AEROSPACE MATERIAL SPECIFICATION

AMS2664	REV. F

Issued 1968-05
Revised 1995-07
Reaffirmed 2014-07

Superseding AMS2664E

Brazing, Silver
For Use Up to 800 °F (427 °C)

RATIONALE

AMS2664F has been reaffirmed to comply with the SAE five year review policy.

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:

This process has been used typically for joints requiring high strength up to 800 ºF (427 ºC), but usage is not limited to such applications.

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 Plating, Nickel, General Purpose
AMS 2424 Plating, Nickel, Low Stressed Deposit
AMS 3411 Flux, Silver Brazing, High Temperature
AMS 3417 Flux, Brazing, High Temperature

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/AMS2664F

2.1 (Continued):

AMS 4765 Filler Metal, Silver, Brazing, 56Ag - 42Cu - 2.0Ni, 1420 to 1640 ºF (771 to 893 ºC) Solidus-Liquidus Range
AMS 4772 Silver Alloy Brazing Filler Metal, 54Ag - 40Cu - 5.0Zn - 1.0Ni, 1325 to 1575 ºF (718 to 857 ºC) Solidus-Liquidus Range
AMS 4774 Silver Alloy Brazing Filler Metal, 63Ag - 28.5Cu - 6.0Sn - 2.5Ni, 1275 to 1475 ºF (691 to 802 ºC) 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 DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

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 purchaser.

3.1.2 Filler Metal: Shall conform to AMS 4765, AMS 4772, or, when specified, 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 polished.

3.2.2 Nickel Plating (Required for Induction and Furnace Brazing Without Flux): 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 percent. Thickness of plating shall be 0.0001 to 0.0006 inch (2.5 to 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 (R) Post Plating Stress Relief Treatment: Prior to brazing, nickel plated tube joints shall be induction heated to 1850 ºF ± 50 (1010 ºC ± 28) and held at heat for not less than ten seconds to avoid stress corrosion. Other parts may also be stress relieved, as required, to avoid stress corrosion. Stress relief prior to brazing 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, shall be assembled so that the clearances between mating surfaces are within tolerances specified on the drawing. Where clearances are not specified, joint clearance shall be as shown in Table 1.

TABLE 1 - Joint Clearance

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

3.3.2.2 Filler Metal Preplacement: Sufficient filler metal shall be fed or 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 (R) Fixturing: The assembly shall be supported so that parts will be in proper alignment after brazing. Unless otherwise specified, fusion arc 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 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, (See 3.3.3.3), 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 ºF (1038 ºC).

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 ºF (-32 ºC).

3.3.3.2.2 Argon of not less than 99.99% purity and dew point not higher than -35 ºF (-37 ºC).

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

3.3.3.3 Silver brazing by the torch method shall be performed only by operators who have been qualified, by a procedure acceptable to purchaser, to braze metals specified for each assembly.

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 a manner which prevents cracks and minimizes internal stress, distortion, oxidation, decarburization, and scaling.

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

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

3.4.1 Coverage:

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

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

3.4.2 (R) Proof Pressure Test: When specified by purchaser, any part from a lot shall pass the proof pressure test.

3.5 Quality:

3.5.1 Brazed joints, as received by purchaser, 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, nitriding, dezincification, and heavy temper color or oxidation.

3.5.1.2 Surfaces of assemblies shall be free from pitting and burning, and free 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.

3.5.1.4 (R) Surfaces of brazed parts shall be free of residual flux.

4. QUALITY ASSURANCE PROVISIONS:

4.1 (R) Responsibility for Inspection:

The processor of brazed assemblies shall supply all samples for processor's tests and shall be responsible for performing all required tests. Parts, if required for test, shall be supplied by purchaser. 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:

4.2.1 (R) Acceptance Tests: All technical requirements, except for presence of carburizing, decarburizing, nitriding, and dezincification (3.5.1.1), are acceptance tests and shall be performed on each lot.

4.2.2 (R) Preproduction Tests: All technical requirements are preproduction tests and shall be performed prior to or on the initial shipment of brazed parts to a purchaser, when a change in material and/or processing requires approval by the cognizant engineering organization (See 4.4.2), and when purchaser deems confirmatory testing to be required. For preproduction testing, at least one joint shall be destructively examined for braze coverage and for evidence of carburization, decarburization, nitriding, dezincification, and other deleterious effects.

4.2.2.1 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 that shown in Table 2, with samples selected randomly from the lot, unless another sampling plan is specified by purchaser. A lot shall be all parts of the same part number brazed in the same operators work shift, or, for furnace brazing, in the same furnace load, and presented for processor's inspection at one time.

TABLE 2 - Sampling for Acceptance Testing

Number of Parts	Quality (See 4.3.1)	Tests (See 4.3.2)	Tests (See 4.3.3)
1 to 6	All	3	0
7 to 15	All	4	0
16 to 40	All	4	0
41 to 110	All	5	1
111 to 300	All	6	2
301 to 500	All	7	3
501 to 700	All	8	5
701 to 1200	All	10	7
over 1200	All	15	10

4.3.1 Quality includes close visual inspection of all joints for completeness of fillet and absence of visual residual flux.

4.3.2 Tests include braze internal coverage tests (3.4.1.1) when determined non-destructively, proof pressure (3.4.2) tests, and, when halide-containing fluxes are used, tests for residual halides (4.3.4).

4.3.3 The test for internal coverage may be destructive as in tear testing or metallographic cross-sectioning, or may be non-destructive as in ultrasonic or radiographic inspection. The test method shall be any method acceptable to purchaser. When determined metallographically or by tear test, test frequency shall be as shown. Where determined metallographically or by tear test, test frequency shall be as shown. Where individual lots are smaller than 41 parts, the frequency shall be one part for each forty parts brazed, regardless of the lot sizes or frequencies.

4.3.4 Halide Test: If the flux is known not to contain fluorides or chlorides, the test for fluorides or

(R) chlorides, as applicable, need not be performed. If tests indicate the presence of halide, all parts shall be subjected to additional cleaning and testing operations until removal is complete. Test methods are not specified. Commercial test kits are available for qualitative analysis for fluorides. However, in case of dispute the following referee test methods shall apply:

4.3.4.1 Chlorides: Rinse the test area with 40 to 50 ML of hot (approximately 180 ºF (82 ºC)) ASTM D 1193, Type IV, water. Collect the rinse water in a 100 mL beaker and add 3 to 5 drops of concentrated nitric acid (sp gr 1.42) and 2 to 3 mL of 10% silver nitrate solution. Stir the contents of the beaker and allow to stand 5 to 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 (R) Fluorides: Rinse the test area with approximately 200 mL of hot (approximately 180 ºF (82 ºC)) ASTM D 1193, Type IV, water. Collect the rinse water in a 250 mL beaker. Use approximately 200 mL of ASTM 1193, Type IV, water as a comparison sample. Test both samples in accordance with ASTM D 1179. A higher concentration of fluoride in the rinse water than in the comparison sample indicates the presence of fluoride containing residual flux.

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

4.4 Approval:

4.4.1 (R) The process and control factors, a preproduction sample brazed part, or both, whichever is specified by purchaser, shall be approved by the cognizant engineering organization before production parts are supplied.

4.4.2 The processor shall make no significant change to materials, processes, or control factors from those on which approval was based, unless the change is approved by the cognizant engineering organization. A significant change is one which, in the judgment of the cognizant engineering organization, could affect the properties of the parts.

4.4.3 (R) Control factors shall include, but are not limited to, the following:

Brazing flux or atmosphere used
Braze filler metal
Placement of filler metal
Type of heating equipment
Brazing cycle
Method of flux removal

4.5 Reports:

The processor of brazed parts shall furnish with each shipment a report stating that the parts have been brazed and tested in accordance with specified requirements and that they conform to the acceptance test requirements. This report shall include the purchase order number, lot number, AMS 2664F, part number, and quantity. The report shall state the braze filler metal used, flux used if any, and the heating method such as torch, induction, or furnace. Where proof tests are required, the report shall state the method of proof test and results of all tests, including retests.