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MILITARY STANDARD

WELDING, GAS METAL-ARC AND GAS TUNGSTEN-ARC, ALUMINUM
ALLOYS, READILY WELDABLE FOR STRUCTURES, EXCLUDING ARMOR

AMSC No. A4433

/AREA THJM/

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MIL-STD-372(MR)

DEPARTMENT OF DEFENSE
WASHINGTON, DC 20360

Welding, Gas Metal-Arc and Gas Tungsten-Arc, Aluminum
Alloys, Readily Weldable for Structures, Excluding Armor

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1. This Military Standard is approved for use by the Army Materials Technology Laboratory, Watertown, MA, Department of the Army, and is available for use by all Departments and Agencies of the Department of Defense.
2. 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 Laboratory Command, Materials Technology Laboratory, ATTN: SLCMT-MEE, Watertown, MA 02172-0001 by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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FOREWORD

This standard prescribes the classification of methods for the welding of aluminum alloys by the gas metal-arc or gas tungsten-arc welding processes. Included in the document are the factors required in the joint-welding procedures for structural applications other than armor.

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1. SCOPE

1.1 Scope. This standard covers the welding of all aluminum alloys other than armor to armor or aerospace applications using the gas metal-arc or gas tungsten-arc welding process.

1.2 Classification. Welding performed under this standard shall be classified in accordance with the nature of the service requirements of the weldment as follows:

Class A - Weldments whose failure could result in injury to personnel or in an assigned mission not being fulfilled.

Class B - Weldments whose failure would not result in injury to personnel or in unfulfillment of an assigned mission.

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2. REFERENCED DOCUMENTS

2.1 Issues of documents. The following documents, of the issues in effect on date of invitation for bids or request for proposal form a part of this standard to the extent specified herein.

SPECIFICATIONS

MILITARY

DOD-D-1000 - Drawings Engineering and Associated lists

STANDARDS

MILITARY

DOD-STD-100 - Engineering Drawing Practices

MIL-STD-22 - Welded Joint Designs

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes

MIL-STD-370(MR) - Visual Acceptance Criteria for Inspection of Aluminum alloy welds.

MIL-STD-410 - Nondestructive Testing Personnel Qualification and Certification

MIL-STD-453 - Inspection, Radiographic

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

2.2 Other publications. The following document(s) form a part of this standard to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted shall be those listed in the issue of the DODISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS shall be the issue of the nongovernment documents which is current on the date of the solicitation.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) STANDARDS

ASTM E8 - Methods of Tension Testing of Metallic Materials

ASTM E23 - Methods for Notched Bar Impact Testing of Metallic Materials

ASTM E290 - Method for Semi-Guided Bend Test for Ductility of Metallic Materials

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

AMERICAN WELDING SOCIETY (AWS)

ANSI/AWS A2.4 - Symbols for Welding and Nondestructive Testing, including Brazing

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ANSI/AWS A3.0 - Welding Terms and Definitions

ANSI/AWS A5.10 - Aluminum and Aluminum Alloy Bare Welding Rods and
Electrodes, Specification For

ANSI/AWS D1.2 - Structural Welding Code - Aluminum

(Application for copies should be addressed to American Welding Society,
550 N.W. LeJeune Road, P.O. Box 351040, Miami, FL 33135.)

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

Boiler and Pressure Vessel Code Section IX, Welding Qualifications

(Applications for copies should be addressed to the American Society of
Mechanical Engineers, 345 East 47th Street, New York City, NY 10017)

(Non-Government standards and other publications are normally available
from the organizations which prepare or which distribute the documents. These
documents also may be available in or through libraries or other informational
services.)

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3. DEFINITIONS

3.1 Difference between contractor and manufacturer. The term "contractor" as used in this standard is defined as the organization having a direct contract with the Government agency. The term "manufacturer" is defined as the organization actually performing the operations covered by this standard. The contractor may or may not be the manufacturer; hence, when "contractor or manufacturer" is used, it designates them as separate parties or as one and the same when "or both" is used.

3.2 Welding symbols. Symbols for welding shall be as specified in AWS A2.4.

3.3 Welding terms and definitions. Welding terms and definitions shall be as specified in AWS A3.0.

3.4 Weldment. Weldment, as used in this document, refers to any unit whose parts are joined by one or more welds.

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4. GENERAL REQUIREMENTS

4.1 Base materials. The base materials considered by this standard shall be aluminum alloys which are weldable by the processes stipulated in 1.1.

4.2 Preparation of welding procedures and drawings. When specified in the contract, drawing or procurement order and prior to the production fabrication of any weldment, the contractor or manufacturer shall prepare in accordance with DoD-STD-100 and DoD-D-1000 an isometric, perspective, or other suitable drawing of the structure showing the location of each joint and shall establish a recorded joint welding procedure(s) to cover all welding to be performed under this standard (see 6.2). When specified in the contract, Class A welding and repair welding procedures shall be qualified and recorded in accordance with AWS D1.2 or ASME Boiler and Pressure Vessel Code, Section IX for pressure containers or per the contractor's approved welding procedures which include the factors in table 1 where applicable.

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5. DETAILED REQUIREMENTS

5.1 Filler metal. Unless otherwise specified in the contract, drawing or procurement order, the aluminum welding rods and electrodes shall conform to ANSI/AWS A5.10. When the filler metal is not specified and a suitable type is not available in the applicable standard, a commercial type shall be selected which is capable of depositing a weld which will either meet or exceed the minimum mechanical requirements of the base material as specified on the drawings, contract or order.

5.2 Shielding gas. The shielding gas used shall be of uniform composition and quality. Impurities, particularly moisture as shown by dew point determination, shall be within maximum guaranteed by the contractor. The shielding gas used shall be suitable for the welding of aluminum.

5.3. Joint design. Joint design shall be in accordance with MIL-STD-22.

5.4 Preproduction requirements.

5.4.1 Submittal of procedures and drawings. When specified in the contract or order, for Class A weldments, the recorded joint welding procedure (see 6.2) and drawings shall be prepared in triplicate to the contracting officer who will forward two copies to the procuring activity for approval. Unless otherwise specified for Class B weldments, the joint welding procedure shall be retained by the contractor or manufacturer and made available to the Government upon request. Prior to repair of base metal and repair of welded joints for both Class A and B weldments, the recorded joint welding procedure, drawings, and a general outline for the repair of base metal and repair of welded joints shall be reviewed and approved by the contracting officer or his representative.

5.4.2 Recertification of welding procedure. When changes are made in any of the essential variables as indicated in table 1, the recorded joint welding procedure shall be revised and regualified. If the weld procedures are qualified per specifications AWS D1.2 or ASME Section IX, the procedure shall be revised and regualified when changes are made to the essential variables so defined in the appropriate specification. For class A welding procedures, the contracting officer shall be notified for review and concurrence.

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TABLE I. Factors required in the joint welding procedure and the changes in the factors wherein the welding procedure must be recertified.

Essential variables	The recorded joint welding procedure for class A weldments shall be re-certified when:
1. Alloy of base material	A change in alloy outside the aluminum producer's declared chemical range is made, unless a specific waiver is granted by the contracting officer.
2. Thickness of the base material	The basis thickness plus tolerance is changed.
3. Alloy of filler metal	A change in the alloy of the filler metal is made or when a change in brand of the same alloy of filler metal is made except when the new brand is classified under ANSI/AWS A5.10.
4. Filler metal sizes for all passes.	The filler metal diameter is changed.
5. Position of welding	Change in welding position.
6. Welding process (see 1.1) and operation (manual, semi-automatic and automatic)	(a) A change from manual to semi-automatic or vice-versa. (b) A change is made from semi-automatic to automatic (including robotic).
7. Shielding gas composition	A change is made in the composition of the gas involving one or more of the following: (1) A change from one inert-gas to another. (2) When using mixed inert-gas shielding, a change in excess of plus or minus 30 percent of the minor gas constituent. (3) When active gases or other additives are combined with the inert-gas.
8. Shielding gas flow	A change of plus or minus 25 percent is made in the rate of gas flow for each nozzle size shown in each welding procedure.
9. Joint design	The originally established geometry or basic dimensions plus tolerances are changed.

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TABLE I. Factors required in the joint welding procedure and the changes in the factors wherein the welding procedure must be recertified.
(cont'd)

Essential variables	The recorded joint welding procedure for class A weldments shall be re-certified when:
10. Number and sequence of passes	Number, sequence, or both are changed.
11. Welding current and arc-voltage range for all passes	Outside the limits established in recorded joint welding procedure.
12. Type of current, A.C. or D.C. and polarity if D.C. is used.	A change in type of current, and in the case of D.C., the type polarity.
13. Method of joint edge preparation	A change is made from mechanical to thermal, a combination of mechanical and thermal to mechanical or thermal; or vice versa.
14. Method of preparing root joint before welding second side.	Method of preparation is changed.
15. Backing or spacer strip if used.	Backing or spacer strip is added or removed; or basic type of material of backing or spacer strip is changed.
16. Starting, preheat and inter-pass temperature ranges.	Range is changed.
17. Method of preweld and inter-pass cleaning	Method of cleaning is changed.
18. Postheating	Any change from the approved heat treatment is made.
19. Type and diameter of tungsten electrode	Any change in type and diameter of tungsten electrode.
20. Welding travel speed	A change above or below the specified range of travel speed when welds are mechanized.

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5.4.3 Procedure for repair welding. The welding procedure for the repair of welded joints (see 5.4.1) shall include the applicable factors listed under table I and in addition shall include the following:

- (a) Method to be used in (chipping or other) for removing defects.
- (b) Method of inspection used to insure removal of defects.
- (c) Contour of cavity prior to welding, such as minimum root dimensions and included angle.

5.4.4 Workmanlike specimens. Unless otherwise specified in the contract, drawing or procurement order and prior to the production fabrication of any welded joints, the contractor shall prepare workmanship specimens of all welded joints representing the acceptable weld quality to be used in production. These specimens shall also represent the minimum acceptable cleaning procedure. These specimens shall be prepared using the welding procedures to be used in production and may be either an actual part or sample simulating all of the proposed welds. Specimens prepared to represent multiple pass welds shall be made in such a manner as to have at least two inches of each layer of weld metal exposed. All specimens shall be cross-sectioned and etched prior to examination. All specimens shall be cross-sectioned, etched and shall be identified by the manufacturer and procedure number/letter. Upon approval, specimens shall be returned to the manufacturer, protected from damage and environmental deterioration and shall be maintained in the fabrication area for reference.

If radiographic inspection of the final weld is required by the drawings or the contract, the workmanship specimens shall also be radiographed for acceptance. Unless otherwise specified by contract or order visual examination for Class A and Class B workmanship specimens (see 5.6) shall conform to the requirements of MIL-STD-370(MR) for the applicable grade. Unless otherwise specified by contract or order both Class A and B fine scattered (average pore diameter equal to or less than 0.030 inches) porosity exceeding 13 pores in any one square inch of weld face shall be rejected. Not more than two pores may exceed 0.030 inches in diameter; coarse scattered (average diameter greater than 0.030 inches) porosity exceeding 2 pores in any one square inch of weld face shall be rejected. No single pore may exceed 0.060 inches in diameter, linear surface porosity in excess of 0.500 inches or in excess of 25 percent of total length, whichever is less, shall be rejected.

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Class A workmanship specimens shall be accepted by the procuring agency prior to engaging in production welding.

5.4.5 Position drawings for radiographic inspection. For development of Level III drawings and when radiography is specified on the drawings, in the contract or order, a position drawing or drawings shall be prepared in accordance with DoD-STD-100 and DoD-D-1000 for each weldment by the contractor employing symbols in accordance with AWS A2.4 and using welding terms and definitions in accordance with AWS A3.0. The position drawings shall contain the following information, as applicable:

- (a) Location of joints in weldment
- (b) Joint type (welding symbols may be used as shown in AWS A2.4)
- (c) Thickness of plate
- (d) Location of films
- (e) Position of films
- (f) Direction of radiation
- (g) Soundness standard for each joint
- (h) Film type
- (i) Kilovoltage
- (j) Focal distance
- (k) Penetrameter used

This information shall be submitted to the contracting officer for approval.

5.4.6 Qualification of welder or welding operator. For Class A, the contractor or manufacturer shall be responsible for qualifying all welders and welding operators in accordance with AWS D1.2 or ASME Boiler and Pressure Vessel Code, Section IX, as appropriate or per the contractor's approved qualification procedure, as appropriate. For Class B, welders and welding operators shall be qualified in accordance with AWS D1.2 or per the contractor's approved qualification procedure, as appropriate. Qualifications shall be done following the recorded welding procedures. Records of all qualifications shall be maintained by the manufacturer or contractor and shall be made available upon the Government's request for review for conformance to all requirements specified. The Government reserves the right to request that all welders and welding operators be recertified when it is deemed necessary to assure conformance to this standard.

5.4.7 Qualification of inspection personnel. For personnel performing visual inspection of welds, the contractor/manufacturer shall be responsible for determining the capability of inspection personnel to evaluate welds in accordance with the criteria established in this specification. Personnel performing other non-destructive testing techniques shall be qualified for the applicable method to MIL-STD-410.

5.5 Production requirements.

5.5.1 Fabrication. Fabrication of all weldments shall be in accordance with the contractor's certified recorded joint welding procedure.

5.5.2 Soundness. Unless otherwise specified in the contract, drawing or procurement order, soundness as determined by radiographic or macroscopic inspection will not be required (see 5.4.5 and 5.6).

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5.5.3 Dimensional fillet welds. Dimensional fillet welds shall be measured using fillet weld gages. For fillet welds, the weld dimension shall be the minimum as specified on the drawing symbol.

5.6 Workmanship. Welds shall meet the applicable visual inspection criteria specified in paragraph 5.4.4 for the appropriate class of weld. Tack welds shall be of the same quality as the final welds if consumed by the final weld.

5.7 Visual examination. All class A weldments shall be visually examined to determine compliance with this standard. Unless otherwise specified the number of Class B weldments to be visually examined for compliance with this standard shall be in accordance with MIL-STD-105, Level I, AQL of 0.65% (see 6.2).

5.8 Testing and inspection. When radiographic inspection and tests for mechanical properties; Tension test (ASTM E8), Charpy Impact test (ASTM E23), Cold-Bending test (ASTM E290) are specified on the drawings, in the contract or order, methods of inspection and test specimens shall be in accordance with MIL-STD-453 and applicable ASTM Document at the frequency specified in the contract or order (see 5.4.4).

5.8.1 Testing. Unless otherwise specified on the drawings, in the contract or order, the amount and type of testing other than visual, shall be performed at the discretion of the contractor or manufacturer.

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6. NOTES

6.1 Intended use. The intended purpose of this standard is to cover general welding of aluminum alloys for structural uses other than armor. Examples of weldment classifications are as follows:

Class A	Class B
1. Pressure and liquid tight containers	1. Storage containers
2. Turret platform	2. Heater duct work
	3. Fenders
	4. Heat deflectors

6.2 Data requirements. When this standard is used in an acquisition and data are required to be delivered, the data requirements identified below shall be developed as specified by an approved Data Item Description (DD Form 1664) and delivered in accordance with the approved Contract Data Requirements List (CDRL), incorporated into the contract. When the provisions of DOD FAR Supplement, Part 27, Sub-Part 27.475-1 (DD Form 1423) are invoked and the DD Form 1423 is not used, the data specified below shall be delivered by the contractor in accordance with the contract or purchase order requirements. Deliverable data required by this standard are cited in the following paragraphs.

<u>Paragraph No.</u>	<u>Data Requirement Title</u>	<u>Applicable DID No.</u>
4.2	Drawings, Engineering and Associated Lists	DI-E-7031
4.2 and 5.4.1	Qualification Data, Welding Procedure	UDI-H-23384

(Copies of data item descriptions related to this specification, and identified in section 6 will be approved and listed as such in DOD 5010.12L, ~~AMSDL~~ AMSDL. Copies of data item descriptions required by the contractors in connection with specific acquisition functions should be obtained from the Naval Publications and Forms Center or as directed by the contracting officer.)

6.3 Subject term (key words) listing.

Aluminum Alloys
 Gas - metal-arc
 Gas - Tungsten-arc
 Joint-welding
 Welding

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Custodian:
Army - MR

Review activities
Army - AR, AT

User activities:
Army - ME, AL

Preparing activity:
Army - MR

Project: THJM-A253

(WP# ID-0909A/DISK-0003A. FOR MTL USE ONLY)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions - Reverse Side)

1. DOCUMENT NUMBER
MIL-STD-372(MR)

2. DOCUMENT TITLE
WELDING, GAS METAL-ARC AND GAS TUNGSTEN-ARC, ALUMINUM

3a. NAME OF SUBMITTING ORGANIZATION
ALCOA, READILY WELDABLE FOR STRUCTURES, EXCLUDED FOR (one)

☐ VENDOR

☐ USER

☐ MANUFACTURER

☐ OTHER (Specify): _____

b. ADDRESS (Street, City, State, ZIP Code)

7. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

8. REMARKS

9a. NAME OF SUBMITTER (Last, First, MI) - Optional

b. WORK TELEPHONE NUMBER (Include Area Code) - Optional

c. MAILING ADDRESS (Street, City, State, ZIP Code) - Optional

8. DATE OF SUBMISSION (YYMMDD)

