

# AEROSPACE MATERIAL SPECIFICATION



AMS 2665F

Issued DEC 1947  
Revised FEB 1996

Superseding AMS 2665E

Submitted for recognition as an American National Standard

## BRAZING, SILVER 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, which is used in some brazing alloys, presents a health hazard to persons if ingested.

#### 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.

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user"

SAE reviews each technical report at least every five years at which time it may be reaffirmed, revised, or canceled. SAE invites your written comments and suggestions.

## 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 3410	Flux, Silver Brazing
AMS 4763	Silver Alloy Brazing, Filler Metal, 56Ag - 22Cu - 17Zn - 5.0Sn, 1145 to 1205 °F (618 to 652 °C) Solidus - Liquidus Range
AMS 4770	Silver Alloy Brazing Filler Metal, 50Ag - 18Cd - 16.5Zn - 15.5Cu, 1160 to 1175 °F (629 to 635 °C) Solidus - Liquidus Range
AMS 4771	Silver Alloy Brazing Filler Metal, 50Ag - 16Cd - 15.5Zn - 15.5Cu - 3.0Ni, 1170 to 1270 °F (630 to 688 °C) Solidus - Liquidus Range
AMS 4773	Silver Alloy Brazing Filler Metal, 60Ag - 30Cu - 10Sn, 1115 to 1325 °F (602 to 718 °C), Solidus - Liquidus Range
AMS 4774	Silver Alloy Brazing Filler Metal, 63Ag - 28.5Cu - 6.0Sn - 2.5Ni, 1275 to 1475 °F (691 to 802 °C) Solidus - Liquidus Range
AMS 4788	Silver Alloy Brazing, Filler Metal, 50Ag - 28Zn - 20Cu - 2.0Ni, 1220 to 1305 °F (660 to 707 °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 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:

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

3.1.2 Filler Metal: Shall conform to AMS 4763, AMS 4770, or AMS 4771 except that AMS 4771 (R) shall be used for brazing austenitic corrosion-resistant steels. AMS 4773, AMS 4774, or AMS 4788 may be used when permitted 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 polished.

3.2.2 Nickel Plating: Joint surfaces may be nickel plated in accordance with AMS 2403 or AMS 2424: thickness of plating, when used, shall be 0.0001 to 0.0006 inch (2.5 to 15  $\mu\text{m}$ ). 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 mating surfaces are within tolerances specified on the drawing. Where specific clearances are not given, joint clearances shall be 0.001 to 0.004 inch (2.5 to 10  $\mu\text{m}$ ) or 0.002 to 0.005 inch (5 to 12.7  $\mu\text{m}$ ) across a diameter.

3.3.2.2 Filler Metal Placement: When preplaced, sufficient filler metal shall 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 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 Unless otherwise specified, fusion-arc tack welding is not permitted on tube joints.

(R)

3.3.3 Heating for Joining: May be accomplished by any convenient means, such as furnace, (R) induction, resistance, molten 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 molten salt baths, may be used (R) only when hardness of the detail parts will not be reduced below drawing limits.

3.3.3.2 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. Processor shall have qualification requirements and procedures for testing operations to show conformance to this requirement.

- 3.3.3.3 (R) When AMS 4763, AMS 4770, or AMS 4771 filler metal is used, the maximum temperature shall not exceed 1350 °F (732 °C). When AMS 4773 or AMS 4788 is used, the maximum temperature should not exceed 1450 °F (788 °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.
- 3.3.3.4 (R) Furnace atmospheres, molten salts, and fluxes shall be such that parts are protected from surface contamination, such as carburization, decarburization, dezincification, or oxidation, or other changes in surface character.
- 3.3.3.5 A neutral flame shall be used for torch brazing.
- 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 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 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 area of the mating portions of the assembly.
- 3.4.2 Proof Pressure Test: When specified on the drawing, any assembly from a lot shall pass that test.
- 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, and 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.

3.5.1.4 Surfaces of brazed parts shall be free of residual flux.

#### 4. QUALITY ASSURANCE PROVISIONS:

##### 4.1 Responsibility for Inspection:

(R)

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 testing, shall be supplied by purchaser. 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:

4.2.1 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 Preproduction Tests: All technical requirements are preproduction tests and shall be performed prior to or on the initial shipment of brazed assemblies 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.

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 1, with samples selected randomly from the lot, unless another sampling plan is specified by purchaser. 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 processor'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, dezincification, and other deleterious effects.

TABLE 1 - Sampling for Acceptance Tests

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 proof pressure (3.4.2) and braze internal coverage when determined nondestructively, 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 nondestructive 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 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 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 performed. If tests indicate the presence of halides, all parts shall be subjected to additional cleaning and testing until removal is complete. Test methods are not specified. Commercial test kits are available for simple qualitative analysis for fluorides. However, in case of dispute the following test methods shall apply:
- 4.3.4.1 Chlorides: Rinse the test area with 40 to 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 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 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.

4.3.4.2 Fluorides: Rinse the test area with approximately 200 mL of hot (approximately 180 °F (R) (82 °C)) 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.

#### 4.4 Approval:

4.4.1 The process and control procedures, 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 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 2665F, part number, quantity, and braze filler metal used. Where proof pressure tests are required, the report shall state the method of test and the results of all tests.

#### 4.6 Resampling and Retesting:

4.6.1 If results of any nondestructive test fails to meet the specified requirements, all parts shall be inspected for that requirement. Parts that conform to requirements shall be accepted: parts that are nonconforming may be reworked as required or shall be subject to rejection.

4.6.2 If results of any destructive test fails to meet the specified requirements, disposition of the parts may be based on the destructive testing of three additional parts for each original nonconforming part. Failure of any retest part to meet the specified requirements shall be cause for rejection of the parts represented. Results of all tests shall be reported.