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400 Commonwealth Dr., Warrendale, PA 15096

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

SAE AMS 2685B

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Superseding AMS 2685A

WELDING, TUNGSTEN ARC, INERT GAS
Non-Consumable Electrode
(GTAW Method)

1. SCOPE: This specification defines the requirements for joining metals and alloys using the gas-tungsten-arc welding (GTAW) method.

1.1 Application: Primarily for joining metallic assemblies.

1.2 Classification: Weldments produced in accordance with this specification shall be of the following classes and methods of welding (manual or automatic) as specified on the applicable drawing:

1.2.1 Class A (Critical): Weldments whose fractures would cause injury to personnel, loss of a vehicle or weapon, or failure to complete an assigned mission.

1.2.2 Class B (Non-Critical): All weldments that are not classified Class A.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications 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.

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods
AMS 2635 - Radiographic Inspection
AMS 2640 - Magnetic Particle Inspection
AMS 2645 - Fluorescent Penetrant Inspection
AMS 2646 - Contrast Dye Penetrant Inspection
AMS 2759 - Heat Treatment of Steel Parts, General Requirements
AMS 2770 - Heat Treatment of Wrought Aluminum Alloy Parts
AMS 4901 - Titanium Sheet, Strip, and Plate, 70,000 psi (485 MPa) Yield Strength

2.2 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19103.

2.2.1 Federal Specifications:

BB-H-1168 - Helium, Technical

2.2.2 Military Specifications:

MIL-H-6875 - Heat Treatment of Steel, Process for
MIL-A-18455 - Argon, Technical
MIL-H-81200 - Heat Treatment of Titanium and Titanium Alloys

2.2.3 Military Standards:

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 AWS Publications: Available from American Welding Society, P.O. Box 351040, Miami, FL 33135.

AWS A2.0 - Welding Symbols
AWS A3.0 - Welding Terms and Definitions

3. TECHNICAL REQUIREMENTS:

3.1 Materials:

3.1.1 Parent Materials: Shall be as 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 and as specified in the welding procedure. 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 Cleaning Materials: Cleaning materials, chemical solvents, and etching solutions shall be as specified on the part drawing or in the welding procedure.

3.2 Equipment: Automatic welding equipment shall be suitable for producing welds meeting the requirements of 3.6.

3.2.1 Manual Welding: Manual welding of titanium, titanium alloys, refractory metals, and refractory-metal alloys shall be performed in rigid or flexible chambers. After purging the chamber, a weld bead made using no filler metal on an AMS 4901 titanium test piece nominally 0.060 in. (1.50 mm) in thickness, unless another method of testing is specified, if analyzed, shall have an oxygen content not more than 10 ppm higher than the base metal and the total interstitial content of the weld shall be not more than 25 ppm higher than the base metal. Silver or light straw discolorations are acceptable on the surface of the weld deposit and the parent metal. Medium straw is acceptable on the surface of the parent metal but is not acceptable on the weld deposit.

3.2.2 Automatic Welding (Machine Welding): Assemblies may be welded without chambers with automatic machines using appropriate leading, trailing, or both, inert-gas shielding devices approved by purchaser. A test bead made with this equipment shall meet the requirements of 3.2.1.

3.3 Preparation and Preweld Cleaning:

3.3.1 Cleaning and Surface Preparation: Surfaces to be joined shall be cleaned, prior to welding, by abrasive blasting, wire brushing, or chemical etching or by wiping with suitable solvents. Materials used for surface preparation shall have no deleterious effect on the parent metal or joint.

3.3.2 Setup for Welding: The parts to be joined shall be positioned, in a locating fixture if desired, so that the finished assembly will conform to the dimensions of the applicable drawing. When permitted, the parts may be tack welded.

3.3.2.1 Shielding Gases: The areas to be welded and the heat affected zones of the parent metal shall be blanketed with an environment of 99.985% pure argon conforming to MIL-A-18455. Helium conforming to BB-H-1168 may also be used alone or mixed with argon when required by the processing schedule (See 3.5.1). The total content of oxygen, hydrogen, nitrogen, carbon dioxide, carbon monoxide, and hydrocarbon compounds shall not exceed 50 ppm; the dew point of the gas shall be not higher than -50°F (-45°C).

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

3.5 Welding Procedures, Symbols, and Definitions: Interpretation of welding symbols and definitions shall be in accordance with AWS A2.0 and AWS A3.0, respectively.

3.5.1 Processing Schedule: A schedule shall be established for processing of each welded assembly. This schedule shall cover all significant operations and shall include not less than 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
Weld position
Cleaning procedures for 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, and 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
Protective treatments

3.5.2 Post-Weld Heat Treatment: For all thermal operations above 500°F (260°C), the assemblies shall be placed in a furnace conforming to the requirements of AMS 2759, AMS 2770, or MIL-H-81200, depending upon the parent metal alloy, heated to the prescribed temperature range, held at the selected temperature within ±25°F (±15°C) for the time prescribed, and cooled as specified in the schedule. Facilities used for metals and alloys not covered in AMS 2759, AMS 2770, or MIL-H-81200 shall meet the requirements of MIL-H-6875. The environment shall be as specified on the applicable drawing or as agreed upon by purchaser and vendor.

3.5.2.1 After welding, assemblies shall be inspected and accepted prior to post-weld cleaning.

3.5.2.1.1 Post-weld cleaning shall be in accordance with 3.3.1.

3.6 Quality: In the absence of criteria specified on the drawing, the following shall apply:

3.6.1 Visual Inspection: Shall be conducted at 3X if base metal thickness (t) is 0.063 in. (1.5 mm) and over and at 1X if t is under 0.063 in. (1.5 mm).

3.6.1.1 Groove Welds: Groove welds in sheet or tube which have any of the following defects are unacceptable:

3.6.1.1.1 Any type of crack.

3.6.1.1.2 Incomplete joint penetration.

3.6.1.1.3 Underfill.

3.6.1.1.4 Overlap.

3.6.1.1.5 For test welds with a base metal thickness over 0.063 in. (1.5 mm), undercut at any location in excess of 0.05t or 0.032 in. (0.8 mm), whichever is the lesser. The total length of reduced thickness shall be not more than 10% of the weld length for Class A and 15% for Class B.

3.6.1.1.6 Mismatch at any location in excess of 10% of the base metal thickness or 0.12 in. (3 mm), whichever is less, except that a mismatch up to 25% is allowed for a base metal thickness 0.063 in. (1.5 mm) and under.

3.6.1.1.7 Reinforcement of the weld face or the weld root in excess of that shown in Table I.

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TABLE I

Maximum Allowable Weld Reinforcement

Base Metal Thickness t, in. (mm)	Maximum Allowable Weld Reinforcement 1/			
	Face		Root	
	2/Base Metal Group	Any Location	2/Base Metal Group	Any Location
0.063 (1.5) and under	All	0.020 in. (0.50 mm) + t or 0.050 in. (1.25 mm)	IV and V	0.030 in. (0.75 mm) + t or 0.070 in. (1.75 mm)
			Ia, Ib, IIa, IIb, IIIa, IVb, VI, and VII	0.020 in. (0.50 mm) + t or 0.050 in. (1.25 mm)
Over 0.063 (1.5)	All	0.8t or 0.25 in. (6 mm)	IV and V	1t or 0.25 in. (6 mm)
			Ia, Ib, IIa, IIb, IIIa, IIIb, VI, and VII	0.8t or 0.25 in. (6 mm)

1/ The applicable maximum is the smaller of the two values given in the body of the table.
2/ Base metal groups are defined in MIL-STD-1595.

3.6.1.2 Fillet Welds: Fillet welds in sheet or tube which have any type of either crack or overlap are unacceptable:

3.6.1.2.1 Fillet welds in sheet or tube with a base metal thickness over 0.063 in. (1.5 mm), which have any of the following defects, are unacceptable:

3.6.1.2.1.1 Undercut at any location in excess of 0.1t or 0.063 in. (1.5 mm), whichever is the lesser.

3.6.1.2.1.2 Fusion evident at any sheet or tube surface opposite the weld bead.

3.6.1.2.1.3 For base metal thickness 1 in. (25 mm) and under, a leg size less than t. For a base metal thickness over 1 in. (25 mm), the minimum leg size shall be 1 in. (25 mm). Where the members of the test weld differ in thickness, the minimum leg size shall be based on the thinner member.

3.6.1.2.1.4 For base metal thickness 1 in. (25 mm) and under, a leg size in excess of 3t, or t plus 0.25 in. (6 mm), whichever is the lesser. For a base metal thickness over 1 in. (25 mm), the maximum leg size shall be 1.25 in. (31 mm). Where the members of the test weld differ in thickness, the maximum leg size shall be based on the thinner member.

3.6.1.2.1.5 A ratio of the leg of larger size to the leg of smaller size greater than 1.5 at any location.

3.6.1.2.1.6 For a convex weld, at any location a convexity in excess of 0.1 times the average leg size at that location.

3.6.1.2.1.7 For a concave weld, a theoretical throat size of less than 0.5t at any location. Where the members of the test weld differ in thickness, the minimum theoretical throat size shall be based on the thinner member.

3.6.1.2.2 Visual inspection criteria for base metal thickness 0.063 in. (1.5 mm) and under shall be the same as that for metallographic examination (3.6.2).

3.6.2 Metallographic examination shall be conducted at 10X or higher magnification on not less than four cross sections from an actual weld or sample. It is required on all fillet welds with 0.063 in. (1.5 mm) and over and is recommended on other weldments.

3.6.2.1 Interpretation of Defects:

3.6.2.1.1 A linear defect is defined as one whose maximum dimension is more than three times its minimum dimension.

3.6.2.1.2 Non-linear defects with major and minor dimensions shall be evaluated as of an equivalent estimated average circle. The estimated diameter shall be the size used in determining the acceptability of the defect and the area corresponding to this estimated diameter shall be used in calculating the area of a defect.

3.6.2.1.3 Tungsten inclusions shall be counted as porosity.

3.6.2.1.4 In a test weld with base metal thickness 0.063 in. (1.5 mm) and under, disregard all defects under 0.002 in. (0.05 mm) in size.

3.6.2.1.5 In a test weld with a base metal thickness over 0.063 in. (1.5 mm), disregard all defects under 0.005 in. (0.12 mm) or 0.02t in size, whichever is greater.

3.6.2.2 Fillet Weld Defects: Fillet welds in any thickness (t) of material which have any of the following defects are unacceptable:

3.6.2.2.1 Any crack.

3.6.2.2.2 Incomplete fusion at the weld face.

3.6.2.2.3 Overlap.

3.6.2.2.4 Undercut at any location in excess of 0.1t or 0.063 in. (1.5 mm), whichever is the lesser.

3.6.2.2.5 For base metal thickness 1.00 in. (25.0 mm) and under, a leg size less than t. For a base metal thickness over 1.00 in. (25.0 mm), the minimum leg size shall be more than 1 in. (25.0 mm). Where members of the test weld differ in thickness, the minimum leg size shall be based on the thinner member.

3.6.2.2.6 A ratio of the leg of larger size to the leg of smaller size greater than 1.5 at any cross section.

3.6.2.2.7 For a convex weld, an actual throat size under 0.5t at any cross section. Where members of the test weld differ in thickness, the minimum actual throat shall be based on the thinner member.

3.6.2.2.8 For a concave weld, an actual throat size of less than 0.5t at any cross section. Where members of the test weld differ in thickness, the minimum actual throat shall be based on the thinner member.

3.6.2.2.9 Any linear defect in excess of 0.3 times the actual throat size or 0.12 in. (3.0 mm), whichever is the lesser.

3.6.2.2.10 A total porosity area, on any cross section, greater than 0.05 times the area of the weld metal.

3.6.2.3 Fillet welds in sheet or tube with a base metal thickness (t) 0.063 in. (1.5 mm) and under, which have any of the following defects, are unacceptable:

3.6.2.3.1 Weld metal at a sheet or tube surface opposite the weld bead and extending more than t beyond the sheet or tube surface at any cross section.

3.6.2.3.2 A leg size larger than 6t or t plus 0.18 in. (4.5 mm), whichever is the lesser. Where members of the test weld differ in thickness, the maximum leg size shall be based on the thinner member.

3.6.2.3.3 Incomplete fusion, at either weld leg, as shown in Fig. 1, with a dimension b in excess of 0.3 times the actual throat size.

3.6.2.3.4 An individual pore size in excess of 0.6t, where t is the thickness of the thicker member of the test weld.

3.6.2.4 Fillet welds in sheet or tube with a base metal thickness over 0.063 in. (1.5 mm), which have any of the following defects, are unacceptable:

3.6.2.4.1 Fusion evident at any sheet or tube surface opposite the weld bead.

3.6.2.4.2 A leg size larger than 3t or t plus 0.25 in. (6.0 mm), whichever is the lesser. Where members of the test weld differ in thickness, the maximum leg size shall be based on the thinner member.

3.6.2.4.3 Less than complete fusion to the root of the joint as illustrated in Fig. 1.

3.6.2.4.4 An individual pore size in excess of 0.4t or 0.18 in. (4.5 mm), whichever is the lesser. Where the members of the test weld differ in thickness, t shall be based on the thickness of the thicker member.

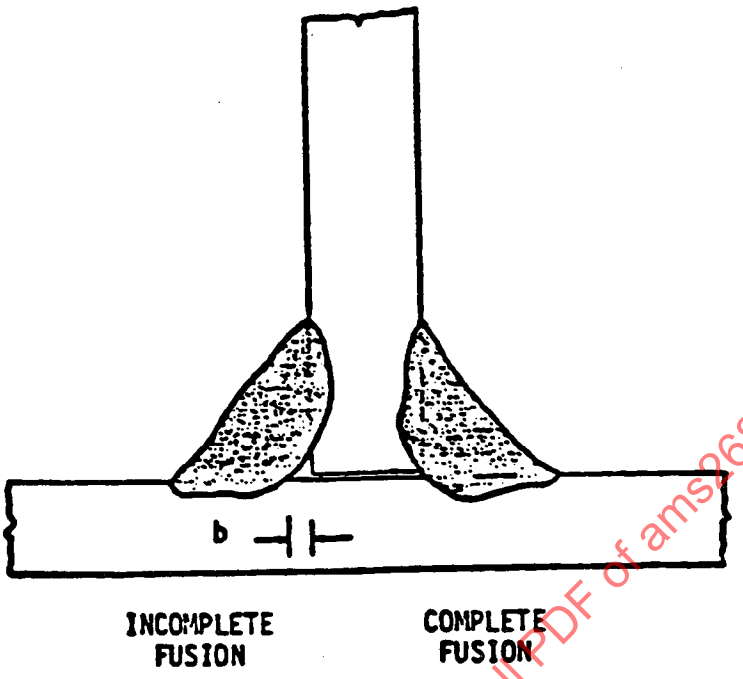

FIGURE 1 - COMPLETE AND INCOMPLETE FUSION IN FILLET WELDS

3.6.3 Welds shall be uniform in quality and condition, sound, and free from foreign materials and from imperfections detrimental to fabrication or to performance of assemblies. Welds shall have uniform surfaces and shall be clean. Welded joints shall fall evenly into the parent metal, shall be uniform in size and contour, and shall be free of incomplete fusion, overlaps, cracks, burn-through, or exessive undercutting.

3.6.4 Welds shall be produced under radiographic control. Examination shall consist of inspection of all welds in accordance with AMS 2635 until suitable techniques are established and thereafter at a frequency specified on the applicable drawing or as agreed upon by purchaser and vendor.

3.6.5 Welds shall be subjected to magnetic particle inspection in accordance with AMS 2640 or to fluorescent penetrant or contrast dye penetrant inspection in accordance with either AMS 2645 or AMS 2646 as specified.

3.6.6 Radiographic, magnetic particle, fluorescent penetrant, or contrast dye penetrant inspection, and other quality standards shall be as agreed upon by purchaser and vendor.