



Designation: B 80 – 01<sup>e1</sup>

## Standard Specification for Magnesium-Alloy Sand Castings<sup>1</sup>

This standard is issued under the fixed designation B 80; 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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

*This standard has been approved for use by agencies of the Department of Defense.*

<sup>e1</sup> NOTE—Changes were made to Table 1 editorially November 2002.

### 1. Scope

1.1 This specification covers magnesium-alloy sand castings designated as shown in **Table 1**.

1.2 The values stated in inch-pound units are to be regarded as the standard. The SI values in parentheses are provided for information only.

### 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:

**B 93/B93M** Specification for Magnesium Alloys in Ingot Form for Sand Castings, Permanent Mold Castings, and Die Castings<sup>2</sup>

**B 275** Practice for Codification of Certain Nonferrous Metals and Alloys, Cast and Wrought<sup>2</sup>

**B 296** Practice for Temper Designations of Magnesium Alloys, Cast and Wrought<sup>2</sup>

**B 557** Test Methods of Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products<sup>2</sup>

**B 660** Practices for Packaging/Packing of Aluminum and Magnesium Products<sup>2</sup>

**B 661** Practice for Heat Treatment of Magnesium Alloys<sup>2</sup>

**E 29** Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications<sup>3</sup>

**E 35** Test Methods for Chemical Analysis of Magnesium and Magnesium Alloys<sup>4</sup>

**E 88** Practice for Sampling Nonferrous Metals and Alloys in Cast Form for Determination of Chemical Composition<sup>4</sup>

**E 94** Guide for Radiographic Testing<sup>5</sup>

**E 155** Reference Radiographs for Inspection of Aluminum

and Magnesium Castings<sup>5</sup>

**E 165** Test Method for Liquid Penetrant Examination Method<sup>5</sup>

**E 527** Practice for Numbering Metals and Alloys (UNS)<sup>6</sup>

**E 716** Practices for Sampling Aluminum and Aluminum Alloys for Spectrochemical Analysis<sup>7</sup>

#### 2.3 Federal Standards:

**Fed. Std. No. 123** Marking for Shipment (Civil Agencies)<sup>8</sup>  
**Fed. Std. No. 184** Identification Marking of Aluminum, Magnesium and Titanium<sup>8</sup>

#### 2.4 Military Standards:

**MIL-STD-129** Marking for Shipment and Storage (Military Agencies)<sup>8</sup>

**MIL-STD-276** Impregnation of Porous Non-ferrous Metal Castings<sup>8</sup>

**MIL-I-13857** Impregnation of Metal Castings<sup>8</sup>

**MIL-M-46062** Magnesium Alloy Castings, High Strength<sup>8</sup>

**MIL-M-6857** Heat Treatment of Magnesium Alloy Castings<sup>8</sup>

#### 2.5 ANSI Standard:<sup>9</sup>

**ANSI Z1.4** Sampling Procedures and Tables for Inspection by Attributes

### 3. Terminology

#### 3.1 Definitions:

3.1.1 *casting lot*—unless otherwise agreed, shall consist of not more than 1000 pounds of cleaned castings from the same melt or heat, except where this weight limit may be exceeded by a single casting. In such cases, each casting shall be considered a lot.

3.1.2 *heat treat lot*—for the purpose of mechanical property testing, a lot shall consist of all castings heat treated in the same furnace charge to the same temper.

3.1.3 *sand casting*—metal object produced by pouring molten metal into a sand mold and allowing it to solidify.

<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 B07.04 on Magnesium Alloy Cast and Wrought Products.

Current edition approved Apr. 10, 2001. Published May 2001. Originally published as B 80 – 30 T. Last previous edition B 80 – 97.

<sup>2</sup> *Annual Book of ASTM Standards*, Vol 02.02.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 14.02.

<sup>4</sup> *Annual Book of ASTM Standards*, Vol 03.05.

<sup>5</sup> *Annual Book of ASTM Standards*, Vol 03.03.

<sup>6</sup> *Annual Book of ASTM Standards*, Vol 01.01.

<sup>7</sup> *Annual Book of ASTM Standards*, Vol 03.06.

<sup>8</sup> Available from Standardization Documents, Order Desk, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, ATTN: NPODS.

<sup>9</sup> Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

**TABLE 1 Chemical Requirements<sup>A</sup>**

NOTE 1—Analysis shall regularly be made only for the elements specifically mentioned in this table. If, however, the presence of other elements is suspected or indicated in amounts greater than the specified limits, further analysis shall be made to determine that these elements are not present in excess of the specified limits.

NOTE 2—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 shall be rounded to the nearest unit in the last right-hand place of figures used in expressing the specified limit.

Alloy Number <sup>B</sup>		Composition %												
ASTM	UNS	Iron	Magne- sium	Alu- minum	Man- gane- se	Zinc	Yttrium <sup>C †</sup>	Rare Earths	Zirconium	Silicon	Copper	Nickel	Others (Metallic Impurities Each)	Total <sup>D</sup> Impu- rities
AM100A	M10100	...	remainder	9.3–10.7	0.10–0.35	0.30	...	...	...	0.30	0.10	0.01	...	0.30
AZ63A	M11630	...	remainder	5.3–6.7	0.15–0.35	2.5–3.5	...	...	...	0.30	0.25	0.01	...	0.30
AZ81A	M11810	...	remainder	7.0–8.1	0.13–0.35	0.40–1.0	...	...	...	0.30	0.10	0.01	...	0.30
AZ91C	M11914	...	remainder	8.1–9.3	0.13–0.35	0.40–1.0	...	...	...	0.30	0.10	0.01	...	0.30
AZ91E	M11919	0.005 <sup>E</sup>	remainder	8.1–9.3	0.17–0.35	0.40–1.0	...	...	...	0.20	0.015	0.0010	0.01	0.30
AZ92A	M11920	...	remainder	8.3–9.7	0.10–0.35	1.6–2.4	...	...	...	0.30	0.25	0.01	...	0.30
EQ21A <sup>F</sup>	M18330	...	remainder	...	...	...	...	1.5–3.0 <sup>G</sup>	0.40–1.0	...	0.05–0.10	0.01	...	0.30
EZ33A	M12330	...	remainder	...	...	2.0–3.1	...	2.5–4.0	0.50–1.0	...	0.10	0.01	...	0.30
K1A	M18010	...	remainder	...	...	...	...	...	0.40–1.0	...	...	...	...	0.30
QE22A <sup>H</sup>	M18220 <sup>H</sup>	...	remainder	...	...	...	...	1.8–2.5 <sup>G</sup>	0.40–1.0	...	0.10	0.01	...	0.30
WE43A	M18430	0.01	remainder	...	0.15	0.20	3.7–4.3	2.4–4.4 <sup>I</sup>	0.40–1.0	0.01	0.03	0.005	0.2	...
WE43B	M18432	0.010	remainder	...	0.03	0.20 <sup>J</sup>	3.7–4.3	2.4–4.4 <sup>I</sup>	0.40–1.0	...	0.02	0.005	0.01 <sup>K</sup>	...
WE54A	M18410	...	remainder	...	0.03	0.20	4.75–5.5	1.5–4.0 <sup>I</sup>	0.40–1.0	0.01	0.03	0.005	0.20	...
ZC63A	M16331	...	remainder	...	0.25–0.75	5.5–6.5	...	...	...	0.20	2.4–3.0	0.01	...	0.30
ZE41A	M16410	...	remainder	...	0.15	3.5–5.0	...	0.75–1.75	0.40–1.0	...	0.10	0.01	...	0.30
ZE63A	M16630	...	remainder	...	...	5.5–6.0	...	2.1–3.0	0.40–1.0	...	0.10	0.01	...	0.30
ZK51A	M16510	...	remainder	...	...	3.6–5.5	...	...	0.50–1.0	...	0.10	0.01	...	0.30
ZK61A	M16610	...	remainder	...	...	5.5–6.5	...	...	0.6–1.0	...	0.10	0.01	...	0.30

<sup>A</sup>Limits are in weight % max unless shown as a range or stated otherwise.

<sup>B</sup>ASTM alloy designations were established in accordance with Practice B 275. UNS designations were established in accordance with Practice E 527.

<sup>C †</sup>Editorially corrected.

<sup>D</sup>Includes listed elements for when no specific limit is shown.

<sup>E</sup>If iron exceeds 0.005 %, the iron to manganese ratio shall not exceed 0.032.

<sup>F</sup>Silver content for alloy EQ21A shall be 1.3 to 1.7 %.

<sup>G</sup>Rare earth elements are in the form of didymium, with not less than 70 % neodymium, and the remainder substantially praeosodymium.

<sup>H</sup>Silver content for alloy QE22A shall be 2.0 to 3.0 %.

<sup>I</sup>Rare earths are 2.0 to 2.5, 2.0 to 2.5, and 1.5 to 2.0 % Neodymium for WE43A, WE43B, and WE54A, respectively, the remainder being principally<sup>C †</sup> heavy rare earths.

<sup>J</sup>Zinc + Silver shall not exceed this value.

<sup>K</sup>Lithium shall not exceed 0.2 %.

## 4. Ordering Information

4.1 Orders for castings under this specification shall include the following information:

- 4.1.1 Applicable drawing or part number,
- 4.1.2 Quantity of each casting,
- 4.1.3 Specification number and title,
- 4.1.4 Alloy (Section 9 and Table 1),
- 4.1.5 Temper (Section 11, Table 2 and X1.2),
- 4.1.6 Whether foundry control is required (Section 8),
- 4.1.7 Whether test specimens cut from castings are required in addition to, or instead of, separately cast test specimens (Section 12 and Table X1.2),
- 4.1.8 Whether liquid penetrant inspection is required (15.2),
- 4.1.9 Whether radiographic inspection is required (15.3),
- 4.1.10 Whether pressure testing is required (15.4),
- 4.1.11 Whether source inspection is required (Section 17),
- 4.1.12 Whether repairs are permissible (Section 19),
- 4.1.13 Whether chemical analysis and mechanical property reports or certifications, or both, are required (Section 20),
- 4.1.14 Whether special packaging is required for shipment (Section 22).

## 5. Responsibility for Quality Assurance

5.1 *Responsibility for Inspection*—Unless otherwise specified in the contract or purchase order, the supplier is respon-

sible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the purchaser. The purchaser reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

## 6. Material Requirements

6.1 Unless otherwise specified, only magnesium alloy ingots or producer's foundry scrap conforming to Specification B 93 shall be used for pouring castings. Additions of small amounts of grain refining elements and material for melt process losses are permitted.

6.2 Pure materials and master alloys may be used provided chemical analysis verifying conformance to Table 1 is done prior to pouring any castings.

## 7. Manufacture

7.1 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 supplier, except when pattern

**TABLE 2 Tensile Requirements**

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

Alloy Number		Temper <sup>A</sup>	Tensile Strength, min, ksi (MPa)	Yield Strength <sup>B</sup> (0.2 % offset), min, ksi (MPa)	Elongation in 2 in., (50.8 mm) min, %
ASTM	UNS				
AM100A	M10100	T6	35.0(241)	17.0(117)	<sup>C</sup>
AZ63A	M11630	F	26.0(179)	11.0(76)	4
		T4	34.0(234)	11.0(76)	7
		T5	26.0(179)	12.0(83)	2
		T6	34.0(234)	16.0(110)	3
AZ81A	M11810	T4	34.0(234)	11.0(76)	7
AZ91C	M11914	F	23.0(158)	11.0(76)	<sup>C</sup>
		T4	34.0(234)	11.0(76)	7
		T5	23.0(158)	12.0(83)	2
		T6	34.0(234)	16.0(110)	3
AZ91E	M11919	T6	34.0(234)	16.0(110)	3
AZ92A	M11920	F	23.0(158)	11.0(76)	<sup>C</sup>
		T4	34.0(234)	11.0(76)	6
		T5	23.0(158)	12.0(83)	<sup>C</sup>
		T6	34.0(234)	18.0(124)	1
EQ21A	M18330	T6	34.0(234)	25.0(172)	2
EZ33A	M12330	T5	20.0(138)	14.0(96)	2
K1A	M18010	F	24.0(165)	6.0(41)	14
QE22A	M18220	T6	35.0(241)	25.0(172)	2
WE43A	M18430	T6	32.0(221)	25.0(172)	2
WE43B	M18432	T6	32.0(221)	25.0(172)	2
WE54A	M18410	T6	37.0(255)	26.0(179)	2
ZC63A	M16331	T6	28.0(193)	18.0(125)	2
ZE41A	M16410	T5	29.0(200)	19.5(133)	2.5
ZE63A	M16630	T6	40.0(276)	27.0(186)	5
ZK51A	M16510	T5	34.0(234)	20.0(138)	5
ZK61A	M16610	T6	40.0(276)	26.0(179)	5

<sup>A</sup>These temper designations were established in accordance with Practice B 296.

<sup>B</sup>See X1.4.1.

<sup>C</sup>Not required.

equipment is furnished by the purchaser. Sufficient stock shall be allowed for shrinkage, and where requested, for finishing; but castings of excessive weight shall not be furnished.

7.2 The castings may be subjected to such heat treatment as deemed necessary to produce material that will conform to the requirements specified. Heat treatment shall be performed on the whole of a casting, never on a part only, and shall be applied in a manner that will produce the utmost uniformity.

NOTE 1—Alloy ZE63A requires solution heat treatment in hydrogen as explained in X1.1.12.

## 8. Foundry Control

8.1 When specified, castings shall be produced under foundry control approved by the purchaser. Foundry control shall consist of examination of the 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 set by purchaser or agreed to 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  $\pm 50^{\circ}\text{F}$  from the established nominal temperature are permissible.

## 9. Chemical Composition Requirements

9.1 *Limits*—The castings shall conform to the chemical composition limits prescribed in Table 1. Conformance shall be determined by analyzing samples taken when the castings are poured, or by analyzing samples taken from the finished product. If the chemical composition has been determined during the course of manufacture, sampling and analysis of the finished product shall not be necessary.

## 10. Sampling for Chemical Composition

10.1 For determination of chemical composition, one sample of each casting lot shall be taken in accordance with Practice E 88 for chemical analysis or Practice E 716 for spectrochemical analysis.

10.1.1 Samples for other methods of chemical analysis shall be suitable for the form of material being analyzed and the type of analytical method used. In case of dispute, analyses should be made by methods given in Methods E 35.

## 11. Heat Treatment

11.1 Unless otherwise specified, heat treatment for the applicable tempers designated in Table 2 and X1.2 shall be in accordance with Military Specification MIL-M-6857 or Practice B 661. Heat treatment shall be performed on the whole casting and never on a portion.

11.2 Each heat treat furnace charge shall contain at least one set of test bars of the same composition range as the castings. The satisfactory heat treatment of the furnace charge shall be

determined by the results from these test bars, which must conform to the requirements of Table 2 or Table X1.2 where required.

12. Tensile Requirements Tensile Requirements

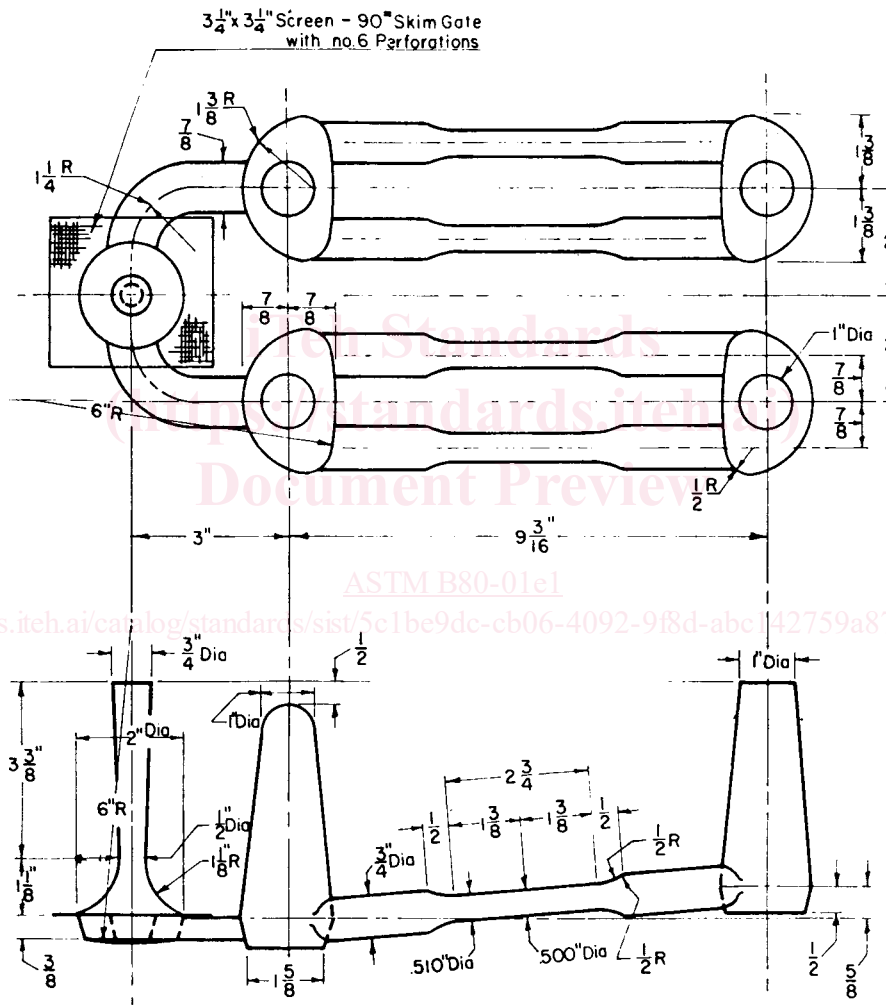
12.1 Limits—The tension test specimens representing the castings shall conform to the requirements of Table 2.

12.2 Number of Tests—At least one tension test specimen shall be tested from each casting lot, or fraction thereof, to represent the castings poured from the same melt. If the castings are to be heat treated, the specimens shall be heat treated with production castings of the same alloy and in the same temper as the specimens. The specimens shall then be

tested to judge the ability of their corresponding melts to respond to the type of heat treatment to which the specimens were subjected.

12.2.1 Test Specimens—The tension test specimens shall be separately cast in the system sand mix in use and shall be cast to size in accordance with the dimensions shown in Fig. 1 or Fig. 2.

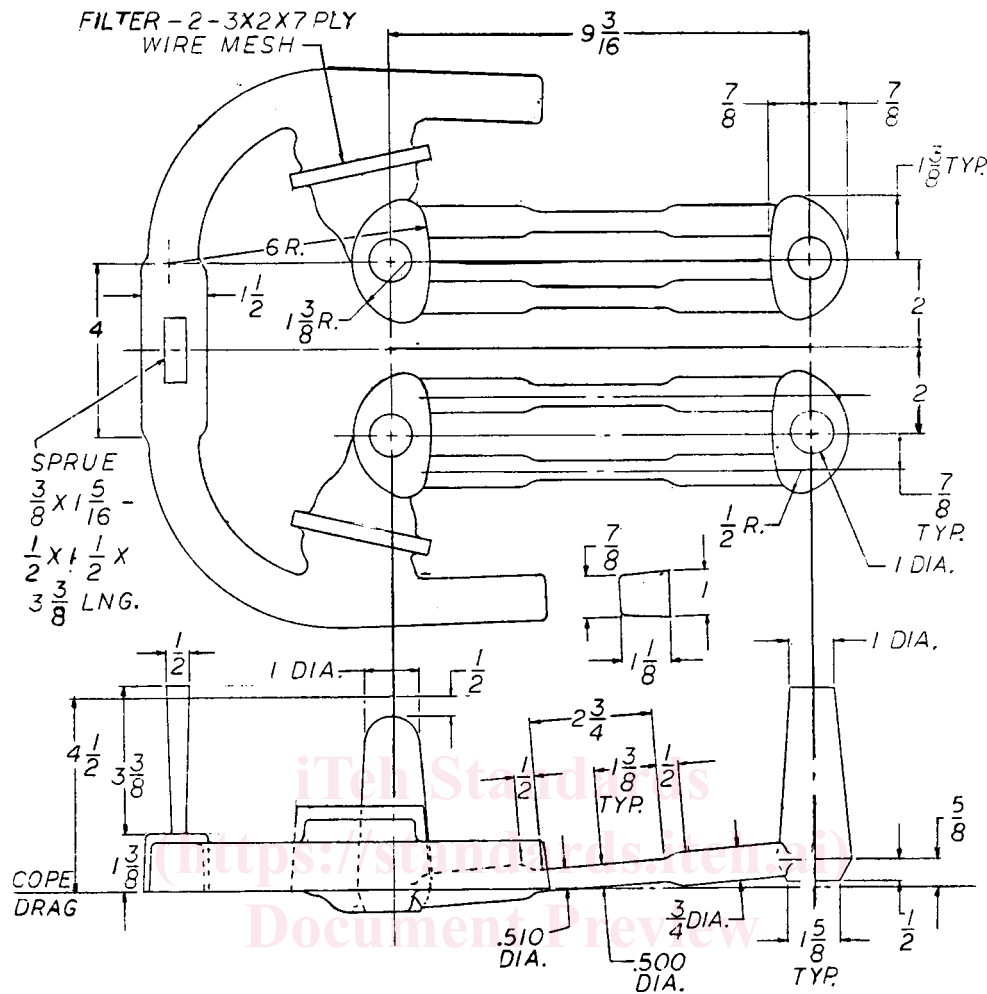
12.3 When specified, the tensile strength and yield strength values of specimens cut from castings shall conform to Table X1.2. Elongation values shall not be less than 25 % of the values specified in Table 2.



ASTM B80-01e1  
<https://standards.iteh.ai/catalog/standards/sist/5c1be9dc-cb06-4092-9f8d-abc142759a87/astm-b80-01e1>

		Metric Equivalents					
in.	mm	in.	mm	in.	mm	in.	mm
0.500	12.70	7/8	22.2	1 1/8	34.9	3	76.2
0.510	12.95	1	25.4	1 1/8	41.37	3 1/4	82.5
3/8	9.5	1 1/8	28.6	2	50.8	6	152.4
1/2	12.7	1 1/4	31.8	2 3/4	69.8	9 3/16	233.4
5/8	15.9						

FIG. 1 AFS Test Bar for Sand-Cast Magnesium Alloys



NOTE 1—This test bar mold is particularly suitable for those magnesium alloys containing Zr.

FIG. 2 Proposed Gating System for ASTM Magnesium Test Bars

<https://standards.iteh.ai/catalog/standards/sist/7c7b69dc-6800-4922-9188-abe142759a87/astm-b80-01e1>

12.3.1 When tensile properties of castings are to be determined, tension test specimens shall be cut from the locations designated on the drawing. If no locations are designated, specimens shall be taken from each test casting to include at least one from the thinnest and one from thickest section of the casting. At least three specimens are required.

12.3.2 The machined tension test specimen shall be the standard 0.500 in. diameter specimen or the largest smaller size specimen proportional to the standard specimen shown in Fig. 8 of Test Methods B 557.

12.3.3 Where a round specimen is not feasible a standard  $\frac{1}{2}$  in. wide rectangular specimen shown in Fig. 6 of Test Methods B 557 may be used, but in no case shall its area be less than that of the sub size  $\frac{1}{4}$  in. wide specimen.

12.4 If any tension test specimen is improperly machined or shows flaws upon testing, it may be discarded and another specimen for the same heat or melt used instead. If no additional specimen is available, the supplier and the purchaser shall agree on an alternative procedure.

12.5 *Test Methods*—The tension tests shall be made in accordance with Test Methods B 557.

12.6 *Mechanical properties at 400 to 500°F*—Alloys EQ21A, EZ33A, QE22A, WE54A, WE43A and WE43B shall

be capable of meeting the requirements shown in Table X1.2 when tested in the following manner. Tensile test specimens shall be heated to  $400 \text{ to } 500^\circ\text{F} \pm 5^\circ\text{F}$ , as applicable, held for 10 min before testing and loaded at this temperature at a rate of 0.005 in./in./min up to the yield strength, and at a rate of 0.10 in./in./min above the yield strength.

### 13. Special Test Methods

13.1 When the castings have critical functional requirements, special tests to simulate the stress conditions incurred in service may be requested. The requirements and methods of these tests shall be as agreed upon between the producer and the purchaser.

### 14. Finish

14.1 The finished castings shall be uniform in quality, free of injurious blowholes, porosity, shrinkage, cracks and other discontinuities except as designated and agreed upon as acceptable by the purchaser.

14.2 Unless otherwise specified, the castings shall be chrome-pickled prior to shipment (see X1.5).



## 15. Foundry Inspection

15.1 Requirements of surface finish parting lines, and removal of gates and risers may be checked visually. It is advisable to have mutually agreed upon observational standards to represent acceptable material.

### 15.2 Liquid Penetrant Inspection:

15.2.1 When specified liquid penetrant inspection shall be in accordance with Practice E 165, and the required sensitivity shall be specified.

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

### 15.3 Radiographic Inspection:

15.3.1 When specified, radiographic inspection shall be in accordance with Guide E 94 and Reference Radiographs E 155 to determine soundness. Areas of the casting subject to soundness requirements shall be specified by the purchaser. It is advisable to document an agreed upon radiographic technique including source parameters, film size, and orientation of the radiographs.

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

15.4 When specified, the castings shall be subject to hydrostatic or aerostatic pressure as required. Acceptance pressure and allowable leak rates shall be specified by the purchaser.

NOTE 2—**Warning:** Take appropriate safety precautions to protect inspectors prior to any pressure application.

## 16. Sampling for Foundry Inspection

16.1 For the purpose of visual and dimensional examination, casting lots may be combined up to a maximum of 5000 lbs. From this accumulated lot, a sample shall be selected at random in accordance with the tables of ANSI Z1.4 at inspection level II, with lot acceptance and rejection based on acceptable quality level (AQL) equal to 1.5 % defective. When the accumulation of lots is not practical, the sample shall be selected from each casting lot. Samples selected for dimensional examination may be the same as those selected for visual examination, but the determination of acceptance or rejection shall not be based on the cumulative sample for both characteristics.

16.2 For the purpose of liquid penetrant or radiographic inspection, a random sample of castings shall be selected from

each casting lot. The number of castings selected shall be in accordance with ANSI Z1.4 at inspection quality level II with lot acceptance and rejection based on AQL of 0.65 % defective.

16.3 Sampling for hydrostatic and aerostatic pressure tests shall be as specified by the purchaser.

16.4 Modifications of the above sampling plans must be agreed upon between the producer and the purchaser.

## 17. Source Inspection

17.1 If the purchaser desires that inspection be made at the supplier's works where the material is made, it shall be so stated in the contract or purchase order.

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

## 18. Rejection, Retest and Rehearing

18.1 Material failing to conform to the requirements of this specification, or in which defects are found during subsequent manufacturing operations, may be rejected. If rejected, the supplier shall be responsible only for replacement of the material to the purchaser. As much as possible of the rejected original material shall be returned to the supplier.

18.1.1 Any sample unit containing one or more characteristics which fail to meet any of the requirements of this standard shall be rejected. If the number of defective units in any sample exceeds the acceptance number specified for that sample size, the entire lot represented by the sample shall be rejected.

18.1.2 A rejected lot may be screened by 100 % inspection for the rejectable item and resubmitted for acceptance inspections. Any deviation from this procedure must be approved by the purchaser.

18.2 *Retests*—If the results of the tension tests of alloys in heat-treated tempers do not conform to the requirements prescribed in Table 2 or Table X1.2, the castings may be reheat treated but not more than twice. The results of acceptable tests shall conform to the requirements as to tensile properties specified in Table 2 or Table X1.2.

18.3 In the case of dissatisfaction regarding rejections, the producer may make a claim for rehearing as the basis for

**TABLE 3 Discontinuity-Level Requirements for Magnesium Sand Castings (Reference Radiographs E 155)**

Discontinuity	Grade A		Grade B		Grade C		Grade D	
	1/4	3/4	1/4	Section Thickness, in. 3/4	1/4	3/4	1/4	3/4
Gas holes	none		1	1	2	2	5	5
Microshrinkage (feathery)	none		1	1	2	2	4	3
Microshrinkage (sponge)	none		1	1	2	2	4	3
Foreign material (less dense)	none		1	1	2	2	4	4
Foreign material (more dense)	none		1	1	2	2	4	3
Cracks	none			none		none		none
Cold shuts	none			none		none		none
Surface irregularity				not to exceed drawing tolerance				
Core shift				not to exceed drawing tolerance				