MIL-M-26075D(ASG)
6 MARCH 1969

Superseding
MIL-M-26075C(ASG)
8 September 1965

MILITARY SPECIFICATION

MAGNESIUM-ALLOY SHEET AND PLATE (HK31A)

This specification has been approved by the Department of the Air Force and by the Naval Air Systems Command.

1. SCOPE

1.1 Scope. - This specification covers magnesium-alloy (HK31A) sheet and plate.

1.2 Classification. - Magnesium-alloy sheet and plate shall be furnished in the following tempers, as specified (see 6.2):

Condition O - Annealed, recrystallized
Condition H24 - Strain hardened, then partial annealed

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein:

SPECIFICATIONS

Military

MIL-M-3171	Magnesium Alloy, Processes for Pretreatment and Prevention of Corrosion on

STANDARDS

Federal

FED. TEST METHOD STD. NO. 151	Metals, Test Methods
FED. STD. NO. 184	Identification Marking of Aluminum, Magnesium and Titanium
FED. STD. NO. 245	Tolerances for Aluminum Alloy and Magnesium Alloy Wrought Products

FSC 9535

Military

MIL-STD-129	Marking for Shipment and Storage
MIL-STD-649	Aluminum and Magnesium Products, Preparation for Shipment and Storage

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

* 2.2 Other publications. - The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

American Society for Testing and Materials

ASTM E8 - 66	Tension Testing of Metallic Materials
ASTM E21 - 66T	Short Time Elevated Temperature Tension Tests of Materials

(Copies of ASTM Standards may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.)

Atomic Energy Commission

Code of Federal Regulations - Title 10, Part 20 - Standards for Protection Against Radiation

(Application for copies should be addressed to the Division of Licensing and Regulation, U.S. Atomic Energy Commission, Washington, D.C. 20545.)

3. REQUIREMENTS

3.1 Materials. - The material shall be such as to produce sheet and plate conforming to all the requirements of this specification.

3.2 Chemical composition. -

* 3.2.1 The chemical composition of the material furnished under this specification shall conform to table I.

TABLE I. Chemical composition

Element	Percent by weight	
	Min.	Max.
Thorium	2.5	4.0
Zirconium	0.45	1.0
Other impurities, each	-	1/ 0.15
Other impurities, total	-	1/ 0.30
Magnesium	Remainder	

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

3.3 Mechanical properties. -

3.3.1 The mechanical properties of magnesium-alloy sheet and plate, measured in the longitudinal direction, the direction of rolling, shall conform to table II as specified (see 6.2).

* TABLE II. Mechanical requirements

Alloy and temper	Specified thickness (inches)	Tensile strength (psi)	Yield strength at 0.2 percent offset, minimum (psi)	Elongation in 2 inches, or 4D minimum (percent)
HK31A-H24	0.016-0.125	34,000 (min)	26,000	4
	0.126-0.250	34,000 (min)	24,000	4
	0.251-1.000	34,000 (min)	25,000	4
	1.001-3.000	33.000 (min)	25,000	4
HK31A-O	0.016-0.250	30,000 (min) 38,000 (max)	18,000	12
	0.251-0.500	30,000 (min)	16,000	12
	0.501-1.000	30,000 (min)	15,000	12
	1.001-3.000	29,000 (min)	14,000	12

3.3.1.1 Minimum mechanical properties of magnesium-alloy sheet and plate for thicknesses not shown in table II shall be agreed upon between the supplier and the procuring activity (see 6.2).

3.3.2 Tensile properties of 600° F. - Material 0.016 to 0.250 inch thick of each lot shall be capable of conforming to the minimum mechanical properties (table III) at 600° F when tested as specified in 4.4.3.2.

TABLE III. Minimum mechanical properties

Condition	Tensile strength, minimum (psi)	Elongation, percent in 2 inches, minimum
H24	10,000	20

* 3.3.3 Bending properties. - Annealed material shall be capable of bending without cracking at room temperature through an angle of 90 degrees around a diameter equal to the bend factor given in table IV times the specified sheet thickness with the axis of bend perpendicular to the direction of rolling.

TABLE IV. Bend factors

Nominal thickness (inch)	Bend factor
0.016 to 0.063, incl.	8
Over 0.063 to 0.082, incl.	10
Over 0.082 to 0.125, incl.	12

3.4 Tolerances. - Magnesium-alloy sheet and plate shall not vary from the specified dimensions or from true straightness of edge by an amount greater than the tolerances specified for flatness, squareness, thickness, width, length, and lateral bow in FED. STD. NO. 245 for plate, flat sheet, or coiled sheet, as applicable.

3.4.1 Tolerances for size of sheet and plate not covered by FED. STD. NO. 245 shall be as specified by the procuring activity (see 6.2).

3.5 Identification of product. - Each sheet and plate shall be marked for identification in accordance with FED. STD. NO. 184. The specification number and material condition shall appear as part of the marking.

3.6 Protective treatment. - Magnesium-alloy sheet and plate up through 0.500 inch thick shall be pickled. All thicknesses of sheet and plate shall be oiled or chrome pickled, as specified, as a final process before shipment (see 6.2). Unless otherwise specified by the procuring activity the sheet or plate shall be given a chrome pickle treatment in accordance with type I of MIL-M-3171.

3.7 Reports. -

3.7.1 Chemical analysis report. - The contractor shall include with each heat a chemical analysis of that heat, performed as specified in 4.3.2 and 4.4.2 showing the percentage of each of the elements specified in table I.

3.7.1.1 This chemical analysis and report, performed by the contractor, may be waived by the procuring activity, provided that the composition control is acceptable to the procuring activity, and provided that all material in the lot can be identified as being from heats previously analyzed and found to be in conformance with the chemical composition requirements.

3.7.2 Mechanical properties test report. - The contractor shall certify that the material shipped conforms to this specification. When requested on the contract or order (see 6.2), the contractor shall submit with each lot a report indicating the material conforms to 3.3.1 and shall show the results of tests performed in accordance with 4.4.3.1.

3.8 Precautionary information. - The processing, handling, and shipment of products covered by this specification shall be as specified in the Code of Federal Regulations, Title 10, Part 20 - Standards for Protection Against Radiation.

3.9 Workmanship. - The material shall be uniform in quality and condition, clean, sound, smooth, commercially flat, and free from severe buckles and other injurious defects. Discoloration resulting from annealing operations, and superficial surface abrasions which are not of sufficient depth to affect adversely the static or dynamic mechanical properties or formability of the material, shall not be cause for rejection.

3.9.1 The material shall be given such uniform treatment as the manufacturer desires to produce material that will conform to the requirements specified herein. The treatment shall be done in a manner that will produce utmost uniformity. Annealing operations shall be performed on the whole of a product, never only on a part of the product.

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 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 General. - Sampling, inspection, and tests shall be performed in accordance with the applicable methods of Federal Test Method Standard No. 151, and as specified herein.

4.3 Sampling. -

4.3.1 Lot. - A lot shall consist of sheet or plate of the same condition and thickness submitted for inspection at one time.

* 4.3.2 Samples for chemical composition analysis. - A sample for chemical analysis shall be obtained, as described in Method 111 of Federal Test Method Standard No. 151, from each 4,000 pounds or less or a heat of the alloy when chemical analysis is made at the time of melting. When chemical analysis is made of the finished sheet or plate, a sample for chemical analysis shall be taken from each 1,000 pounds or less of material comprising the lot. Samples for chemical analysis shall represent the full cross section of the material. Chemical composition shall be in conformance with 3.2.1.

* 4.3.3 Samples for mechanical property tests. - At least one test sample for each of the mechanical property tests specified under 4.4.3.1 and 4.4.3.4 shall be selected to represent each 1,000 pounds or less of sheet or 2,000 pounds or less of plate comprising a lot, except that in no case shall less than two tests represent a lot. The test samples that represent a lot shall not be selected from the same sheet or plate. Mechanical properties shall be in conformance with 3.3.1 and 3.3.2.

* 4.3.3.1 Location of test specimens. - Test specimens of the full thickness of the material shall be used up to 0.500 inch in thickness; the specimen shall be taken midway between the two plate surfaces for plate in thicknesses of 0.500 inch up through 1.500 inch, and midway between the center and the surface (quarter point) of plate over 1.500 inch in thickness.

4.3.4 Rejection and retest. -

4.3.4.1 Rejection. - If a test specimen fails to pass any of the tests required by this specification, the lot represented by the samples shall be rejected.

4.3.4.2 Retests. - Retests shall be permitted in accordance with requirements of the applicable methods of Federal Test Method Standard No. 151.

4.3.4.3 Reheat treatment. - When failure of any lot of material to conform to this specification is due to inadequate annealing, the material may be reannealed and resubmitted for test. Only two such reannealings shall be allowed.

4.4 Inspection methods. -

4.4.1 Inspection of product. - Each sheet and plate shall be carefully examined to determine conformance with this specification with respect to workmanship and marking. Sufficient spot checks shall be made to insure conformance with the tolerances specified in FED. STD. NO. 245. On approval of the procuring activity, a system of statistical quality control may be used.

4.4.2 Chemical analysis. - Chemical analysis shall be made by standard wet chemical or spectrographic methods. In case of dispute, chemical analysis by standard wet chemical methods shall be the basis for acceptance.

* 4.4.3 Mechanical property tests. -

4.4.3.1 Tension test, room temperature. -

* 4.4.3.1.1 Tension test specimens. - For material less than 0.500 inch in thickness, the tension test specimen shall be the rectangular specimen illustrated in ASTM E8. For material 0.500 inch or more in thickness, the tension test specimen shall be a round tension test specimen as illustrated in ASTM E8.

4.4.3.1.2 Tension test. - The tension test shall be performed in accordance with ASTM E8.

4.4.3.2 Tension test, elevated temperature. -

* 4.4.3.2.1 Tension test specimens. - Test specimens shall be rectangular specimen shown in ASTM E8, and shall be cut parallel to the direction of rolling. Elongation requirements apply only to sheets 3/4 inch and over in width.

* 4.4.3.2.2 Tension test. - The tension test shall be performed in accordance with ASTM E21. Unless otherwise specified, tensile tests specimens shall be heated to 600° ±5° F, held at 600° ±5° F for 10 minutes before testing, and tested at 600° ±5° F at a rate no greater than 0.005 inch per inch per minute up to the yield strength and at a rate of 0.10 to 0.14 inch per inch per minute above the yield strength.

* 4.4.3.3 Yield strength. - Yield strength shall be determined by the offset method in accordance with ASTM E8.

* 4.4.3.4 Bending tests. - Bending tests shall be performed in accordance with Method 231 of Federal Test Method Standard No. 151. Unless otherwise specified, the specimen shall be approximately 1 inch wide and 4 inches long, with the edges smooth and free from rough, sheared surfaces. Bending properties shall be in conformance with 3.3.3.

4.5 Preservation, packaging, packing, and marking. - Preparation for delivery shall be exained for conformance with section 5.

5. PREPARATION FOR DELIVERY

5.1 General. - Unless otherwise specified (see 6.2), all material shall be separated by condition, size, and thickness and packed in crates or boxes of the size commonly used for shipment. Individual plates and sheets which have been given a chrome pickle surface treatment shall be separated by a non-corrosive, nonhygroscopic paper to protect the finish. Oiled sheets or plates are not required to be separated by paper.

5.2 Preservation, packaging, and packing. - Preservation, packaging and packing of the material shall be in accordance with MIL-STD-649, as specified for the applicable level.

5.3 Marking. - In addition to any special marking specified in the contract or order, the shipping containers shall be marked in accordance with MIL-STD-129.

6. NOTES

6.1 Intended use. - The magnesium-alloy (HK31A) sheet and plate covered by this specification is intended for use in components where weldability and good strength-to-weight ratio up to 600° F is required.

* 6.2 Ordering data. - Procurement documents should specify the following:

(a) Title, number, and date of this specification.
(b) Temper (see 1.2).
(c) Size and thickness (see 3.3.1).
(d) Mechanical properties and tolerances for materials outside the specification limits (see 3.3.1.1).
(e) Tolerances for sizes of sheet and plate not covered by FED. STD. NO. 245 (see 3.4.1).
(f) Whether chrome pickled or oiled plate or sheet is desired (see 3.6).
(g) If a mechanical properties testing report is required.
(h) Precautionary marking and Atomic Energy Commission licence number (see 3.8).
(i) Applicable levels of packaging and packing (see section 5).

6.3 Local exhaust of fumes resulting from welding magnesium alloy is required.

* 6.4 Marginal indicia. - The margins of this specification are marked with an asterisk to indicate where changes (additions, modifications, corrections, deletions) from the previous issue were made. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content, irrespective of the marginal notations and relationship to the past previous issue.

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Project No. 9535-0193