. When a graphite mold is used the process is known as *graphite permanent mold casting*.

3.2.5 *sand casting, n*—metal object produced by introducing molten metal by gravity into a sand mold and allowing it to solidify.

3.2.6 *semipermanent mold casting, n*—permanent mold casting which is made using an expendable core such as sand.

4. Ordering Information

4.1 Orders for die castings shall include the following basic information in addition to the requirements listed in Specification B949:

4.1.1 Alloy (Table 1), and

4.1.2 Drawing of casting, when required, giving all necessary dimensions and showing latest revisions and allowances for matching, if any. Location of ejector pin marks or parting lines shall be at the option of the producer, unless specifically designated on the drawing.

4.2 Additional tests, options, and special inspection requirements as provided as follows 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.

4.2.1 Chemical analysis (6.1.1),

4.2.2 Quality assurance (Section 15),

4.2.3 Special proof tests or mechanical properties (Section 7),

4.2.4 General quality options for internal soundness or for finish (Section 14),

4.2.5 Source inspection (Section 9),

4.2.6 Certification (Section 11),

4.2.7 Marking for identification (Section 12), and

4.2.8 Special packaging (Section 13).

5. Material

5.1 The metal used in the manufacture of die castings shall be zinc alloy of a specified chemical composition conforming to the requirements of Specification B240.

6. Chemical Requirements

6.1 *Limits*—The casting shall conform to the requirements as to chemical composition prescribed in Table 1. Conformance shall be determined by the producer by analyzing samples taken at the time that castings are made. If the producer has determined the chemical composition of the metal during the course of manufacture, he shall not be required to sample and analyze the finished product.

NOTE 1—The chemical compositions prescribed in Table 1 (not including the footnotes) for Alloys 3, 5, 2, ZA-8, ZA-12, and ZA-27 conform to the prescribed chemical compositions in ISO 15201.

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

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

6.2 *Number of Samples*—When required, samples for determination of chemical composition shall be taken to represent the following:

6.2.1 A sample shall be taken from each of two representative castings selected from each lot defined in 15.2.

6.3 *Methods of Sampling*—See appropriate sections within Section 6 of Specification B949 for methods of sampling.

6.4 *Method of Analysis*—The determination of chemical composition shall be made in accordance with suitable analytical methods. In case of dispute, the results secured by an approved method (or combination of approved methods), or by a method agreed upon by both parties, shall be the basis of acceptance.

6.4.1 Approved methods include: Test Methods E536, ISO 3815-1, or ISO 3815-2.

NOTE 2—Test Methods E536 is directly applicable, in an unmodified form, only to alloys 3, 5, and 7. ISO 3815-1 and ISO 3815-2 are generic methods applied to zinc and zinc alloys. Each of the methods may be modified and formatted for the alloy to be assayed. An experienced chemist, using suitable and/or traceable standards along with valid quality assurance techniques, will be able to perform and validate the methods and demonstrate acceptable precision and accuracy.

7. Physical Properties, Mechanical Properties and Tests

7.1 Unless specified in the contract or purchase order, or specified on the detail drawing, acceptance of castings under this specification shall not depend on mechanical properties determined by tension or impact tests.

7.1.1 Appendix X2 shows typical mechanical properties, determined on separately cast test bars produced under carefully controlled conditions.

7.1.2 While these typical mechanical properties of separately cast test bars are useful for comparing the relative properties of various casting alloys, they should not be used to establish design limits or acceptance criteria.

7.1.3 If tension or impact tests are made on separately cast test bars, test specimens conforming to the dimensions shown in Test Methods B557 (the figure entitled, Standard Tension Test Specimen for Die Castings), Test Methods E8, (the figure entitled Standard Test Specimen for Cast Iron), and of Test Methods E23 (the figure entitled, Charpy (Simple-Beam) Impact Test Specimens, Types A, B, and C) shall be used, and process operating variables shall be optimized for the specific mold or die being used.

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

7.2 Appendix X3 shows typical physical properties of zinc and zinc-aluminum (ZA) casting alloys and does not constitute a part of this specification but is provided for informational purposes only.

8. Dimensions, Mass, and Permissible Variations

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

8.1.1 For die castings, any dimensions for which a tolerance is not specified shall be in accordance with NADCA Product Specification Standards for Die Castings.

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

9. Source Inspection

9.1 See Section 9 of Specification B949.

10. Rejection and Rehearing

10.1 See Specification B949, Sections 8.1 through 8.3.

11. Certification

11.1 See Specification B949, Section 9.

12. Identification Marking

12.1 When specified in the contract or purchase order, or in the detail drawing, all castings shall be properly marked for identification with the part number and name or brand of the producer as specified.

13. Preparation for Delivery

13.1 *Packaging*—Unless otherwise specified, the castings shall be packaged to provide adequate protection during

normal handling and transportation. Each package shall contain only one type item unless otherwise agreed upon. The type of packaging and gross weight of containers shall, unless otherwise agreed upon, be at the producer's discretion, provided they are such as to ensure acceptance by common or other carriers for safe transportation at the lowest rate to the delivery point.

13.2 *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 for civil agencies and MIL-STD-129 for military agencies.

13.3 *Preservation*—Material intended for prolonged storage in unheated locations shall be adequately packed and protected to avoid deterioration and damage. When specified in the contract or purchase order, material shall be preserved, packaged, and packed in accordance with the requirements for MIL-P-116. The applicable levels shall be as specified in the contract or order.

14. General Quality

14.1 *Internal Soundness*—When specified, the soundness of 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, photographs, or sectioned castings.

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

14.3 *Workmanship*—Castings shall be of uniform quality and free of injurious discontinuities that will adversely affect their serviceability.

14.4 *Finish*—When specified in the contract or purchase order for die castings, 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.

14.5 *Pressure Tightness*—When specified in the contract or purchase order, the pressure tightness of die castings shall

conform to standards agreed upon between the purchaser and the producer or supplier, or as specified in NADCA Product Specification Standards for Die Castings.

15. Quality Assurance

15.1 *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.

15.2 For normal inspection purposes, an inspection lot shall consist of production from each mold or die during a single production run, as defined and recorded by the producer, and shipped, or available for shipment, at one time.

15.3 The producer or supplier shall examine each casting of a randomly or statistically selected sample to determine conformance to the requirements with respect to general quality and specific requirements of the contract, purchase order, or part drawing. The results of this inspection shall be recorded.

15.4 Unless otherwise specified in the contract, purchase order, or part drawing, detailed dimensional conformance shall normally be determined on one or more preproduction samples.

15.5 When specified in the contract, purchase order, or part drawing, special inspection lot definitions may be established, for a specific part.

16. Keywords

16.1 bar stock; castings; concast; continuous cast bar stock; die castings; foundry castings; permanent mold castings; pressure die castings; prototyping; sand castings; ZA alloys; Zamak; zinc; zinc-aluminum alloys; zinc metal

APPENDIXES

(Nonmandatory Information)

X1. NOMENCLATURE SYSTEMS FOR ZINC AND ZINC-ALUMINUM (ZA) ALLOYS

X1.1 The information in this appendix does not constitute a part of this specification but is provided for informational purposes only. The nomenclature covers commercial zinc and zinc-aluminum (ZA) alloys in ingot form for remelting for the manufacture of pressure die castings and foundry castings, as designated and specified in [Table 1](#).

X1.2 Several different systems of nomenclature have evolved over the years to designate the zinc alloys used for

casting, as listed in [Table X1.1](#).

X1.2.1 Common names refer to the long established zinc casting alloys by number based on their sequential development preceded by the word Alloy. Zinc-aluminum alloys (with a higher aluminum content than the conventional zinc die casting alloys) use the prefix ZA followed by their approximate aluminum content. These terms are in common usage.

TABLE X1.1 Nomenclature Systems for Zinc and Zinc-Aluminum (ZA) Alloys

Common	Traditional	ASTM	UNS
Alloy 3	Zamak 3	AG 40A	Z33525
Alloy 7	Zamak 7	AG 40B	Z33527
Alloy 5	Zamak 5	AC 41A	Z35533
Alloy 2	Zamak 2	AC 43A	Z35545
ZA-8	ZA-8	...	Z35638
ZA-12	ZA-12	...	Z35633
ZA-27	ZA-27	...	Z35841

X1.2.2 Traditional names for the long established zinc casting alloys use the prefix ZAMAK which was devised based on the major elements present: zinc, aluminum, magnesium and kopper (copper). Zinc-aluminum alloys use the prefix ZA followed by their approximate aluminum content. These terms are in common usage.

X1.2.3 ASTM designations are established in Practice **B275** based on alloy chemistry. The first letter, A, refers to the principal alloying element, aluminum. The second letter, G (magnesium) or C (copper), refers to the second most signifi-

cant alloying element. The first number, 4, refers to the nominal aluminum content. The second number refers to the nominal content of the second most significant alloying element. The last letter, A or B, differentiates between alloys of similar composition. Prior to the adoption of this designation system by ASTM, alloys were identified by Roman numerals, for example, XXI, XXIII and XV designated AC43A, AG40A and AC41A, respectively.

X1.2.4 UNS numbers are established in Practice **E527** (SAE J1086) as part of a Unified Numbering System to provide a unique designation for each metal grade and alloy in use worldwide. Zinc alloys start with the prefix “Z” followed by five numbers. The first digit is based on the major alloying element, the second digit provides a further sub-classification based on secondary and tertiary alloying elements, the third digit designates the nominal composition of the major alloying element, the fourth digit designates the nominal concentration of the second most important alloying element, and the fifth digit allows a unique number to be established to differentiate between similar compositions.

X2. TYPICAL MECHANICAL PROPERTIES OF ZINC AND ZINC-ALUMINUM ALLOY TEST SPECIMENS

X2.1 The data in **Table X2.1** do not constitute a part of this specification. However, they will indicate to the purchaser the mechanical properties that may be expected of test specifications made under best known conditions from remelted alloy ingot as provided in this specification.

X2.2 It is not considered good engineering practice to specify mechanical property values for tension or impact specimens cut from castings, and the values in **Table X2.1** do not represent the properties of specimens cut from castings. See **7.1.4** for proof tests.

TABLE X2.1 Typical Mechanical Properties of Zinc and Zinc-Aluminum Alloy Test Specimens

		Z33525 Alloy 3 AG40A Zamak 3	Z33527 Alloy 7 AG40B Zamak 7	Z35533 Alloy 5 AC41A Zamak 5	Z35545 Alloy 2 AC43A Zamak 2	Z35638 ZA-8			Z35633 ZA-12			Z35841 ZA-27		
						Sand Cast	Perm Mold	Die Cast	Sand Cast	Perm Mold	Die Cast	Sand Cast	Sand Cast Ht ^A	Die Cast
Ultimate tensile strength	psi × 10 ³ MPa	41 283	41 283	48 328	52 359	38 263	32-37 221-255	54 374	40-46 276-317	45-50 310-345	58 404	58-64 400-441	45-47 310-324	61 425
Tensile yield strength ^B	psi × 10 ³ MPa	32 221	32 221	33 228		29 198	30 208	42 290	31 211	39 268	46 320	54 371	37 257	55 376
Compressive yield strength ^C	psi × 10 ³ MPa	60 414	60 414	87 600	93 641	29 199	31 210	37 252	33 230	34 235	39 269	48 330	37 257	52 385
Elongation % in. 2 in. (51 mm)		10	13	7	7	1-2	1-2	6-10	1-3	1-3	4-7	3-6	8-11	1-3
Shear strength	psi × 10 ³ MPa	31 214	31 214	38 262	46 317		35 241	40 275	37 253	≥35 241	43 296	42 292	33 225	47 325
Hardness Brinell ^D		82	80	91	100	85	87	103	94	89	100	113	94	119
Impact strength	ft-lbf J	43 ^E 58	43 ^E 58	48 ^E 65	35 ^E 47	15 ^F 20		31 ^E 42	19 ^F 25	21 ^F 29		35 ^E 48	43 ^E 58	9.4 ^F 12.8
Fatigue strength ^G	psi × 10 ³ MPa	6.9 47.6	6.8 46.9	8.2 56.5	8.5 58.6		7.5 51.7	15 103	15 103		17 117	25 172	15 103	21 145
Young's Modulus	psi × 10 ⁶ MPa × 10 ³	≥12.4 ≥85.5	≥12.4 ≥85.5	≥12.4 ≥85.5	≥12.4 ≥85.5	12.4 85.5	12.4 85.5	12.4 85.5	12.0 82.7	12.0 82.7	12.0 82.7	11.3 77.9	11.3 77.9	11.3 77.9
Torsional Modulus	psi × 10 ⁶ MPa × 10 ³	≥4.8 ≥33.1	≥4.8 ≥33.1	≥4.8 ≥33.1	≥4.8 ≥33.1	≥4.8 ≥33.1	≥4.8 ≥33.1	≥4.8 ≥33.1	≥4.6 ≥31.7	≥4.6 ≥31.7	≥4.6 ≥31.7	≥4.3 ≥29.6	≥4.3 ≥29.6	≥4.3 ≥29.6

^A 3 h at 610°F (320°C) and furnace-cooled.

^B 0.2 % offset.

^C 0.1 % offset.

^D 500-kg load, 10-mm ball.

^E ¼ in. unnotched Charpy.

^F 10-mm unnotched Charpy.

^G Rotary bend 5 × 10⁸ cycles.

X3. PHYSICAL PROPERTIES OF ZINC AND ZINC-ALUMINUM (ZA) ALLOY

X3.1 The physical property data given in [Table X3.1](#) do not constitute a part of this specification. Properties are given for informational purposes only.

TABLE X3.1 Physical Properties of Zinc and Zinc-Aluminum (ZA) Alloy

		Z33525 Alloy 3 (AG40A) Zamak 3	Z33527 Alloy 7 (AG40B) Zamak 7	Z35533 Alloy 5 (AC41A) Zamak 5	Z35545 Alloy 2 (AC43A) Zamak 2	Z35638 ZA-8	Z35633 ZA-12	Z35841 ZA-27
Density	lb/in. ³	0.24	0.24	0.24	0.24	0.227	0.218	0.181
	g/cm ³	6.60	6.60	6.60	6.60	6.3	6.03	5.00
Melting Range	°F	718-728	718-728	717-727	715-734	707-759	710-810	708-903
	°C	381-387	381-387	380-386	379-390	375-404	377-432	375-487
Specific heat	BTU/lb °F	0.10	0.10	0.10	0.10	0.104	0.107	0.125
	J/kg · K	419	419	419	419	435	450	525
Coefficient of thermal expansion	μin./in./°F	15.2	15.2	15.2	15.4	12.9	13.4	14.4
	μm/m/°C	27.4	27.4	27.4	27.7	23.3	24.2	26.0
Thermal conductivity	BTU · ft/h · ft ² · °F	65.3	65.3	62.9	60.5	66.3	67.1	72.5
	W/m · K	113.0	113.0	108.9	104.7	114.7	116.1	125.5
Electrical conductivity	% IACS	27	27	26	25	27.7	28.3	29.7
Electrical resistivity	μΩ in. at 68°F	2.5	2.5	2.6	2.7	2.4	2.4	2.3
	μΩ CM at 20°C	6.4	6.4	6.5	6.9	6.2	6.1	5.8
Solidification shrinkage %		1.17	1.17	1.17	1.25	1.1	1.3	1.3
Pattern makers ^A shrinkage	in./ft					1/8	5/32	5/32
	mm/m					10.4	13.0	13.0
Die makers ^B shrinkage	in./in. mm/mm	0.007	0.007	0.007	0.007	0.007	0.0075	0.008

^A Sand cast and permanent mold.

^B Die cast.

X4. METRIC EQUIVALENTS

X4.1 The SI unit for strength properties (MPa) is in accordance with the International System of Units (SI). The derived SI unit for force is the newton (N), which defined as that force which when applied to a body having a mass of 1 kg gives it an acceleration of 1 m/s² (N = kg·m/s²). The derived SI unit for

pressure or stress is the newton per square metre (N/m²), 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/m² and N/mm².

SUMMARY OF CHANGES

Committee B02 has identified the location of selected changes to this standard since the last issue (B86 - 11) that may impact the use of this standard. (Approved February 1, 2013.)

(1) UNS numbers were added.

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