

**MIL-W-18326A**

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**SUPERSADING****MIL-W-18326(Aer)**

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**MILITARY SPECIFICATION****WELDING OF MAGNESIUM ALLOYS, GAS AND  
ARC, MANUAL AND MACHINE PROCESSES FOR**

*This specification has been approved by the Department of Defense and is  
mandatory for use by the Departments of the Army, the Navy and Air Force.*

**1. SCOPE**

**1.1 Scope.** This specification covers the requirements for the welding of magnesium alloys.

**1.2 Classification.** This specification covers the following types of processes:

oxy acetylene  
inert-gas metal-arc (tungsten electrode)  
inert-gas metal-arc (consumable electrode)

**2. APPLICABLE DOCUMENTS**

**2.1** The following specifications and standards of the issue in effect on date of invitation for bids, form a part of this specification:

**SPECIFICATIONS****MILITARY**

MIL-M-3171 —Magnesium Alloy:  
Processes for Cor-  
rosion Protection  
of  
MIL-T-5021 —Tests; Aircraft  
Welding Opera-  
tor's Certification  
MIL-C-6021(ASG)—Castings, Classifica-  
tion and Inspec-  
tion of (for Aero-  
nautical Applica-  
tions)  
MIL-I-6865(ASG)—Inspection; Radio-  
graphic  
MIL-I-6866(ASG)—Inspection; Pene-  
trant Method

MIL-F-6943

—Flux, Magnesium  
Alloy Welding

MIL-R-6944

—Rods, Welding,  
Magnesium Alloy**STANDARDS****MILITARY**

MIL-STD-19

—Welding Symbols

MIL-STD-20

—Welding Terms and  
Definitions

(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.)

**3. REQUIREMENTS**

**3.1 Welders or welding operator.** Welding shall be performed only by welders or welding operators who have met the requirements of Specification MIL-T-5021 for the particular alloys and types of welding involved.

**3.2 Equipment.**

**3.2.1 General.** Welding equipment, such as welding machines, welding torches, regulators, and filler metal feed mechanisms shall be capable of making satisfactory welds, when operated by a certified welder or welding operator using a satisfactory filler rod or electrode where applicable.

**3.2.1.1** If the government representative has reason to doubt the capability of any welding apparatus to function satisfactorily, he shall re-

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quire welder's certification tests as described in Specification MIL-T-5021 applicable to the type of work for which the equipment is intended. The tests are to be made by a welding operator certified for the material and type of welding, and selected by the government representative. Multiple operator sets shall be tested while the maximum number of operators are welding. If under these conditions the applicable certification requirements cannot be met, the equipment shall not be used until the necessary repairs, adjustments, or replacements have been made.

**3.2.2 Furnaces.** Furnaces used for preheating parts prior to welding shall have suitable pyrometric controls. Torches may be used for preheating provided the specified temperature range is maintained by using a suitable contact pyrometer, approved temperature-indicating sticks, or approved temperature-indicating liquids.

**3.2.2.1 Cooling Ovens.** Cooling ovens shall be provided with suitable means for controlling the cooling rate, in order to prevent damage to castings and other parts which are preheated prior to welding. Preheating furnaces may be used as cooling ovens.

**3.2.3 Ventilation.** Suitable blowers, exhausters, or other approved safety devices shall be provided where needed to protect personnel against fumes resulting from flux, filler rods, etc.

## 3.3 Materials.

**3.3.1 Base Metal.** The alloy compositions, listed in table I, in any combination except as restricted by paragraph 3.3.2, may be welded by the indicated welding processes without specific authorization. Authority to weld other alloys or to use other types of welding must be obtained from the procuring agency.

TABLE I. Chemical composition.

Commercial Designation	Magnesium %	Nominal Alloy Composition		Manganese %	Oxyacetylene	Types of Welding Are in Inert Atmosphere	
		Aluminum %	Zinc %			Tungsten Electrode	Consumable Electrode <sup>1</sup>
M1A <sup>1</sup>	Remainder	—	—	1.5	X	X	X
AZ31B <sup>1</sup>	Remainder <sup>1</sup>	3.0	1.0		X	X	X
AZ61A <sup>1</sup>	Remainder	6.5	1.0		X	X	X
AZ80A <sup>1</sup>	Remainder	8.5	0.5			X	X
AZ63A <sup>1</sup>	Remainder	6.0	3.0			X	X
AZ91C <sup>2</sup>	Remainder	9.0	1.0			X	X
AZ92A <sup>1</sup>	Remainder	9.0	2.0			X	X
AM100A <sup>3</sup>	Remainder	10.0	—			X	X
EZ33A <sup>1</sup>	Remainder <sup>4</sup>	—	3.0			X	X

<sup>1</sup> Wrought alloys.

<sup>2</sup> Cast alloys.

<sup>3</sup> Low calcium grade with 0.04 % maximum Co preferred.

<sup>4</sup> Composition includes 0 % rare earths.

<sup>5</sup> Welding in the flat, horizontal and vertical down position only.

"X" indicates the type of welding which may be used.

**3.3.2 Filler Metal.** Welding rods and welding wire used in the welding of magnesium alloys shall be capable of producing satisfactory welds when used by a certified welding operator with satisfactory welding apparatus and shall have a composition suitable for producing welds conforming to the requirements specified herein. Welding rods shall be in accordance with Military Specification MIL-R-6944. Magnesium-aluminum-zinc alloys shall not be welded with

magnesium-manganese filler metal. Magnesium-manganese alloys may not be gas welded but may be arc welded with magnesium-aluminum-zinc filler metal.

**3.3.3 Flux.** Flux for the gas welding of magnesium alloys shall conform to Military Specification MIL-F-6943.

**3.3.4 Gases.** Gases used in the welding of magnesium alloys shall be free from harmful

percentages of impurities, diluent gases, and moisture. Inert gases shall be of a grade designated for welding.

### 3.4 Weld design.

**3.4.1 General.** Welds of sheet material 0.040 inch thick or less may be of the flange, butt, lap or fillet joints, as applicable. Welds of material thicker than 0.040 inch shall be of the butt or fillet type, except that lap joints may be used subject to the approval of the government representative when the joint design and welding process are such that flux is not entrapped in the joint.

**3.4.2 Joint Design.** Joint design should, in general, be in accordance with the latest practices recommended by the American Welding Society.

**3.4.3 Accessibility.** All portions of a weld shall be accessible to proper cleaning.

### 3.5 Welding procedure.

**3.5.1 Procedure Certification.** Prior to engaging in production welding, the contractor shall demonstrate to the authorized government inspector the satisfactory quality of representative welds by means of the tests specified in Section 4. Procedure certification is intended to cover a technique of operations rather than a specific application and accordingly shall not be repeated for different weld assemblies, unless recertification is warranted by a break in the continuity of production, by a substantial increase in the complexity of the work being performed, or by substantial changes in procedure.

**3.5.2 Preparation of Surfaces.** Surfaces to be welded shall be free from grease or other foreign matter and shall be as free as possible from oxide and protective coatings. (Cleaning with a wire brush or abrasive paper is a satisfactory method for removing oxides and protective coatings).

**3.5.3 Preparation of Castings.** Salvage of cracked castings by welding may be accomplished only when permitted by procuring agency directives or other authority. Salvage of castings with defects other than cracks may be accomplished with the consent of the authorized government representative. The defect shall be

chipped, ground, or filed out whenever the section involved is heavier than  $\frac{1}{8}$  inch.

**3.5.4 Use of Flux.** The use of flux is mandatory in gas welding all alloys and frequently useful as a back-up in electric welding where the joint is not completely enveloped in inert gas. However, the flux should be used sparingly for most satisfactory results. The flux shall be thoroughly mixed with water (distilled water desirable but not mandatory), in the proper proportions to produce a thin paste. The paste shall be applied to both the welding rod and the surfaces to be welded (except in tack welding) by dipping, or with a small swab or brush. Flux which has hardened or caked may not be used unless it is reworked to a smooth consistency.

**3.5.5 Smoothness and Weld Contour.** Where practicable, all weld joints shall fair into the adjacent metal in gradual, smooth curves. Beads shall be smooth and shall be free of slag, undercut, or excessive spatter. Sufficient metal shall be added to provide a suitable fillet or reinforcement unless otherwise specified. Welds shall be sealed on all sides to prevent the entrance of air or moisture.

**3.5.6 Preheating.** Forgings and plate material need not be preheated except locally as required to start welding. For repairing castings by welding, the castings are generally preheated before welding. For the magnesium-aluminum-zinc alloys a minimum preheating temperature of 650° F shall be used. Preheating, when employed, shall not be at so high a temperature as to cause incipient melting, excessive grain growth, or other undesirable structural changes. Heat treated alloys shall not be preheated at a temperature which will reduce their mechanical properties or seriously impair their resistance to corrosion, unless they are subsequently reheat treated. During welding the preheated part shall be maintained at the preheat temperature by satisfactory methods, such as an arrangement of torches and by the use of satisfactory insulating materials to prevent the rapid dissipation of heat.

**3.5.7. Burning or Burn-through.** Fusion through the full thickness of the base material, in areas other than those where 100% penetration is a requirement of the joint design, shall

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not be acceptable when welding materials above 0.050 inch in thickness or in structural or critical areas. In no case shall the weld metal be burnt (oxidized) or contain holes or pores through the material.

**3.5.8 Cooling.** Parts which have been preheated for welding shall be cooled slowly, preferably in the preheating furnace, after completion of the welding operation.

**3.5.9. Flux Removal.** Excess welding flux shall be completely and promptly removed after welding, as serious corrosion will occur if the flux is allowed to remain any appreciable amount of time in the welded joint. Flux shall be removed by vigorously scrubbing with a stiff brush under very hot running water until the surface is clean. The welded parts shall then be immersed for one hour in a 2 to 5 percent solution of sodium dichromate maintained at 180°-212° F and thoroughly rinsed in cold running water. Alternate methods of flux removal may be employed provided they are demonstrated to be capable of passing the test specified in paragraph 3.5.9.1.

**3.5.9.1 Test for Flux Removal.** At the discretion of the government representative, welds shall be tested to determine when flux has been properly removed, by leaching the welded area with distilled water and adding a few drops of nitric acid and a few drops of five percent silver nitrate to the leach. When a white precipitate is formed, further cleaning will be required.

**3.5.9.2 Flux removal** shall be promptly followed by one of the treatments specified in Specification MIL-M-3171 unless heat treatment is necessary. The success of such treatments is dependent upon effective prior flux removal.

**3.5.10 Heat Treatment.** Unless it can be shown that welded alloys, which depend upon heat treatment for their specified mechanical properties, possess mechanical properties equal to or greater than the design values for that part, they shall be reheat-treated to obtain the specified mechanical properties. Welded parts, except those of magnesium—1.5 percent manganese alloy and parts reheat-treated after welding, shall be furnished in a stress relieved

condition. Heat treatment operations shall be promptly followed by one of the treatments specified in Specification MIL-M-3171.

**3.5.11 Marking.** Each welded assembly shall be marked by the contractor so as to positively identify it with the welding operator who made the welds, using a method of identification approved by the Government representative. Identification shall remain on the part at least until final inspection and acceptance of welds. Permanent marking shall be used when not injurious to the serviceability of the part.

#### **4. QUALITY ASSURANCE PROVISIONS**

**4.1 General.** All parts welded in accordance with this specification shall be subject to inspection by authorized government representatives who shall be given all reasonable facilities to determine conformance with the requirements of this specification and Specification QQ-M-151.

##### **4.2 Procedure certification.**

**4.2.1 Sampling for Procedure Certification.** For consideration of procedure approval, the government representative shall select sufficient samples of welded assemblies, prepared under production conditions, to establish the quality of welding. Insofar as it is practicable, he shall select samples made by different welding operators.

**4.2.2 Procedure Data.** The following information, as applicable, shall be furnished with all welded specimens, submitted for consideration of approval of procedure (Tests conducted and data submitted for the certification of welders or welding operators under Specification MIL-T-5021 may also be used for procedure certification):

- (a) Manufacturer, type, and serial number of welding machine.
- (b) Brand of electrode or rod.
- (c) Nominal chemical analysis of electrode or rod.
- (d) Type and purity of gases used, rate of flow, and flame characteristics.
- (e) Nominal composition or type of flux.
- (f) Pre- and post-heat-treatment, if any.

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- (g) Welding operators' name and identification symbol.
- (h) Drawings of the application.
- (i) Date welded.

### 4.3 Quality control of production.

**4.3.1 Sampling for Production.** Not less than 5 percent of the representative weldments from each welding operator's production shall be selected for examination and test. The method of selecting samples shall be acceptable to the Government representative.

**4.3.2 Inspection for Production.** All samples selected as in paragraph 4.3.1. shall be subjected to detailed visual inspection and to penetrant inspection. Where necessary, this examination shall be supplemented by macroscopic and microscopic inspection of representative parts for the following items:

- (a) Fusion, including root and joint penetration.
- (b) Convexity, concavity, and size of beads.
- (c) Undercutting and overlapping.
- (d) Cracks.
- (e) Porosity and inclusions.
- (f) Other metallic discontinuities.

**4.3.2.1** In addition, at least 1 percent of the representative critical weldments from each welding operator's production shall be checked by radiography for items 4.3.2 (a), (d), (e) and (f) above. Radiography may be waived in applications where it can be demonstrated to the government representative that this type of inspection does not add to the information obtained under paragraph 4.3.2.

### 4.4 Quality control of repair welds.

**4.4.1 Sampling Repair Welds.** All repairs in castings classed as Class I under Military Specification MIL-C-6021(ASG), where such repairs are permitted, shall be subject to examination and test. Not less than ten percent of repairs in Class II castings shall be selected for examination and test. The method of selecting samples shall be acceptable to the government representative.

**4.4.2 Inspection of Repair Welds.** All samples selected as in paragraph 4.4.1 shall be subjected to the requirements of paragraph 4.3.2.

**4.4.2.1** In addition, 100% of the repairs in Class I castings and 3% of the repairs in Class II castings shall be checked by radiography for items 4.3.2 (a), (d), (e) and (f) above.

### 4.5 Test methods.

**4.5.1** Radiography shall be performed in accordance with the requirements of Specification MIL-I-6865(ASG).

**4.5.2** Penetrant inspection shall be performed in accordance with the requirements of Specification MIL-I-6866(ASG).

**4.5.3** The preparation of microscopic and macroscopic specimens shall be in accordance with standard metallographic practice. Macroscopic inspection for defects should be conducted at magnifications below 40 diameters. Microscopic examination for grain size, melting, etc., shall be conducted at 100 diameters magnification or higher.

**4.6** Contractors shall have laboratory facilities for conducting the metallurgical and radiographic examinations, or shall engage the services of a commercial laboratory satisfactory to the government representative.

**5. PREPARATION FOR DELIVERY.** Not applicable.

### 6. NOTES

**6.1** The standard welding symbols that are accepted for designation on drawings, are listed in MIL-STD-19.

**6.2** The standard nomenclature and definitions for terms relating to welding are listed in MIL-STD-20.

**Patent notice.** When government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related government procurement operation, the United States Government

thereby incur no responsibility nor any obligation whatsoever; and the fact that the government may have formulated, furnished, or in any way supplied the said drawings, specification, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

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