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Submitted for recognition as an American National Standard

**SILVER BRAZING
FOR USE UP TO 400 °F (204 °C)**

1. SCOPE:

1.1 Purpose:

This specification covers the engineering requirements for producing brazed joints in parts fabricated from steels, iron alloys, nickel alloys, cobalt alloys, and copper alloys by use of silver alloys, and the properties of such joints.

1.2 Application:

This procedure has been used typically for joints requiring high strength up to 400 °F (204 °C), but usage is not limited to such applications.

1.3 Warning:

Numerous scientific studies have determined that cadmium presents a health hazard to persons who are exposed to it.

1.4 Safety - Hazardous Materials:

While the materials, methods, applications, and processes described or referenced in this specification may involve the use of hazardous materials, this specification does not address the hazards which may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

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2. APPLICABLE DOCUMENTS:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications:

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

AMS 2403 Nickel Plating, General Purpose

AMS 2424 Nickel Plating, Low Stressed Deposit

AMS 3410 Flux, Silver Brazing

AMS 4770 Brazing Filler Metal, Silver, 50Ag - 18Cd - 16.5Zn - 15.5Cu,
1160 - 1175 °F (625 - 635 °C) Solidus - Liquidus Range

AMS 4771 Brazing Filler Metal, Silver, 50Ag - 16Cd - 15.5Zn - 15.5Cu -
3.0Ni, 1170 - 1280 °F (630 - 690 °C) Solidus - Liquidus Range

AMS 4774 Brazing Filler Metal, Silver, 63Ag - 28.5Cu - 6.0Sn - 2.5Ni,
1275 - 1475 °F (690 - 800 °C) Solidus - Liquidus Range

2.2 ASTM Publications:

Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM D 1179 Fluoride Ion in Water

ASTM D 1193 Reagent Water

2.3 U.S. Government Publications:

Available from Standardization Documents Order Desk, Building 4D, 700
Robbins Avenue, Philadelphia, PA 19111-5094.

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

MIL-STD-2073-1 DOD Materiel, Procedures for Development and Applications of
Packaging Requirements

3. TECHNICAL REQUIREMENTS:

3.1.1 Flux: Shall conform to AMS 3410 or other flux acceptable to purchaser.
(R)

3.1.2 Filler Metal: Shall conform to AMS 4770 or AMS 4771 except that AMS 4771
(R) shall be used for brazing austenitic corrosion-resistant steels. AMS 4774
shall be used when specified by purchaser (See 3.3.3.2).

3.2 Preparation:

3.2.1 Surface Condition: The surfaces to be joined shall be clean prior to
assembly. Surfaces shall not be highly polished.

3.2.2 Nickel Plating: Joint surfaces may be nickel plated in accordance with (R) AMS 2403 or AMS 2424; thickness of plating when used shall be 0.0001 - 0.0006 inch (2.5 - 15 μm). Plating shall be limited to the joint and adjacent fillet areas.

3.3 Procedure:

3.3.1 Fluxing: Flux shall be applied so that surfaces to be joined are completely coated.

3.3.2 Assembly:

3.3.2.1 Clearances: Parts shall be assembled so that the clearances between (R) mating surfaces are within tolerances specified on the drawing. Where no specific clearances are given, joint clearances shall be 0.001 to 0.004 inch (2.5 to 10 μm) or 0.002 to 0.005 inch (5 to 12.7 μm) across a diameter.

3.3.2.2 Filler Metal Placement: When preplaced, sufficient filler metal shall (R) be placed at only one end of the joint. When hand fed, filler metal shall be fed from only one end of the joint. Not more than 15% of the mating surfaces may be shimmed with filler metal to aid in setting clearances.

3.3.2.3 Fixturing: The assembly shall be supported so that parts will be in (R) proper alignment after brazing. Staking and prick punching may be used where applicable provided they are completely covered with filler metal in the completed assembly.

3.3.2.3.1 Fusion arc tack welding is not permitted. (R)

3.3.2.3.2 Tack welding is not permitted on tube joints. (R)

3.3.3 Heating for Joining: May be accomplished by any convenient means, such as (R) furnace, induction, resistance, salt bath or torch, unless a specific method is required by purchaser, subject to the following restrictions:

3.3.3.1 Methods that heat entire assemblies, such as furnaces or salt baths, may (R) be used only when hardness of the detail parts will not be reduced below drawing limits.

3.3.3.2 When AMS 4770 or AMS 4771 filler metal is used, the maximum temperature (R) shall not exceed 1350 °F (732 °C). When AMS 4774 filler metal is specified, the maximum temperature should not exceed 1550 °F (843 °C), unless otherwise permitted by purchaser. Parts shall be heated for sufficient time to form the joint, with further heating kept to a minimum.

3.3.3.3 (R) Furnace atmospheres, salts, and fluxes shall be such that parts are protected from surface contamination such as carburization, decarburization, dezincification, oxidation, or other changes in surface character.

3.3.3.4 (R) A neutral flame shall be used for torch brazing.

3.3.3.5 Silver brazing by torch method shall be performed only by operators who have been qualified, by a procedure acceptable to purchaser, to braze the metals specified for each assembly. Vendor shall have qualification requirements and procedures for testing operations to show conformance to this requirement.

3.3.4 Cooling: After brazing, but prior to handling, assemblies shall be cooled for sufficient time to allow the filler metal to solidify and in such a manner as to prevent cracks and minimize internal stress, distortion, and scaling.

3.3.5 (R) Flux Removal: After brazing and cooling, flux shall be removed by any method not injurious to the base material and specified surface finish.

3.4 Properties:

Brazed parts shall conform to the following requirements:

3.4.1 Coverage:

3.4.1.1 (R) Examination of all visible joint edges shall show presence of brazing filler metal for 100% of each joint.

3.4.1.2 (R) The area joined by filler metal shall be not less than 80% of the area of the mating portions of the assembly. The test for coverage may be destructive, as in tear tests or metallographic cross-sectioning, or non-destructive, as in radiography or ultrasonic inspection. The test method shall be any method acceptable to purchaser.

3.4.2 Proof Test: When a proof test is specified on the drawing, any assembly from a lot shall pass that test.

3.4.3 (R) Halide Tests: Tests shall be conducted on brazed assemblies to ensure that residual halide-containing fluxes have been removed. If the flux is known not to contain chlorides or fluorides, the test for chlorides or fluorides, as applicable, need not be done. If tests indicate the presence of halides, all parts shall be subjected to additional cleaning and testing until removal is complete. In case of dispute, the methods of 3.4.3.1 and 3.4.3.2 shall apply.

3.4.3.1 Chlorides: Rinse the test area with 40 - 50 mL of hot (approximately 180 °F (82 °C)) ASTM D 1193, Type IV, water. Collect the rinse water in a 100 mL beaker and add 3 - 5 drops of concentrated nitric acid (sp. gr. 1.42) and 2 - 3 mL of 10% silver nitrate solution. Stir the contents of the beaker and allow to stand 5 - 10 minutes. A resultant solution as clear as a blank of ASTM D 1193, Type IV, water, treated in the same manner as the rinsings, indicates the absence of chlorides. A white-to-gray precipitate or turbidity indicates the presence of residual flux.

3.4.3.2 Fluorides: Rinse the test area with approximately 200 mL of hot (approximately 180 °F (82 °C)) ASTM D 1193, Type IV, water. Collect the rinse water in a 250 mL beaker. Using two 100 mL Nessler or equivalent color comparison tubes, pour 100 mL of the rinsings into one tube, and 100 mL of ASTM D 1193, Type IV, water, into the other as a blank. Treat the water in the two tubes in accordance with ASTM D 1179, Method B, or use an equivalent colorimetric method. Allow the color to develop. A color in the rinse water deeper than that of the blank indicates the presence of residual flux.

3.5 Quality:

3.5.1 Brazed joints shall be sound, clean, and free from foreign materials and from imperfections detrimental to performance of the brazed joints.

3.5.1.1 Surfaces shall be free from carburization, decarburization, dezincification, nitriding, and heavy temper color or scale.

3.5.1.2 Surfaces of assemblies shall be free from pitting, burning, and from excessive filler metal that may interfere with form, fit, or function.

3.5.1.3 Joints shall be free from cracks and from unflowed filler metal.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

(R)

The vendor of brazed assemblies shall supply all samples for vendor's tests and shall be responsible for performing all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the product conforms to the requirements of this specification.

4.2 Classification of Tests:

(R)

Tests for all technical requirements are acceptance tests and preproduction tests and shall be performed prior to or on the initial shipment of processed parts to a purchaser, on each lot, when a change in material and/or processing requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.

4.2.1 For direct U.S. Military procurement, substantiating test data and, when requested, preproduction test material shall be submitted to the cognizant agency as directed by the procuring activity, contracting officer, or request for procurement.

4.3 Sampling and Testing:
(R)

Shall be not less than the following: a lot shall be all assemblies of the same part number brazed in the same furnace or immersion load, or in the same shift for parts processed one at a time, and presented for vendor's inspection at one time. In preproduction tests, at least one joint shall be destructively examined for braze coverage and for evidence of carburization, decarburization, nitriding, and other deleterious effects.

4.3.1 Visual: Each assembly.
(R)

4.3.2 Proof Test: As specified. Where a proof test is specified and no
(R) frequency is given, the minimum number of tests shall conform to MIL-STD-105, acceptance number = 0.

4.3.3 Internal Coverage: One assembly per lot unless a sampling plan is
(R) specified by purchaser.

4.3.4 Halide Test: As required to ensure that all assemblies are free from residual flux but not less than once each working shift.

4.4 Approval:

4.4.1 The process, control, and inspection methods used for processing parts,
(R) and, when specified, sample assemblies brazed to the requirements of this specification shall be approved by purchaser before parts for production use are supplied, unless such approval be waived by purchaser.

4.4.2 Vendor shall use a brazing process, flux, filler metal, filler metal
(R) placement, type of equipment, environment, brazing cycle, and methods of inspection for production assemblies which are essentially the same as those used on preproduction sample assemblies. Production assemblies brazed by a revised procedure shall not be shipped prior to complete preproduction testing of the revised procedure. Where sample assemblies are required by purchaser, production assemblies brazed by a revised procedure shall not be shipped until a sample assembly brazed to the revised procedure is approved by purchaser.

4.5 Reports:
(R)

The vendor of brazed parts shall furnish with each shipment a report stating that the parts have been brazed and tested in accordance with the requirements of this specification and that they conform to the acceptance test requirements. This report shall include the purchase order number, lot number, AMS 2665E, part number, quantity, and braze filler metal used. Where proof tests are required, the report shall state the method of proof tests and the results of all tests.