# AEROSPACE MATERIAL SPECIFICATION

| AMS2665™ | REV. J |
|---|---|

Issued 1947-12
Reaffirmed 2018-08
Revised 2023-05

Superseding AMS2665H

## Brazing, Silver for Use up to 400 °F (204 °C)

RATIONALE

AMS2665J results from a Five-Year Review and update of this specification with the addition of ordering information, addition of equipment and pyrometry (3.3), addition of method to be agreed upon for coverage (3.6.1.2), added testing for residual flux to 3.6.1.4 and moved to 3.6.3, reworded acceptance tests for clarity (4.2.1), and added test method for coverage to control factors (4.4.3).

NOTICE

ORDERING INFORMATION: The following information shall be provided to the brazing processor by the purchaser.

1. Purchase order shall specify not less than the following:
   - AMS2665J
   - Quantity of pieces to be brazed
   - Material types of components being joined
   - Applicable CEO engineering drawings
   - Filler metal if specific type is to be used (3.2)
   - Method for determining coverage (3.5.1.2)
2. Parts manufacturing operations such as heat treating, forming, joining, and media finishing can affect the condition of the substrate for brazing or, if performed after brazing, could adversely affect the brazed part. The sequencing of these types of operations should be specified by the cognizant engineering organization or purchaser and is not controlled by this specification.



## 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.



**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**

**For more information on this standard, visit**
https://www.sae.org/standards/content/AMS2665J/

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 inhaled.

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.

2. APPLICABLE DOCUMENTS

The issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-7323 (outside USA), www.sae.org.

AMS2403 Plating, Nickel, General Purpose

AMS2424 Plating, Nickel, Low-Stressed Deposit

AMS2750 Pyrometry

AMS3410 Flux, Silver Brazing

AMS4763 Silver Alloy, Brazing Filler Metal, 56Ag - 22Cu - 17Zn - 5.0Sn, 1145 to 1205 °F (618 to 652 °C) Solidus-Liquidus Range

AMS4770 Silver Alloy Brazing Filler Metal, 50Ag - 18Cd - 16.5Zn - 15.5Cu, 1160 to 1175 °F (627 to 635 °C) Solidus-Liquidus Range

AMS4771 Silver Alloy, Brazing Filler Metal, 50Ag - 16Cd - 15.5Zn - 15.5Cu - 3.0Ni, 1170 to 1270 °F (632 to 688 °C) Solidus-Liquidus Range

AMS4773 Silver Alloy, Brazing Filler Metal, 60Ag - 30Cu - 10Sn, 1115 to 1325 °F (602 to 718 °C), Solidus-Liquidus Range

AMS4774 Silver Alloy Brazing Filler Metal, 63Ag - 28.5Cu - 6.0Sn - 2.5Ni, 1275 to 1475 °F (691 to 802 °C) Solidus-Liquidus Range

AMS4788 Silver Alloy Brazing Filler Metal, 50Ag - 28Zn - 20Cu - 2.0Ni, 1220 to 1305 °F (660 to 707 °C) Solidus-Liquidus Range

AS7766 Terms Used in Aerospace Metals Specifications

2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585 or www.astm.org.

ASTM D1179 Fluoride Ion in Water

ASTM D1193 Reagent Water

2.3 Definitions

Terms used in AMS are defined in AS7766.

3. TECHNICAL REQUIREMENTS

3.1 Flux

Shall conform to AMS3410 or other flux acceptable to the cognizant engineering organization.

3.2 Filler Metal

Shall conform to AMS4763, AMS4770, or AMS4771. AMS4773, AMS4774, or AMS4788 may be used when permitted by the cognizant engineering organization (see 3.5.3.3).

3.3 Equipment

If furnaces are used for brazing (see 3.5.3) when brazing is concurrent with heat treatment, the pyrometry requirements of the applicable heat-treatment specification shall be applied. Otherwise, pyrometry shall be in accordance with AMS2750.

3.4 Preparation

3.4.1 Surface Condition

The surfaces to be joined shall be clean prior to assembly. Surfaces shall not be polished.

3.4.2 Nickel Plating

Joint surfaces may be nickel plated in accordance with AMS2403 or AMS2424. Thickness of plating, when used, shall be 0.0001 to 0.0006 inch (2.5 to 15 µm). Plating to assist brazing shall be limited to the joint and adjacent fillet areas.

3.5 Procedure

3.5.1 Fluxing

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

3.5.2 Assembly

3.5.2.1 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 (25 to 1.2 µm) or 0.002 to 0.005 inch (51 to 127 µm) across a diameter.

3.5.2.2 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.

3.5.2.3 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.

3.5.2.3.1 Unless otherwise specified, fusion-arc tack welding is not permitted on tube joints.

3.5.3 Heating for Joining

May be accomplished by any convenient means, such as furnace, induction, resistance, molten salt bath, or torch, unless a specific method is specified, subject to the following restrictions:

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

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

3.5.3.3 When AMS4763, AMS4770, or AMS4771 filler metal is used, the maximum temperature shall not exceed 1350 °F (732 °C). When AMS4773 or AMS4788 is used, the maximum temperature shall not exceed 1450 °F (788 °C). When AMS4774 filler metal is used, the maximum temperature shall not exceed 1550 °F (843 °C), unless otherwise permitted by the purchaser. Parts shall be heated for sufficient time to form the joint with further heating kept to a minimum.

3.5.3.4 Furnace atmospheres, molten salts, and fluxes shall be such that parts are protected from surface contamination, such as carburization, decarburization, dezincification, nitriding, or oxidation, or other changes in surface character.

3.5.3.5 A neutral flame shall be used for torch brazing.

3.5.4 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.

3.5.5 Flux Removal

After brazing and cooling, flux shall be removed by any method not injurious to the base material and specified surface finish.

3.6 Properties

Brazed parts shall conform to the following requirements:

3.6.1 Coverage

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

3.6.1.2 The area joined by filler metal shall be not less than 80% of the area of the mating portions of the assembly, determined by a method specified by or agreed upon with the cognizant engineering organization (see 4.3.3).

3.6.2 Proof Pressure Test

When specified, any assembly from a lot shall pass that test.

3.6.3 Residual Flux

Surfaces of brazed parts shall be free of residual flux. If the flux contains halides, tests shall be performed to ensure that residual flux has been removed (see 4.3.4).

3.7 Quality

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

3.7.1.1 Surfaces shall be free from surface contamination such as carburization, decarburization, dezincification, nitriding, or oxidation, or other changes in surface character.

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

3.7.1.3 Joints shall be free from cracks and from un-flowed filler metal.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The processor of brazed assemblies shall supply all samples for the processor's tests and shall be responsible for performance of all required tests. Parts, if required for testing, shall be supplied by the purchaser. The 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 being free from surface contamination (3.6.1.1), 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 the purchaser deems confirmatory testing to be required.

4.3 Sampling and Testing

Shall be not less than that shown in Table 1, with samples selected randomly from the lot, unless another sampling plan is specified by the 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 the 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, or oxidation or other changes in surface character.

***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 | 1 |
| 7 to 15 | All | 4 | 1 |
| 16 to 40 | All | 4 | 1 |
| 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 (3.5.2) and braze internal coverage when determined nondestructively (3.5.1), and, when halide containing fluxes are used, tests for residual halides (3.6.1.4, 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 the 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 40 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 D1193, Type IV, water. Collect the rinse water in a 100 mL beaker and add three to five 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 D1193, 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 [82 °C]) ASTM D1193, Type IV, water. Collect the rinse water in a 250 mL beaker. Use approximately 200 mL of ASTM D1193, Type IV, water as a comparison sample. Test both samples in accordance with ASTM D1179. 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, 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.