AN AMERICAN NATIONAL STANDARD

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AEROSPACE MATERIAL SPECIFICATION

SAE AMS 2664E

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Superseding AMS 2664D

BRAZING, SILVER
For Use Up to 800°F (427°C)

1. SCOPE:

1.1 Purpose: This specification covers the engineering requirements for producing brazed joints in parts made of steels, iron alloys, nickel alloys, and cobalt alloys by use of silver alloy filler metals, and the properties of such joints.

1.2 Application: Primarily for joints requiring high strength up to 800°F (427°C).

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.

2.1.1 Aerospace Material Specifications:

AMS 2403 - Plating Nickel, General Purpose
AMS 2424 - Plating Nickel, Low Stressed Deposit
AMS 2635 - Radiographic Inspection
AMS 3411 - Flux, Silver Brazing, High Temperature
AMS 3417 - Flux, Brazing, High Temperature
AMS 4765 - Filler Metal, Silver, Brazing, 56Ag - 42Cu - 2.0Ni, 1420° - 1640°F (771° - 893°C) Solidus-Liquidus Range
AMS 4772 - Brazing Filler Metal, Silver, 54Ag - 40Cu - 5.0Zn - 1.0Ni, 1325° - 1575°F (718° - 857°C) Solidus-Liquidus Range
AMS 4774 - Brazing Filler Metal, Silver, 63Ag - 28.5Cu - 6.0Sn - 2.5Ni, 1275° - 1475°F (691° - 802°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-453 - Inspection, Radiographic
MIL-STD-2073-1 - DOD Materiel, Procedures for Development and Application of Packaging Requirements

3. TECHNICAL REQUIREMENTS:

3.1 Materials:

3.1.1 Flux: Shall conform to AMS 3411, AMS 3417, or other flux acceptable to Ø purchaser.

3.1.2 Filler Metal: Shall conform to AMS 4765, AMS 4772, or, when specified, Ø AMS 4774. AMS 4765 is recommended for brazing in protective atmopheres. AMS 4772 is recommended for use with flux.

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 (Required for Induction and Furnace Brazing Without Flux): Ø Joint surfaces on parts made of any steel or alloy having a specified titanium or aluminum content, either as a maximum or a range, shall be nickel plated in accordance with AMS 2403 or AMS 2424, except that plating will not be required on materials in which the specified maximum titanium content is not greater than 0.30% or the specified maximum aluminum content is not greater than 0.20% or the specified maximum sum of aluminum plus titanium contents is not greater than 0.50%. Thickness of plating shall be 0.0001 - 0.0006 inches (2.5 - 15.0 µm). Plating shall not extend beyond the intended joint plus fillet surfaces.

3.2.2.1 Nickel plating may be used on steels and alloys not having a specified titanium or aluminum content when such parts are to be brazed in an atmosphere permitted in 3.3.3.2.

3.2.3 Post Plating Stress Relief Treatment: Prior to brazing, it is recommended Ø that nickel plated parts be induction heated to 1825°F ± 50 (996°C ± 28) and held at heat for not less than 10 seconds to avoid stress corrosion. Induction heating to 1825°F ± 50 (996°C ± 28) shall be required for all nickel plated tube joints. Stress relief is not required for parts to be furnace brazed.

3.3 Procedure:

3.3.1 Fluxing: Unless parts are to be brazed in a protective atmosphere as defined in 3.3.3.2, flux as specified in 3.1.1 shall be applied so that the surfaces to be joined are completely coated.

3.3.2 Assembly:

3.3.2.1 Clearances: Detail parts, after nickel plating, when plating is used, Ø shall be assembled so that the clearances between mating surfaces are within tolerances specific on the drawing. Where clearances are not given, joint clearance shall be as follows:

Diametrally Measured Joints (e.g. Tube to Sleeve Joints)	0.002 - 0.005 inch (0.051 - 0.127 mm)
Lap or Butt Joints	
Furnace Brazed	0.001 - 0.004 inch (0.025 - 0.102 mm)
Other than furnace brazed	0.001 - 0.005 inch (0.025 - 0.127 mm)

3.3.2.2 Filler Metal Preplacement: Sufficient filler metal shall be fed or Ø preplaced, at or in close proximity to only one end of the joint, to completely fill 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 Ø proper alignment after brazing. Fusion (arc) tack welding is not permitted. Tack welding of tube assemblies is not permitted. Staking and prick punching may be used where applicable provided they are completely covered with filler metal in the completed assembly.

3.3.3 Joining: Shall be accomplished by furnace heating in a protective Ø atmosphere as defined in 3.3.3.2, by induction heating with an atmosphere as in 3.3.3.2 surrounding the work, or by using flux and furnace heating, induction heating, or neutral flame torch heating, unless a specific method of heating is specified. Parts shall be heated until the joint is formed. Further heating shall be held to a minimum. Brazing temperature shall not exceed 1900°F (1038°C).

3.3.3.1 When permitted by purchaser, resistance heating may be used for producing nonstructural joints, such as spacing collars on tubes, provided that the heating is accomplished by passing the current through one member of the joint, so that the resistance of the part rather than the resistance across the joint is the source of heating, and, provided that brazing is done in a protective atmosphere as defined in 3.3.3.2.

3.3.3.2 Protective atmospheres for brazing shall be one of the following:

3.3.3.2.1 Hydrogen, 99.95% minimum purity and dew point not higher than -25°F Ø (-32°C).

3.3.3.2.2 Argon of not less than 99.99% purity and dew point not higher than -35°F (-37°C).

3.3.3.2.3 Ø Mixtures of hydrogen and argon as specified in 3.3.3.2.1 and 3.3.3.2.2 in any proportion.

3.3.3.2.4 Ø Vacuum, absolute pressure not exceeding 20 microns (20 µm) of mercury (Hg). Backfilling with argon, up to 20 microns (20 µm) of mercury, is permitted.

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, oxidation, decarburization, and scaling.

3.3.5 Flux Removal: After brazing and cooling, flux shall be removed by a method not injurious to the specified surface finish. The tests of 3.4.3, or equivalent, shall be used to determine that flux has been adequately removed.

3.4 Properties: Brazed parts shall conform to the following requirements:

3.4.1 Coverage:

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

3.4.1.2 Ø The area joined by filler metal shall not be less than 80% of the mating portions of the assembly.

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 Halide Tests: Tests shall be conducted on brazed assemblies to ensure that residual halide-containing flux has been removed.

3.5 Quality:

3.5.1 Ø Brazed joints shall be sound, clean, and free from foreign materials and from imperfections detrimental to performance of the brazed joints. Surfaces shall be free from carburization, decarburization, nitriding, and heavy temper color or oxidation.

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

3.5.3 Ø Joints shall be free from cracks and from unflowed filler metal.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Ø Responsibility for Inspection: 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 processing conforms to the requirements of this specification.

4.2 Classification of Tests: Tests for all technical requirements are Ø acceptance tests and preproduction tests and shall be performed prior to or on the initial shipment of brazed parts to a purchaser, on each lot, when a change in material and/or processing requires reapproval as in 4.4.3, 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: Shall be not less than the following; a lot shall be Ø all assemblies of the same part number brazed in the same operator's work shift, or, for furnace brazing, in the same furnace load, and presented for vendor's inspection at one time.

4.3.1 Visual: Each assembly.
Ø

4.3.2 Proof Test: One assembly per lot.

4.3.3 Coverage:

4.3.3.1 The test for internal coverage may be destructive as in tear testing or Ø metallographic cross-sectioning, or may be non-destructive as in ultrasonic or radiographic inspection. The test method shall be any method acceptable to purchaser.

4.3.3.2 When coverage is determined metallographically or by tear test, test Ø frequency shall be not less than one part per lot or one part per 1000 parts brazed, whichever is more frequent.

4.3.3.3 When coverage is determined non-destructively, as for example, Ø radiography in accordance with AMS 2635 or MIL-STD-453, or ultrasonic inspection of joints in accordance with a specification supplied by purchaser, the minimum number of parts to be tested shall be in accordance with MIL-STD-105.

4.3.3.4 Examination for braze internal coverage may be waived when parts are Ø proof tested in accordance with instructions from purchaser.

4.3.4 Halide Test: As required to ensure that all assemblies are free from Ø residual flux, but not less than once each working shift. If the flux is known not to contain fluorides or chlorides, the test for fluorides or chlorides, as applicable, need not be done. If tests indicate the presence of halide, all parts shall be subjected to additional cleaning and testing operations until removal is complete. In case of dispute, the methods of 4.3.4.1 and 4.3.4.2 shall apply.

4.3.4.1 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 resulting 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.

4.3.4.2 Fluorides: Rinse the test area with approximately 200 mL of hot
Ø (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, and allow the color to develop. A color in the washings deeper than that of the blank indicates the presence of residual flux.

4.3.5 For preproduction testing, at least one joint shall be destructively
Ø examined for braze coverage and for evidence of carburization, decarburization, nitriding, and other deleterious surface effects.

4.4 Approval:

4.4.1 The process, controls, and inspection methods used for processing parts
Ø 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 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.

4.4.3 Vendor shall use a brazing process, flux, filler metal, filler metal
Ø placement, type of equipment, environment, brazing cycle, and methods for inspection for production assemblies which are essentially the same as those used on the approved sample assemblies. If necessary to make any change in type of equipment, processes, or procedures, vendor shall submit for reapproval of the process a statement of the proposed changes in processing and, when requested, sample assemblies. Production assemblies brazed by the revised procedure shall not be shipped prior to receipt of reapproval.