



AEROSPACE MATERIAL SPECIFICATION

AMS2689™

REV. B

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Superseding AMS2689A

Fusion Welding Titanium and Titanium Alloys

RATIONALE

AMS2689B stabilizes this document because it may no longer represent the state of the art and there are other documents that contain similar but not necessarily equivalent requirements.

STABILIZED NOTICE

AMS2689B has been declared "STABILIZED" by AMS B Finishes Processes and Fluids Committee. This document will no longer be updated and may no longer represent standard industry practice. This document was stabilized because it may no longer represent the state of the art and there are other documents that contain similar but not necessarily equivalent requirements. Previously this document was declared Noncurrent in February of 1998. The last technical update of this document occurred in October 1982. Users of this document should refer to the cognizant engineering organization for disposition of any issues with reports/certifications to this specification; including exceptions listed on the certification.

NOTE: In many cases, the purchaser may represent a sub tier supplier and not the cognizant engineering organization.

AMS Committee B recommends that the following similar but not identical specification may be considered for future procurement. This listing does not constitute authority to substitute these specifications for the "STABILIZED" specification.

AWS G2.4/2.4M, "Guide for the Fusion Welding of Titanium and Titanium Alloys" Available from; American Welding Society, 8669 NW 36 Street, #130, Miami, FL 33166.

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Documents

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1. SCOPE:

1.1 Purpose:

This specification defines the procedures and requirements for fusion welding titanium and titanium alloys and the properties of such weldments.

1.2 Application:

Primarily for high-quality, fusion welding of titanium and titanium alloy components for aerospace applications. The procedure covered by this specification uses gas-tungsten-arc-welding (GTAW), gas-metal-arc-welding (GMAW), and plasma-arc-welding (PAW).

2. APPLICABLE DOCUMENTS:

The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications (AMS) shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

2.1.1 Aerospace Material Specifications:

AMS 2350	Standards and Test Methods
AMS 2631	Ultrasonic Inspection of Titanium Alloys
AMS 2635	Radiographic Inspection
AMS 2645	Fluorescent Penetrant Inspection
AMS 4901	Titanium Sheet, Strip, and Plate, Annealed, 70,000 psi (483 MPa) Yield Strength

2.2 U.S. Government Publications:

Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.2.1 Military Specifications:

MIL-I-6866 Inspection, Penetrant Method of
MIL-A-18455 Argon, Technical
MIL-P-27407 Propellant Pressurizing Agent, Helium
MIL-H-81200 Heat Treatment of Titanium and Titanium Alloys

2.2.2 Military Standards:

MIL-STD-453 Inspection, Radiographic
MIL-STD-794 Parts and Equipment, Procedures for Packaging and Packing of
MIL-STD-1595 Qualification of Aircraft, Missile, and Aerospace Fusion Welders

2.3 ANSI Publications:

Available from American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.

ANSI B46.1 Surface Texture

2.4 AWS Publications:

Available from American Welding Society, 2510 North West Seventh Street, Miami, FL 33125.

AWS A2.0 Welding Symbols
AWS A3.0 Welding Terms and Definitions
AWS A5.12 Tungsten Arc-Welding Electrodes

3. TECHNICAL REQUIREMENTS:

3.1 Materials:

3.1.1 Parent Materials: Shall be those titanium and titanium alloys specified on the applicable part drawing.

3.1.2 Filler Metals: Shall be as specified on the applicable part drawing. When not specified, filler metal shall be compatible with the parent metal. If filler metal is not specified for joints consisting of two or more parent metal alloys, the filler metal shall be as agreed upon by purchaser and vendor.

3.1.3 Protective Atmospheres or Environments:

- 3.1.3.1 Environment: Helium conforming to MIL-P-27407 or equivalent, argon conforming to MIL-A-18455 or equivalent, or a mixture of the two shall be used for shielding during the welding operations, unless a specific gas requirement is specified herein or in the approved welding schedule.
- 3.1.3.2 Shielding: The root and face sides of the parent metal and the weld deposit shall be adequately shielded to prevent atmospheric contamination during and after welding until the weld zone has cooled below 900 °F (480 °C).
 - 3.1.3.2.1 The weld bead and an area not less than 1/32 in. (0.8 mm) from each side of the weld bead shall be bright silver to light straw in color on completion of each welding pass.

3.2 Equipment:

- 3.2.1 Welding Environment: Manual welding shall be performed in an inert atmosphere. A weld made using no filler metal on a test piece of AMS 4901 titanium shall show no discoloration of the test piece or the weld metal. The weld deposit, if analyzed, shall have an oxygen content not more than 10 ppm higher than the parent metal of the test piece and the total interstitial content of the weld shall be not more than 25 ppm higher than the parent metal of the test piece.
- 3.2.2 Machine Welding (Automatic and Semi-Automatic): Assemblies may be welded without fixed chambers with automatic or semi-automatic welding machines using appropriate leading and trailing inert-gas shielding devices certified by the approved welding procedure. A test bead made with the equipment and procedures defined in the approved welding procedure shall meet the requirements of 3.2.1.
- 3.2.3 Tooling:
 - 3.2.3.1 Only copper tooling, either solid or water-cooled, shall be used for chilling adjacent to the weld bead.
 - 3.2.3.2 Other metallic materials may be used for weld joint alignment tooling, providing the distance from the edge of the molten weld metal is greater than 1/8 in. (3 mm) for weldment thickness 0.125 in. (3 mm) and under, and greater than 1/4 in. (6 mm) for weldment thicknesses over 0.125 in. (3 mm).
 - 3.2.3.3 Cadmium-plated tools and tooling shall not be used.

3.3 Welding Operator Qualification:

All welding operations shall be performed by welders who are currently qualified to perform the same type of welding on the type of titanium used in the assembly. Qualification shall be in accordance with MIL-STD-1595.

3.4 Welding Procedure, Symbols, and Definitions:

Interpretation of welding symbols and definitions shall be in accordance with AWS A2.0 and AWS A3.0, respectively.

3.4.1 Welding Schedule: A schedule shall be established for processing of each welded assembly. This schedule shall cover all significant operations and shall include, but not be limited to, the following

Parent Metal(s) - Alloys and sizes of all parts including applicable material specifications

Filler Metal - Alloy and wire sizes including applicable material specifications

Tools and Fixtures

Cleaning Procedures - pre- and post-welding

Preheating Temperature Range

Interpass Temperature Controls

Minimum Parent Metal Temperature for Welding

Protective Environment - type, nozzle positions, flow rates

Tack Welds - location, permissible size, number

Welding Schedule - equipment control settings

Post Heating - temperature range, time at heat, environment

Stress-Relieving - temperature range, time at heat, environment

Inspection Procedures and Methods

Repair Procedures (when authorized)

Final Cleaning

3.4.2 Weld Joint Qualification: Unless otherwise specified, weld joints shall be qualified and the following process control requirements shall apply:

3.4.2.1 A weld joint simulating the production part, or the first part, shall be welded in accordance with 3.4.7 or 3.4.8 and inspected to verify conformance to the requirements of this specification and the part drawing prior to production welding.

3.4.2.2 Production parts, after approval of the weld joint qualification specimen, shall be welded with the welding procedures established in accordance with 3.4.7 or 3.4.8.

3.4.3 Edge Preparation: Weld joint and adjacent surface preparation, prior to welding, shall be as follows and shall be included as part of the approved procedure certification

3.4.3.1 Joint Preparation: Joints shall be prepared to conform to requirements of the part drawing. Unless otherwise specified, surfaces of joints shall have a surface texture of 32 - 125 microin. (0.8 - 3.2 µm), determined in accordance with ANSI B46.1.

3.4.4 Weld Start and Run-Off Tabs: Tabs, when used, shall be of the same alloy as the detail parts being welded and shall be cleaned in the same manner as the parts. Tabs shall be integral with the part, either being machined in, or welded to, the part pieces prior to assembly.