



AEROSPACE MATERIAL

Society of Automotive Engineers, Inc. SPECIFICATION

TWO PENNSYLVANIA PLAZA, NEW YORK, N. Y. 10001

AMS 2685

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Revised

WELDING, METAL 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 (AMS) shall apply. The applicable issue of other documents shall be as specified in AMS 2350.
 - 2.1 **SAE Publications:** Available from Society of Automotive Engineers, Inc., Two Pennsylvania Plaza, New York, New York 10001.
 - 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 2770 - Heat Treatment, Aluminum and Aluminum-Base Alloys
 - AMS 4901 - Titanium Plate, Sheet, and Strip, 70,000 psi Yield
 - 2.2 **AWS Publications:** Available from American Welding Society, 2510 North West Seventh Street, Miami, Florida 33125.
 - AWS A2.0 - Welding Symbols
 - AWS A3.0 - Terms and Definitions
 - 2.3 **Government Publications:** Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania, 19103.
 - 2.3.1 **Military Specifications:**
 - MIL-T-5021 - Tests, Aircraft and Missile Welding Operators Qualification
 - MIL-H-6875 - Heat Treatment of Steels (Aircraft Practice), Process for
 - MIL-H-81200 - Heat Treatment of Titanium and Titanium Alloys

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3. TECHNICAL REQUIREMENTS:

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

3.2 Qualification:

3.2.1 Welders (Manual Welding): All manual welding operations shall be performed by welders who are currently qualified to perform the same type of welding on the class of materials used in the assembly. Qualification shall be in accordance with MIL-T-5021.

3.2.2 Automatic Welding: Shall be performed on equipment mutually acceptable to purchaser and vendor.

3.3 Processing Schedule: The vendor of the product shall establish a schedule for processing of each welded assembly. This shall cover all significant operations and shall include, but not be limited to, the following:

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

Filler Metal - Alloy and wire sizes including applicable material specification

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

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

3.4 Cleaning and Surface Preparation: Surfaces to be joined shall be cleaned, prior to welding, by abrasive blasting, wire brushing, chemical etching, or using suitable solvents. Materials used for surface preparation shall have no deleterious effect on the parent metal or joint. After welding, assemblies shall be inspected and accepted prior to the prescribed post-cleaning operations.

3.5 Unless otherwise permitted, for all thermal operations, the assemblies shall be placed in a furnace conforming to the requirements of MIL-H-6875, AMS 2770 or MIL-H-81200, depending upon the type of alloy in the parent metal, heated to within the specified temperature range, held within that range for the time prescribed, and cooled as specified in the schedule. Facilities used for metals and alloys not covered by MIL-H-6875, AMS 2770 or MIL-H-81200 shall meet the temperature uniformity requirements of MIL-H-6875. The environment shall be as specified on the applicable drawing or as agreed upon by purchaser and vendor.

3.6 Filler Metal: Shall be as specified on the applicable drawing. When no filler metal is specified, the filler metal shall be compatible with the base metal. If no filler metal is specified for joints consisting of two or more parent metal alloys, the filler metal shall be as agreed upon by purchaser and vendor.

- 3.7 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. The areas to be welded and the heat affected zones of the parent metal shall be blanketed with an environment of dry argon containing not less than 99.995% argon plus other inert gases (helium, neon, krypton); 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). A mixture of dry argon and helium conforming to the above requirements of purity and dew point may be used.
- 3.7.1 Welding Chambers: Manual welding of titanium, titanium-base 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 a test piece conforming to AMS 4901, unless another material is specified, shall show no discoloration of the surface and the weld metal, 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.
- 3.7.2 Automatic Welding (Machine Welding): Assemblies may be welded without chambers with automatic machines using appropriate leading and/or trailing inert-gas shielding devices approved by the purchaser. A test bead made with this equipment shall be capable of meeting the analytical requirements of 3.7.1.
- 3.8 Welds: Welded joints shall fair evenly into the base metal, shall be uniform in size and contour, and shall be free of incomplete fusion, overlaps, cracks, splatter, burn-through, or excessive undercutting.
- 3.8.1 Dimensional Requirements: Weld beads shall conform to the dimensions specified on the applicable drawing. If dimensions are not specified, the following shall apply:
- 3.8.1.1 Face Reinforcement: Face height and root reinforcement, height of groove, slot, and plug welds shall not exceed the thickness of the thinner member of the joint on each side or $3/32$ in. (2.4 mm), whichever is smaller.
- 3.8.1.2 Penetration of plug or slot welds shall be complete throughout the joint.
- 3.8.1.3 Depth of penetration of edge, flange, and groove welds shall be not less than the thickness of the thinner member.
- 3.8.1.4 For single fillet welds, the leg size shall be 1-1/2 to 3 times the nominal thickness of the thinner member. For double fillet welds, the leg size shall be 1 to 2-1/2 times the nominal thickness of the thinner member.
- 3.8.1.4.1 The throat of each fillet weld from the root to the nominal weld surface measured at an angle midway between the face of the base metal sections shall be not less than 70% of the specified minimum nor more than the specified maximum leg length as defined in 3.8.1.4.
- 3.8.1.5 There shall be no lack of fusion at the root of fillet welds and the average penetration should be not less than 1% of the nominal thickness of the thinner member.
- 3.8.1.6 Melt-Through, Melt-Back, and Undercutting: If not otherwise specified, the following shall apply:
- 3.8.1.6.1 Melt-Through: Shall not be permitted on parts 0.06 in. (1.5 mm) or more in thickness. On parts less than 0.06 in. (1.5 mm), melt-through is permissible provided the buildup does not exceed 0.03 in. (0.8 mm) or the thickness of the base material, whichever is less.
- 3.8.1.6.2 Undercutting and/or Melt-Back: Shall not exceed the following:
- 3.8.1.6.2.1 Class A Welds: At any location, the thickness shall not be decreased more than 5% of the nominal thickness and the total length of reduced thickness sections shall not be more than 10% of the weld length.

- 3.8.1.6.2.2 Class B Welds: At any location, the thickness shall not be decreased more than 15% of the nominal thickness and the total length of reduced thickness sections shall not be more than 15% of the weld length.
- 3.8.1.7 Mismatch: Shall not exceed the following:
- 3.8.1.7.1 Class A Welds: Not more than 10% of the nominal thickness of the thinner member or 0.01 in. (0.3 mm), whichever is larger.
- 3.8.1.7.2 Class B Welds: Not more than 25% of the nominal thickness of the thinner member or 0.02 in. (0.5 mm), whichever is larger.
- 3.8.2 Porosity and Inclusions: Shall not exceed the following:
- 3.8.2.1 Class A Welds: The sum of the area of porosity and inclusions combined shall not exceed 2% of the area in any one linear inch (25 mm) of weld.
- 3.8.2.2 Class B Welds: The sum of the area of porosity and inclusions combined shall not exceed 6% of the area in any one linear inch (25 mm) of weld.
- 3.9 Quality:
- 3.9.1 Welds shall be uniform in quality and condition, sound, and free from foreign materials and from internal and external imperfections detrimental to fabrication or to performance of assemblies. Welds shall have uniform surfaces and shall be clean.
- 3.9.2 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.
- 3.9.3 Welds shall be subject to magnetic particle inspection in accordance with AMS 2640 or penetrant inspection in accordance with either AMS 2645 or AMS 2646 as specified.
- 3.9.4 Radiographic, magnetic particle, and penetrant inspection, and other quality standards shall be as agreed upon by purchaser and vendor.
- 3.9.5 Imperfections and Repairs: Should any area of a welded assembly fail to conform to the specified requirements, the vendor shall notify the purchaser in writing of the location and extent of each imperfection, stating the number of units in which each is located. If repair is authorized, the vendor shall remove all defective material and fair the surfaces smoothly to the adjacent metal prior to rewelding. Reprocessing shall be in accordance with the procedures of 3.3. Repaired areas shall be subject to radiographic inspection and to magnetic particle or penetrant inspection as applicable. Additionally, all other units of the lot shall be radiographically inspected in any area where imperfections were detected in one unit of the lot.
4. QUALITY ASSURANCE PROVISIONS:
- 4.1 Responsibility for Inspection: The welding fabricator shall supply all samples and shall be responsible for performing all required tests. Results of such tests shall be reported to the purchaser as required by 4.6. Purchaser reserves the right to perform such confirmatory testing as he deems necessary to assure that welded assemblies conform to the prescribed requirements. Records of welder's qualification tests, thermal processing cycles used, and specific lots of filler metal used with each lot of assemblies shall be maintained for two years from date of shipment and shall be made available for review by purchaser upon request.
- 4.1.1 Lot: A lot is defined as a group of assemblies of one configuration, processed at one time in sequence, and submitted for inspection at one time.