

MIL-M-46062C
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SUPERSEDING
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MILITARY SPECIFICATION

MAGNESIUM ALLOY CASTINGS, HIGH STRENGTH

This specification is approved for use by the U.S. Army Materials Technology Laboratory, Department of the Army, and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers high strength magnesium alloy castings produced by any casting method.

1.2 Classification. The castings are classified as to alloy and temper as follows:

| <u>UNS No.</u> | <u>Alloy</u> |
|----------------|---|
| M10100 | AM100A-T6 (Permanent mold casting only) |
| M11914 | AZ91C-T6 |
| M11920 | AZ92A-T6 |
| M13310 | HK31A-T6 |
| M18220 | QE22A-T6 |
| M16410 | ZE41A-T5 |
| M16630 | ZE63A-T6 |
| M16620 | ZH62A-T5 |
| M16510 | ZK51A-T5 |
| M16610 | ZK61A-T6 |

2. APPLICABLE DOCUMENTS

2.1 Government documents.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Director, US Army Materials Technology Laboratory, ATTN: SLCMT-MSR-ES Watertown, MA 02172-0001 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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2.1.1 Specifications, standards, and handbooks. Unless otherwise specified, the following specifications, standards, and handbooks of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the solicitation form a part of this specification to the extent specified herein.

SPECIFICATIONS

MILITARY

MIL-M-6857 - Magnesium Alloy Castings, Heat Treatment of
 MIL-I-6866 - Inspection, Penetrant Method of

STANDARDS

FEDERAL

FED-STD-151 - Metals, Test Methods

MILITARY

MIL-STD-129 - Marking for Shipment and Storage
 MIL-STD-453 - Inspection, Radiographic
 MIL-STD-649 - Aluminum and Magnesium Products, Preparation for Shipment
 and Storage
 MIL-STD-2175 - Casting, Classification and Inspection of

(Copies of specifications, standards, handbooks, drawings, and publications required by manufacturers in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Other publications. The following document(s) form a part of this specification to the extent specified herein. The issues of the documents which are indicated as DoD adopted shall be the issue listed in the current DoDISS and the supplement thereto, if applicable.

American Society for Testing and Materials (ASTM) Standards:

E 8 - Tension Testing of Metallic Materials
 E 155 - Reference Radiographs for Inspection of Aluminum and Magnesium
 Castings

(Application for copies of ASTM publications should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.)

(Industry association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

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2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence.

3. REQUIREMENTS

3.1 Preproduction.

3.1.1 Sample castings. Unless otherwise specified in the invitation for bids, contract or order, prior to production, preproduction sample castings shall be furnished which will be poured from the metal representing the composition to be used in production. The number of sample castings and location at which inspection shall be performed shall be as specified by the procuring activity. The castings shall be representative of methods of molding, gating, risering, padding, chilling, pouring and heat treatment to be used in production castings. The preproduction samples shall be subject to any or all tests in this specification, as specified in the invitation for bids, contract or order and may be subject to sectioning by machining or sawing to determine soundness. No changes shall be made in the production of castings after acceptance of the preproduction samples without the approval of the procuring activity.

3.1.2 Foundry procedure. After acceptance of the sample castings, the producer shall prepare the foundry procedure upon a form approved by the procuring activity which covers the casting method for the accepted castings. This procedure should show the following as a minimum:

- (a) Drawings, sketches, or photographs showing gating and risering including size of gates, risers, runners and downsprues.
- (b) Drawings, sketches, or photographs showing location, size, and material of chills.
- (c) Type of mold and core material.
- (d) Pouring temperature range (Minimum and Maximum Ladle Temperatures).
- (e) Heat Treatment.

Copies of the procedure shall be the property of the producer and shall be retained by the producer, and may be reviewed at the producer's plant by the representative of the procuring activity.

3.1.3 Procedure changes Any change in foundry procedure, without written authority of the procuring activity to the contrary, shall require the resubmittal of sample castings for inspection. The written procedure shall be changed after acceptance of the resubmitted castings.

3.2 Chemical composition. The chemical composition of the castings shall meet the requirements for the specified alloy as shown in table I. A ladle analysis of each lot shall be furnished by the producer.

Table I - Chemical composition, percent

| Alloy | Magne- sium | Aluminum | Zinc | Mangan- ese, min. | Silicon, max. | Copper, max. | Nickel, max. | Rare earth | Zirconium | Thorium | Total other elements max. |
|---------------------|----------------|----------|-----------|-------------------------|------------------|-----------------|-----------------|-----------------------|-----------|---------|------------------------------------|
| AM100A | Rem. | 9.3-10.7 | 0.30 max. | 0.10 | 0.30 | 0.10 | 0.01 | -- | -- | -- | 0.30 |
| AZ910 | Rem. | 8.1-9.3 | .40-1.0 | .13 | .30 | .10 | .01 | -- | -- | -- | .30 |
| AZ92A | Rem. | 8.3-9.7 | 1.6-2.4 | .10 | .30 | .10 | .01 | -- | -- | -- | .30 |
| HK31A | Rem. | -- | 0.30 max. | -- | -- | .10 | .01 | -- | 0.50-1.0 | 2.5-4.0 | .30 |
| QE22A ^{1/} | Rem. | -- | 5.5-6.0 | -- | -- | .10 | .01 | 1.8-2.5 ^{2/} | .40-1.0 | -- | .30 |
| ZE41A | Rem. | -- | 3.5-5.0 | .15 | -- | .10 | .01 | 0.75-1.75 | .40-1.0 | -- | .30 |
| ZE63A | Rem. | -- | 5.5-6.0 | -- | -- | .10 | .01 | 2.0-3.0 ^{3/} | .40-1.0 | -- | .30 |
| ZH62A | Rem. | -- | 5.5-6.2 | -- | -- | .10 | .01 | -- | .50-1.0 | 1.4-2.2 | .30 |
| ZK51A | Rem. | -- | 3.6-5.5 | -- | -- | .10 | .01 | -- | .50-1.0 | -- | .30 |
| ZK61A | Rem. | -- | 5.5-6.5 | -- | -- | .10 | .01 | -- | .60-1.0 | -- | .30 |

^{1/}Silver in QE22A - 2.0-3.0 percent

^{2/}Rare earth in QE22A as didymium

^{3/}Rare earth in ZE63A as cerium mischmetal

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Table II - Mechanical properties, from designated areas of castings

| Alloy | Temper | Class ^{2/} | Tensile strength, ksi, (MPa) min. | Yield strength, ksi, (MPa) min., 0.2 percent offset | Elongation, percent, min. |
|----------------------|--------|---------------------|-----------------------------------|---|---------------------------|
| AM100A ^{1/} | T6 | 1 | 38(262) | 20(138) | 3 |
| | | 2 | 35(241) | 18(124) | 1.5 |
| | | 3 | 30(207) | 16(110) | 1 |
| AZ91C | T6 | 1 | 35(241) | 18(124) | 4 |
| | | 2 | 29(200) | 16(110) | 3 |
| | | 3 | 27(186) | 14(97) | 2 |
| AZ92A | T6 | 1 | 40(276) | 25(172) | 3 |
| | | 2 | 34(234) | 20(138) | 1 |
| | | 3 | 30(207) | 18(124) | 0.75 |
| HK31A | T6 | 1 | 33(228) | 16(110) | 6 |
| | | 2 | 29(200) | 14(97) | 3 |
| | | 3 | 25(172) | 12(83) | 1 |
| QE22A | T6 | 1 | 40(276) | 28(193) | 4 |
| | | 2 | 37(255) | 26(179) | 2 |
| | | 3 | 33(228) | 23(159) | 2 |
| ZE41A | T5 | 1 | 32(221) | 22(152) | 5 |
| | | 2 | 29(200) | 20(138) | 3 |
| | | 3 | 27(186) | 19(131) | 2 |
| ZE63A | T6 | 1 | 42(290) | 28(193) | 6 |
| | | 2 | 40(276) | 26(179) | 5 |
| | | 3 | 37(255) | 24(166) | 4 |
| ZH62A | T5 | 1 | 38(262) | 23(159) | 5 |
| | | 2 | 34(234) | 21(145) | 3 |
| | | 3 | 31(214) | 19(131) | 2 |
| ZK51A | T5 | 1 | 36(248) | 21(145) | 6 |
| | | 2 | 32(221) | 19(131) | 4 |
| | | 3 | 29(200) | 17(117) | 3 |
| ZK61A | T6 | 1 | 42(290) | 29(200) | 6 |
| | | 2 | 37(255) | 26(179) | 4 |
| | | 3 | 34(234) | 23(159) | 2 |

^{1/}For permanent mold castings for alloy AM100A-T6.

^{2/}See 6.3.

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3.2.1 Check analysis. When specified in the contract or order, the chemical composition shall be subject to check analysis by the Government.

3.3 Mechanical properties. (see 6.2 and 6.3). The mechanical properties shall meet the following requirements as specified on the drawing or in the contract or order:

- (a) Test specimens taken from specified sections of the castings shall meet the requirements for the specified alloy and class as shown in table II.
- (b) Test specimens taken from castings in unspecified areas of castings shall meet the requirements for the specified alloy as shown in table III.

Table III - Mechanical properties, specimen taken
from unspecified areas of castings

| Alloy | Temper | Tensile strength, ksi, (MPa)min. | Yield strength, ksi, (MPa)min., 0.2 percent offset | Elongation, percent, min. |
|--------|--------|----------------------------------|--|---------------------------|
| AM100A | T6 | 17(117) | 10(69) | 0.75 |
| AZ91C | T6 | 17(117) | 12(83) | .75 |
| AZ92A | T6 | 17(117) | 13(90) | .50 |
| HK31A | T6 | 19(131) | 10(69) | 1.0 |
| QE22A | T6 | 28(193) | 20(138) | 1.0 |
| ZE41A | T5 | 24(166) | 17(117) | 1.25 |
| ZE63A | T6 | 32(221) | 22(152) | 2.5 |
| ZH62A | T5 | 28(193) | 17(117) | 1.25 |
| ZK51A | T5 | 24(166) | 14(97) | 1.25 |
| ZK61A | T6 | 30(207) | 21(145) | 1.25 |

- (c) Mechanical properties of castings tested in full section shall be as agreed upon between the supplier and procuring activity.

3.3.1 Heat treatment. Heat treatment of castings shall be conducted in accordance with MIL-M-6857 to meet the mechanical properties specified in 3.3.

3.4 Soundness. Unless otherwise specified in the invitation for bids, contract or order, the castings shall meet the radiographic requirements for the specified grade in table IV. Radiographs shall be compared with the comparable ASTM E 155 reference radiographs for the particular imperfection and shall be equal to or less severe than the reference radiograph number shown in table IV. Imperfections noted as "none" in table IV shall not be present in the castings. When no grade designation is specified on the drawing or in the contract or order, grade C shall apply to all areas marked "critical" and grade D to unmarked areas.

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Table IV - Maximum acceptable defects; maximum permissible radiographic reference in accordance with ASTM E 155.

| Defects | Radiographic reference ^{1/} | Grade | Grade | Grade | Grade |
|--|--------------------------------------|-------|--------|--------|--------|
| | | A | B | C | D |
| Gas holes | Vol I 1.1 | None | 1 | 2 | 3 |
| Microshrinkage (feathery) | Vol I 2.31 | 1 | 1 | 2 | 3 |
| Microshrinkage (sponge) | Vol I 2.32 | 1 | 1 | 2 | 3 |
| Foreign material (less dense) | Vol I 3.11 | 1 | 2 | 3 | 4 |
| Foreign material (more dense) | Vol I 3.12 | None | 1 | 1 | 2 |
| Eutectic segregation (flowline) ^{2/} | Vol II | None | Note 3 | Note 3 | Note 4 |
| Eutectic segregation (hot tear) ^{2/} | Vol II | None | Note 3 | Note 3 | Note 4 |
| Eutectic segregation (pipe shrink) ^{2/} | Vol II | None | None | Note 3 | Note 3 |
| Eutectic segregation (microshrinkage type) ^{2/} | Vol II | 1 | 2 | 3 | 5 |
| Gravity segregation ^{2/} | Vol II | 1 | 1 | 2 | 3 |
| Reacted sand inclusions | Vol II | 1 | 3 | 4 | 6 |

^{1/}Use 1/4 in (0.64 cm) section referenced radiographs.

^{2/}Ratings for segregation for Zr-containing alloys.

Al-ZN type alloys shall be rated:

| | | | |
|----------------|----------------|----------------|----------------|
| <u>Grade A</u> | <u>Grade B</u> | <u>Grade C</u> | <u>Grade D</u> |
| None | None | 1 | 1 |

^{3/} Allowed up to 1/2 the amount shown in reference radiograph.

^{4/} Allowed up to the amount shown in reference radiograph.

3.5 Surface imperfections. The castings shall not contain cracks, laps, or cold shuts. When specified in the contract or order, castings shall be examined for imperfections by the liquid penetrant method.

3.6 Repair of castings. Castings shall not be welded, plugged or impregnated without written authorization of the procuring activity. When impregnation to prevent leakage is authorized a written procedure of the method shall be prepared by the producer and all castings so treated shall be identified by the symbol IMP.

3.7 Dimensions and tolerances. The dimensions and tolerances shall be as specified in the drawing or contract or order.

3.8 Identification marking. Castings shall bear the producer's name or symbol, melt number, and part or pattern number except castings of small size. Such marking shall be done by stencilling methods or similar techniques.

3.9 Workmanship. Castings shall be clean and free of defects injurious to their intended use.

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4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible 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 facilities or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Classification of inspection.

4.2.1 Preproduction tests. Preproduction testing shall consist of all tests and examinations specified herein to assure conformance to all requirements in section 3 of this specification unless otherwise specified in the invitation for bids, contract or order.

4.2.2 Quality conformance tests. Quality conformance testing shall conform to all of the provisions specified in section 4 of this specification, unless otherwise specified in the invitation for bids, contract or order.

4.3 Lot. A lot shall consist of the number of castings, of the same alloy and of the same part or pattern numbers which are produced from the same melt or pot, and are heat treated by the same heat treating procedure. A lot shall not exceed 1000 pounds (453.6 kg) of rough castings.

4.4 Sampling.

4.4.1 For chemical analysis. When check analysis is specified, at least one sample shall be taken from each lot (see 4.3 and 6.6) for analysis as directed by the procuring activity.

4.4.2 For mechanical properties. Unless otherwise specified in the invitation for bids, contract, or order, sampling of each lot for mechanical property testing shall be in accordance with table V.

Table V - Sampling for mechanical properties

| <u>Lot size</u> | <u>Sample size</u> |
|-----------------|--------------------|
| 1-50 | 1 |
| 51-200 | 2 |
| 201 and over | 2 percent |

4.4.3 For soundness. Each lot shall be sampled for radiographic inspection in accordance with the frequency as specified in MIL-STD-2175.

4.4.4 For surface imperfections determination. Sampling for penetrant inspection shall be as specified by the procuring activity.

4.5 Examination.

4.5.1 Visual. All castings shall be examined for compliance with the requirements for surface imperfections (see 3.5), repair of castings (see 3.6), identification marking (see 3.8) and workmanship (see 3.9).

4.5.2 Dimensions and tolerances. The first casting in each lot plus one out of every 10 castings in each lot shall be measured for compliance with the requirements for dimensions and tolerances (see 3.7).

4.5.3 Preparation for shipment. Examination of the preservation, packaging, packing, and marking for shipment shall be made for conformance to the requirements of section 5.

4.6 Tests.

4.6.1 Test specimens.

4.6.1.1 Chemical composition. Samples for chemical check analysis shall be in accordance with method 111 or 112 of FED-STD-151.

4.6.1.2 Mechanical properties. Tension test specimens shall be taken from the locations specified on the drawing or by the procuring activity from the sample castings. Tension test specimens shall conform to one of the following specimens of ASTM E 8: flat, 1/2 inch (1.27 cm) or 1/4 inch (0.64 cm) wide; round, 0.500 inch (1.27 cm) or 0.250 inch (0.64 cm) nominal diameter. When testing is specified on the full section of the casting the direction or method of loading of the full size casting shall be as specified by the drawing. Tension test specimens sectioned through areas having more than one allowable radiographic soundness region should be tested for information only and shall not be cause for rejection of the casting or lot.

4.6.2 Test methods.

4.6.2.1 Chemical composition. Check analysis of chemical composition shall be conducted in accordance with method 111 to 112 of FED-STD-151.

4.6.2.2 Mechanical properties. Tensile tests shall be conducted in accordance with ASTM E 8.

4.6.2.3 Soundness. Radiographic tests for soundness shall be conducted in accordance with MIL-STD-453. Radiographs shall be compared with the standards of ASTM E 155 to meet the requirements of 3.4.

4.6.2.4 Surface imperfections. Penetrant tests shall be conducted in accordance with MIL-I-6866.

4.7 Rejection.

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4.7.1 Examination. A lot shall be subject to rejection for failure to meet the visual, dimensional, and preparation for shipment requirements when examined in accordance with 4.5.

4.7.2 Tests. A lot shall be subject to rejection for failure to meet the testing requirements when tested in accordance with 4.6.

4.8 Retests. Retesting for failure to meet chemical analysis or mechanical property requirements shall be in accordance with FED-STD-151.

5. PREPARATION FOR DELIVERY

5.1 Packing. Castings shall be packed in accordance with the requirements of MIL-STD-649. The procuring activity shall specify the level required (see 6.2).

5.2 Marking. In addition to any special marking required in the contract or order (see 6.2), shipments shall be marked in accordance with MIL-STD-129.

6. NOTES

6.1 Intended use. Castings to this specification are intended to be used for high strength, high quality structural purposes.

6.1.1 Casting design. The design of castings in the grades and strength levels covered by this specification are of the utmost importance and the designer should work very closely with the foundry engineer.

6.2 Ordering data. Procurement documents should specify the following:

- (a) Title, number, and date of this specification.
- (b) Number of sample castings and test location (see 3.1).
- (c) Alloy and temper (see 1.2 and 3.2).
- (d) Mechanical property classes (see 3.3 and 6.3).
- (e) Grade for radiographic testing (see 3.4).
- (f) Penetrant testing, if required (see 3.5 and 4.4.4).
- (g) Production quality conformance tests, when not required as specified (see 4.2.1 and 4.2.2).
- (h) When check analysis is required (see 4.4.1).
- (i) When sampling for mechanical properties other than in accordance with table V is required (see 4.4.2).
- (j) Level of packing required (see 5.1).
- (k) Special marking, if required (see 5.2).

6.2.1 Information to be included in the invitation for bids, contract or order. The procuring activity should provide a drawing or drawings to the supplier with the following information:

- (a) Dimensions and tolerances.
- (b) Areas of major stress.
- (c) Areas of nondestructive testing both surface and internal.
- (d) Location of test bars and class of mechanical properties at each location.

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6.3 Mechanical properties. Stress levels of various sections of castings should be carefully considered before specifying the class of mechanical properties for any particular casting section. Since a uniform stress level is seldom required in casting design it would be advantageous from the design and foundry aspect to have higher properties in local designated areas with the remainder of the casting having lower properties. Three classes of mechanical properties are therefore incorporated in the specification for various stress levels and the minimum properties for the various alloys are also given for specimens taken from castings for use in designating stress levels on drawings.

6.4 Radiographic soundness. Requirements for soundness in most castings will vary as do the requirements for strength levels. Application of soundness grades to designated areas at varying levels should be investigated by the designer and the foundry engineer. Allowable variations may result in simpler rigging by the foundry with a resultant greater yield and increased productivity at a lower cost.

6.5 Protective treatments. For protective treatments of magnesium casting MIL-M-3171 should be consulted.

6.6 Melt. A melt shall be a single homogeneous batch of molten metal to which all alloying and processing operations have been completed.

Custodian:

Army - MR
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Preparing activity:

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Review:

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User:

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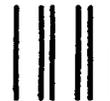
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