

NATIONAL AIRCRAFT STANDARDS COMMITTEE

AIRCRAFT INDUSTRIES ASSOCIATION OF AMERICA, INC., 610 SHOREHAM BUILDING, WASHINGTON 5, D. C.

1. APPLICATION:

1.1 Scope - This interim specification presents requirements for the following phases of the resistance spot and seam welding of commercially pure titanium.

- a. Applications of the process
- b. Permissible materials
- c. Qualification of equipment
- d. Certification of welding schedules
- e. Weld quality standards
- f. Process quality control

The requirements for seam welding are covered by section 9 and as otherwise noted herein.

2. APPLICABLE SPECIFICATIONS:

2.1 Qualification

- a. MIL-W-6858 Welding; Low Carbon Steel, Austenitic Steels, and Nickel Alloys, Spot and Seam (Supersedes AN-W-32)
- b. MIL-W-6860 Welding; Aluminum and Magnesium Alloys Spot and Seam (Supersedes AN-W-30)

2.2 Materials

- a. AMS 4900 Titanium Sheet and Strip Annealed - 55,000 psi yield
- b. AMS 4901 Titanium Sheet and Strip Annealed - 70,000 psi yield

3. MATERIALS:

3.1 Permissible Combinations - Commercially pure titanium listed in Section 2.2 may be welded in any combination.

① INACTIVE FOR DESIGN AFTER 1 NOVEMBER 1962
SEE MIL-W-6858

PREPARED BY AIRCRAFT RESEARCH AND TESTING COMMITTEE

APPROVAL DATE 7/15/54 REVISION 1 15 Nov. 1962

TITLE

SPECIFICATION FOR SPOT AND SEAM WELDING OF
COMMERCIALY PURE TITANIUM

CLASSIFICATION SPECIFICATION

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- 3.2 Surface Condition - The surfaces of the parts to be welded shall be free from objectionable films such as oxides, scale, ink, grease, dust, or other substances detrimental to the welding process.
- 3.3 Mating Parts - Mating parts assembled for welding shall fit so that before the first and each successive weld is made, the surfaces to be joined by the weld are in contact with each other or can be made to contact each other with manual pressure at the area where the weld is to be placed.

4. EQUIPMENT:

- 4.1 General - The welding equipment shall include a suitable source of electrical energy, a pair of electrodes, means for cooling the electrodes, means for applying force between the electrodes, and means of reliably controlling the force, the magnitude of the current, and the time of current flow.
- 4.2 Force-Current Relationship - The force and current controls shall operate so that no current flows until the welding force is applied at the welding electrodes. The current shall be cut off before the force is removed.
- 4.3 Control Settings - All machines shall be provided with suitable means for indicating directly or indirectly the settings for each variable which must be controlled in order to make satisfactory welds.
- 4.4 Maintenance of Equipment - Each item of equipment shall be inspected periodically. Adequate maintenance shall be furnished, and defective parts affecting machine operation shall be replaced before production welding is resumed.
- 4.5 Shear Testing Machine - The contractor shall provide one or more spotweld shear testing machines. The spot weld shear testing machines shall be checked for accuracy at intervals not to exceed 6 months. Testing machines which are not accurate within plus or minus 3 percent of the indicated reading or 10 pounds, whichever is the greater, shall be used with a prominently displayed calibration curve or chart.

5. QUALIFICATION OF SPOT WELDING MACHINES:

- 5.1 General - Qualification tests of welding machines shall be performed in order to determine the consistency of operation of the machines over the desired operating range. To have his equipment qualified, the contractor shall perform qualification tests according to MIL-W-6858 using ferrous, nickel alloy, or titanium test specimens, or according to MIL-W-6860 using aluminum or magnesium alloy test specimens, and shall retain all data in the company's files. Machines having effective qualifications under MIL-W-6858 or MIL-W-6860 shall be considered qualified to weld under this specification.

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- 5.2 Requalification - When the equipment has once been qualified, it need not be requalified for future contracts or production provided no change in range of setting is involved. A change of location within a plant, not involving a change in power line, does not necessitate requalification. Requalification shall be required if the machine is rebuilt or if significant operational changes are made therein.

6. CERTIFICATION OF SPOTWELDING PROCESS OR SCHEDULE:

- 6.1 Welding Schedule - The contractor shall establish suitable welding schedules for each material or permissible combination of dissimilar materials and each gage combination to be spot welded in production from the machine under consideration. Gage combinations falling within both of the following limits shall not require separate welding schedules.
- a. 20% variation in thickness of any outer sheet.
 - b. 10% variation in the overall thickness of the combination to be welded.

The welding schedule shall be established prior to the welding of production parts and shall include the procedure for preparation of the material, all details of the machine set-up, and the control settings for each machine to be used in production welding. Unless a smaller number of specimens is used as provided in section 10, the suitability of the schedules shall be demonstrated by making and testing of not less than 15 consecutive welds for each machine of each type. Test specimens conforming to Figure I shall be welded and tested.

- 6.1.1 Ten welds shall be tested in shear. The remaining welds shall be sectioned for macroscopic examination for internal defects. All welds shall meet the strength and quality requirements specified herein.

- 6.1.2 Machine Schedules - There shall be made readily available to the machine operators and authorized inspection personnel, for reference at any time, the proper machine settings for all variable controls and minimum spot shear strength for all alloys and thickness combinations welded on that machine.

6.2 Shear Strength Requirements

- 6.2.1 Minimum Requirements - The shear strength of each weld shall be in accordance with the minimum requirements of Table II. The failure of one weld shall be cause for rejection of the entire set, and the welding methods or equipment shall be modified and the test repeated, for the particular combination involved.

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THIS DRAWING SUPERSEDES ALL ANTECEDENT STANDARD DRAWINGS FOR THE SAME PRODUCT, AND SHALL BECOME EFFECTIVE FOR VENDOR MANUFACTURERS NOT LATER THAN 6 MONTHS AFTER THE LATEST DATE OF APPROVAL SHOWN.

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- 6.2.2 The average strength of each set of welds shall equal or exceed the average strength value shown in Table II for the thinnest gauge in the combination being welded.
- 6.2.3 Strength Consistency - A variation in shear strength of spot welds in titanium of $\pm 12\frac{1}{2}\%$ of the average value will be permitted in 80% of the specimens tested, and a variation of $\pm 25\%$ in the remaining specimens.
- 6.2.4 Multi Thickness - Combinations of three or more sheets shall be tested at each interface.

7. QUALITY STANDARDS:

- 7.1 Appearance - The outer surfaces of all spot welds prepared under this section shall be smooth, free of cracks, free of tip pick-up, free of pits, and essentially free of defects which indicate that the spot welds were made with dirty electrodes or an improperly prepared surface, or that undue penetration of the weld nugget has taken place.
- 7.1.1 External Defects - Except as noted in Section 8, the following defects are not acceptable: pits, surface flashes, tip pick-up, expulsion of metal between the sheets, external cracks, edge bulge cracks, and blown spots. Where aerodynamic considerations are a requisite, sheet separation between welds is not acceptable in excess of 0.004 inch, as measured at a distance from the edge of the weld approximately equal to half the diameter of the electrode indentation. In all other cases, sheet separation between welds is not acceptable if it is in excess of 10 percent of the thickness of the thinnest outer sheet joined or 0.005 inch whichever is greater.
- 7.1.2 Surface Indentation - Where aerodynamic considerations are a requisite, the electrode indentations shall not exceed 0.003 inches. In all other cases, electrode indentations are not acceptable if the depth exceeds 10 percent of the thickness of the sheet in which the indentation occurs, or 0.003 inches whichever is greater.
- 7.2 Penetration and Internal Defects - Weld penetration and soundness shall be determined by examination of an etched section through the center of spot welds in test specimens welded according to the production welding schedule. The outline of the fusion zone shall be substantially symmetrical and shall approximate a rectangle or an ellipse.
- 7.2.1 Internal Defects - The following constitute internal defects which may be detected by the macro etch test. The size of such defects shall not exceed the limits imposed below:

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