

MIL-Z-63472  
26 September 1980

## MILITARY SPECIFICATION

### ZINC-ALUMINUM SUPERPLASTIC ALLOYS FOR THERMO FORMING, DEEP DRAWING AND STRETCH FORMING

This specification is approved for use by all Departments and Agencies of the Department of Defense.

#### 1. SCOPE

1.1 Scope. This specification covers sheet, plate and strip stock Zn-Al superplastic alloys suitable for the production of parts by thermoforming, deep drawing, stretch forming, compression molding and other similar processes.

1.2 Classification. This specification applies to the Zn-Al superplastic alloys with or without the addition of alloying elements. The available alloys shall be in accordance with types of Table I as specified (see 6.1).

#### 2. APPLICABLE DOCUMENTS

2.1 Issues of documents. 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.

##### Standards

##### FEDERAL

Fed-Std 123 - Marking for Domestic Shipment (Civil Agencies).  
Fed-Std 151 - Metals, Test Methods.

##### 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 contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer).

Beneficial comments (recommendations, additions, deletions), and any pertinent data which may be of use in improving this document, should be addressed to: Commander, US Army Armament Research and Development Command, ATTN: DRDAR-TST-S, Dover, New Jersey 07801, 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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2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless a specific issue is identified, the issue in effect on the date of invitation for bids or request for proposal shall apply.

American Society for Testing and Materials (ASTM)

- ASTM E 8-78 - Tension Testing of Metallic Materials.
- ASTM E 18-74 - Rockwell and Rockwell Superficial Hardness of Metallic Materials, Tests For.
- ASTM E 112-77 - Average Grain Size of Metals, Estimating The.

(Application for copies should be address to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103).

### 3. REQUIREMENTS

3.1 Microstructural. Unless otherwise specified, the supplier shall assure that the alloy have an average grain diameter of  $9 \times 10^{-3}$  mm (.00036 in.) or less in accordance with ASTM E112.\*

3.2 Manufacturer. The sheets and strips shall be of good quality and free of cracks and surface folding.

3.3 Chemical composition. Chemical composition of the alloy shall be ordered to identification types or applicable range of chemical composition limits as specified in Table I.

3.3.1 Lot analysis. A lot analysis or each heat shall be furnished by the supplier.

#### 3.4 Mechanical properties.

3.4.1 Hardness. The superplastic Zn-Al alloy, as-rolled, shall meet the hardness requirements as shown in Table II unless otherwise negotiated between the supplier and the procuring activity.

3.4.2 Tensile properties. Ultimate tensile strength, yield strength (0.2% off-set) and percent elongation shall be as shown in Table II.

#### 3.4.3 Superplastic properties.

3.4.3.1 Strain rate sensitivity. The minimum value for strain rate sensitivity, m, shall be as indicated in Table II.

\*If these alloys conform to the superplastic properties, the grain size will be well below this value. Due to the expense and difficulty in counting the large number of grains this fine, a count should not be required unless there is doubt of complying.

TABLE I - COMPOSITION OF SUPERPLASTIC Zn-Al ALLOYS IN WT.%

<u>Composition</u>	<u>Alloy Type</u>		
	<u>A</u>	<u>B</u>	<u>C</u>
Al	20 - 24%	20 - 24%	20 - 24%
Cu	-	0.4 - 0.6%	0.4 - 0.6%
Mg	-	-	0.005 - 0.03%
Fe max.	.1	.1	.1
Sn max.	0.005	0.005	0.005
Pb max.	0.007	0.007	0.007
Cd max.	0.005	0.005	0.005
Zn	balance	balance	balance

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TABLE II - SUPERPLASTIC Zn-Al - MECHANICAL AND SUPERPLASTIC (K AND m)  
PROPERTIES FOR THE SUPERPLASTIC (AS-ROLLED) CONDITION

<u>Properties (at 23°C):</u>	<u>Alloy Type</u>		
	<u>A</u>	<u>B</u>	<u>C</u>
Tensile Strength, psi	21,000-34,000	34,000-60,000	50,000-65,000
Yield Strength (0.2% offset), psi	18,000-27,000	25,000-50,000	40,000-55,000
% Elongation in 2" gauge section	50-130	40-70	15-35
Rockwell 15T hardness	44-55	65-80	75-85
<u>K (at 250°C), psi/min:</u>			
Over 0.060" thickness	1300	1500	1600
0.040"-0.060" thickness	1400	1600	1700
0.030"-0.040" thickness	1500	1700	1800
0.020"-0.030" thickness	1600	1800	1900
0.020" thickness	-	-	2000
<u>m, minimum (at 250°C):</u>	0.40	0.42	0.43

3.4.3.2 Work hardening coefficient. The minimum values for the work hardening coefficient, K, as a function of specimen thickness shall be as listed in Table II.

3.5 Finish. Unless otherwise specified sheets, plates and strips of the alloy shall be furnished with an "as-rolled" scaleless finish (see 6.1). Hazy finishes and normal surface scratches and roll marks which do not detract the superplastic alloy strip from the forming capabilities are allowed.

3.6 Edge. The edges of the sheets, plates and strips shall be free from wave, cracks and excessive burns. Burn tolerances are slightly relaxed, particularly in heavier gauge due to the hardness of the alloys.

3.7 Dimensions. The sheet, plate and strip shall be furnished in the sizes as specified in the invitation for bids, contract, or order (see 6.1 and 6.2).

3.8 Size and flatness tolerance. Physical size limitations and tolerances vary somewhat depending on gauges and widths specified. Gauges, width and length tolerances are held within standard mill tolerances. No flatness tolerances have been formulated, and when required, flatness tolerances for specified sizes should be negotiated between the supplier and the procuring activity.

3.9 Identification marking. Unless otherwise specified in the contract or order (see 6.1), units or strip, plates and sheets shall be properly identified with manufacturer's name, or trademark, the specification number and type of alloy legibly imprinted on oilproof, waterproof tags.

3.10 Workmanship. The strip, plate or sheet shall be clean and free from imperfections such as laminations, segregation and surface defects as is consistent with good commercial practice.

#### 4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for meeting 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 performing the inspections 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 service conform to prescribed requirements.

4.2 Lot. Unless otherwise specified in the contract or order (see 6.1), a lot shall consist of all items submitted for inspection at one time, of the same heat, the same finish, and the same thickness.

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#### 4.3 Sampling.

4.3.1 Chemical composition. Samples for product analysis of chemical composition shall be taken from three different items in each lot. Each sample shall be analyzed separately.

#### 4.3.2 Mechanical properties.

4.3.2.1 Hardness, tensile and K and m properties. The samples should be cut and prepared from each lot for hardness, tensile and K and m property determinations. The selection of the three samples should be such that one is taken from the early items, one from the middle, and one from the final items of the lot.

4.3.3 Microstructure examination. When specified, a representative sample of the alloy shall be examined for compliance with the microstructure requirements for the superplastic Zn-Al alloys.

#### 4.4 Examination.

4.4.1 Visual. A representative sampling of the alloy shall be examined for compliance with requirements for finish (see 3.5), edge (see 3.6), and workmanship (see 3.10) and identification marking (see 3.9).

4.4.2 Dimensional. A representative number of measurements shall be taken on each lot to determine compliance with the size and tolerance requirements (see 3.8). Thickness measurements shall be made with a micrometer.

4.4.3 Preparation for delivery. Prior to shipment, examination shall be made to determine compliance with the requirements of Section 5.

#### 4.5 Tests.

##### 4.5.1 Test specimens.

4.5.1.1 Chemical composition. Specimens for chemical analysis shall be prepared in accordance with Method 111.2 or 112.2 of Fed. Test Method Std No. 151.

##### 4.5.1.2 Mechanical properties.

4.5.1.2.1 Hardness. Specimens shall be prepared in accordance with ASTM E 18.

4.5.1.2.2 Tensile properties. Specimens shall be prepared in accordance with ASTM E 8.

4.5.1.2.3 K and m properties. Tensile specimens are prepared in accordance with ASTM E 8 shall be used for K and m properties test.

##### 4.5.2 Test methods.

4.5.2.1 Chemical composition. Chemical composition shall be conducted in accordance with Method 111.2 or 112.2 of Fed. Test Method Std No. 151.

4.5.2.2 Mechanical properties.

4.5.2.2.1 Hardness tests. Hardness tests shall be conducted in accordance with ASTM E 18.

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

4.5.2.2.3 K and m tests. The test methods employed in the determination of K and m shall be in accordance with current commercial practice. The basic principles involving the determination of the two parameters are discussed briefly in Appendix A.

4.5.3 Microstructure examination.

4.5.3.1 Microstructure. Examination of the microstructure shall be made at a magnification at least 500X.

4.6 Rejection.

4.6.1 Examination. If representative sampling for visual, dimensional or preparation for delivery fails to meet the requirements of this specification when examined in accordance with 4.4, the lot shall be rejected.

4.6.2 Tests. If a test specimen fails to meet any of the requirements of this specification, the lot represented by the specimen shall be rejected when tested in accordance with 4.5.

4.6.3 Retests. Retests shall be permitted in accordance with Fed. Test Method Std. No. 151. All specimens so selected for retest shall meet the requirements of the specification or the lot shall be subject to rejection.

## 5. PACKAGING

5.1 Presentation, packaging and packing. All sheets, plates and strip stocks, shall be preserved, packaged and packed in accordance with the requirements of MIL-STD-649. Unless otherwise specified (see 6.1), material shall be preserved, packaged, and packed in accordance with level C.

5.2 Marking. In addition to special marking required in the contract or order (see 6.1), the packages and shipping containers shall be marked in accordance with Fed. Std. 123 or MIL-STD-129 as applicable.

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TABLE III. Available Stocks and Dimensions for Superplastic Zn-Al Alloys

<u>Dimension</u>	<u>Coil Stock</u>	<u>Sheet Stock</u>	<u>Plate Stock</u>
Thickness	.02 - .075 in	.049 - .200 in	.200 - 1.25 in
Width	1 to 20 in*	2 - 30 in	up to 30 in
Max length	---	96 in	96 in

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**Notes**

\*For coil stock with thickness from .02 to .03 in, and width over 12 in., special order is required.

\*\*Maximum length applies to .200 in. plat only. For heavier gauge plates, stock length is proportionally shorter.



## 6. NOTES

6.1 Ordering data. Purchasers should select the preferred options permitted herein and include the following information in procurement documents:

- (a) Title, number, and date of this specification.
- (b) Alloy type (see Table I).
- (c) Hardness (see 3.4.1) or tensile strength (see 3.4.2).
- (d) If other than scaleless, finish is required (see 3.5).
- (e) Quantity.
- (f) Size and dimensional requirements.
- (g) Lot size, identification marking, if required (see 4.2).
- (h) Packing requirements.

6.2 Commercial stock available. The standard stocks commercially available for zinc-aluminum superplastic alloys whether in sheet, plate or other forms are listed in Table III.

## Custodians:

Army - AR  
Navy - AS

## Preparing activity:

Army - AR

(Project 9535-0294)

## Review activities:

Army - MR, AT  
Navy -  
DSA - IS

## APPENDIX

DETERMINATION OF  $m$  AND  $K$  FOR  
SUPERPLASTIC ZINC-ALUMINUM  
ALLOYS

## 10. SCOPE

10.1 Scope. This appendix details an example of a method for determining  $m$ , strain rate sensitivity, and  $K$ , work hardening coefficient.

20. Determination of  $m$  and  $K$ . The strain rate sensitivity  $m$  and work hardening coefficient  $K$  may be determined by making use of the stress-strain rate relationship  $\sigma = K(\dot{\epsilon})^m$  where  $\sigma$  is the flow stress and  $\dot{\epsilon}$  is the strain rate. A tensile experiment may be conducted at 482°F (250°C) to obtain the pertinent stress and strain rate data.  $m$  is determined by the slope of the  $\log \sigma - \log \dot{\epsilon}$  plot which is sigmoidal and can be easily separated in three stages (see Figure 1). The middle stage in which  $m$  maintains a high and relatively uniform value for a wide range of strain rates, coincides with the superplastic flow.  $K$  is determined in the stress rate relationship at  $\dot{\epsilon} = 1$  or  $\log \dot{\epsilon} = 0$ .

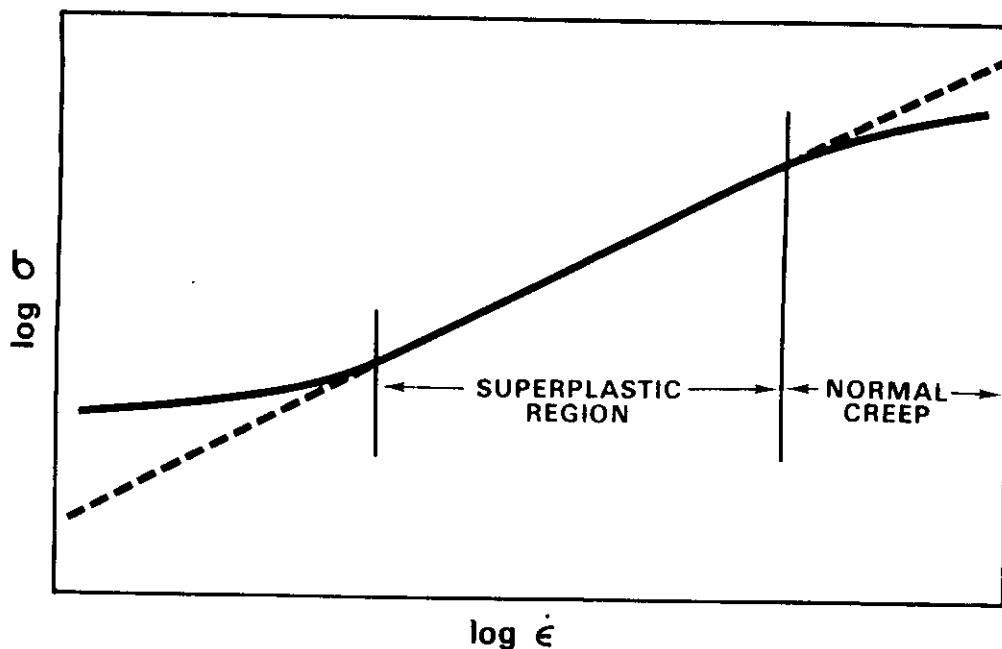


Figure 1. Relationship between strain rate and stress

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DOCUMENT IDENTIFIER (Number) AND TITLE MIL-Z-63472, ZINC-ALUMINUM SUPERPLASTIC ALLOYS  
FOR THERMO FORMING, DEEP DRAWING AND STRETCH FORMING

NAME OF ORGANIZATION AND ADDRESS OF SUBMITTER

☐ VENDOR ☐ USER ☐ MANUFACTURER

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SUBMITTED BY (Printed or typed name and address — Optional)

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DATE

**DD FORM 1426**  
1 OCT 76

EDITION OF 1 JAN 72 WILL BE USED UNTIL EXHAUSTED.