
**Brazing for aerospace applications —
Qualification test for brazers and
brazing operators — Brazing of
metallic components**

*Brasage fort pour applications aérospatiales — Épreuve de
qualification des braseurs et des opérateurs braseurs — Brasage fort
des composants métalliques*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 14, *Welding and brazing in aerospace*.

This second edition cancels and replaces the first edition (ISO 11745:2010), which has been technically revised. It also incorporates the Amendment ISO 11745:2010/Amd 1:2015.

The main changes are as follows:

- [Clause 5](#): visual inspection aligned with ISO 24394;
- designation for filler material added;
- editorial revisions.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html. Official interpretations of ISO/TC 44 documents, where they exist, are available from this page: <https://committee.iso.org/sites/tc44/home/interpretation.html>.

Introduction

The application of this document ensures that a qualification test can be carried out in accordance with a standard test specification on standard test pieces under standard conditions. A brazer or brazing operator qualification test properly passed in accordance with this document ensures that the brazer or brazing operator concerned has proved possession of at least the minimum degree of manual skills and technical knowledge demanded by the state of the art.

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Brazing for aerospace applications — Qualification test for brazers and brazing operators — Brazing of metallic components

1 Scope

This document specifies a qualification test for brazers engaged in manual brazing of parts and brazing operators in aerospace construction.

NOTE Success in the test is an essential precondition for the qualification of brazers and brazing operators in new production and repair work in aerospace. However, brazing equipment operators need not be qualified in accordance with this document.

This document does not apply to general brazing applications covered by ISO 13585.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 18279:2003, *Brazing — Imperfections in brazed joints*

ISO 18490, *Non-destructive testing — Evaluation of vision acuity of NDT personnel*

EN 4179, *Aerospace series — Qualification and approval of personnel for non-destructive testing*

EN 12799, *Brazing — Non-destructive examination of brazed joints*

EN 13134, *Brazing — Procedure approval*

ANSI/AWS B2.2, *Brazing procedure and performance qualification*

NAS 410, *NAS certification & qualification of nondestructive test personnel*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

brazer

person who performs the brazing in a manual operation, guides the heating means, ensures the introduction of the brazing filler material and verifies the braze joint configuration specified by the design

3.2

brazing operator

person who prepares the joint and sets up brazing equipment and thereby has a direct influence on the brazed joint quality

Note 1 to entry: Examples of brazing equipment are furnaces, salt baths and induction equipment.

3.3

brazing equipment operator

person who only operates automatic brazing equipment and has no direct influence on the brazed joint quality

Note 1 to entry: Examples of automatic brazing equipment are furnaces, salt baths and induction equipment that require no brazing operator intervention during the thermal process.

3.4

examiner

person who has been appointed to verify conformity to the applicable standard

Note 1 to entry: In certain cases, an external independent examiner can be required.

[SOURCE: ISO/TR 25901-1:2016, 2.5.29, modified — Definition revised.]

3.5

examining body

organization that has been appointed to verify conformity to the applicable standard

Note 1 to entry: In certain cases, an external independent examining body can be required.

[SOURCE: ISO/TR 25901-1:2016, 2.5.30, modified — Definition revised.]

3.6

design authority

engineering authority

organization that has the responsibility for the structural integrity or maintenance of airworthiness of the hardware and conformity to all relevant documents

Note 1 to entry: In the case of a welded product, the design authority is usually the organization that has responsibility for the engineering definition of the product. Examples of engineering definitions include drawings, 3D models and specifications for manufacturing.

[SOURCE: ISO 24394:2018, 3.8, modified — Definition revised and note to entry added.]

3.7

braze assembly

assembly of parts to be brazed with regard to fit-up procedures

Note 1 to entry: Fit-up procedures can include precleaning and application of brazing filler material, stop-off material or flux.

3.8

brazing coordinator

person responsible for and competent to perform brazing coordination

Note 1 to entry: Different brazing coordinators can be required for different tasks.

4 Requirements for the brazing coordinator

The brazing coordinator shall be designated, in writing, as responsible for the brazer or brazing operator qualification test. The brazing coordinator shall have knowledge and experience relevant to the brazing process and shall be acceptable to the responsible design authority or recognized examining body.

NOTE An example of relevant knowledge is International Welding Engineer (IWE) in accordance with IIW IAB-002-2000/EFW-409.

The brazing coordinator may authorize another person to administer the brazer or brazing operator qualification test.

5 Conditions required for brazer and brazing operator qualification tests

The candidate shall provide documented evidence of satisfactory vision in accordance with the following requirements. Any limitations (e.g. visual aids when required to pass the eyesight test) shall be documented on the brazer or brazing operator test certificate. Any limitations in colour perception shall be evaluated by the brazing coordinator and shall be approved in writing.

Eyesight requirements shall be achieved by using one eye or both eyes. The candidate shall successfully achieve the near vision acuity and colour perception specified herein.

Eyesight tests shall be administered by competent personnel.

The method for testing near vision acuity shall be chosen from one of the following:

- a) Jaeger No. 2 eye chart at approximately 400 mm;
- b) Visus 0,8 at approximately 400 mm;
- c) eyesight requirements of EN 4179/NAS 410 or ISO 18490.

NOTE The results of the three near-vision testing methods are not fully comparable.

Colour perception shall be examined by a suitable method, e.g. the Ishihara test.

Near vision shall be tested to these requirements at least every two years.

Colour perception shall be tested to these requirements at least every five years.

6 Qualification test requirements

6.1 Brazing processes

This document covers qualification testing for the following brazing processes with their reference numbers in accordance with ISO 4063:

- 911: infrared brazing;
- 912: flame brazing, torch brazing;
- 916: induction brazing;
- 918: resistance brazing;
- 919: diffusion brazing;
- 921: furnace brazing;
- 922: vacuum brazing;

- 923: dip-bath brazing;
- 924: salt-bath brazing.

Other brazing processes not specified in ISO 4063 may be covered.

6.2 Material

The brazer or brazing operator qualification tests are performed according to the following material groups. A brazer or brazing operator qualification test is only valid for the material group applied in the qualification test. It does not include any other material group.

- Material group A: unalloyed steels, low-alloyed steels, high-alloyed ferritic steels.
- Material group B: high-alloyed austenitic and martensitic steels, nickel and nickel alloys, cobalt alloys.
- Material group C: titanium and titanium alloys.
- Material group D: aluminium and aluminium alloys, magnesium and magnesium alloys.
- Material group E: materials that do not conform to material groups A to D (e.g. molybdenum, tungsten, copper alloys).

Qualification of material group B also qualifies material group A.

6.3 Material thickness

For the brazer qualification test only, a test brazement with parent material of nominal thicknesses t_1 and t_2 shall qualify brazements within a thickness range of $0,9t_1$ to $1,1t_2$, with $t_1 \leq t_2$.

6.4 Brazing position

For the brazer qualification test only, the test pieces (see 9.3.4) shall be brazed in the following brazing positions:

- a) test pieces TP1 and TP3: flat flow (horizontal flow of braze filler material);
- b) test piece TP2: vertical tube axis (vertical upflow of braze filler material).

NOTE The word “tube”, alone or in combination, is used to mean “pipe”, “tube” or “hollow section”.

These brazing positions and flow directions qualify for any brazing position and any flow direction.

6.5 Filler material

For the brazer qualification test only, the ranges of qualification for brazing filler material application and liquidus temperatures are given in Tables 1 and 2, respectively.

Table 1 — Range of qualification for brazing filler material application

Test piece brazing filler material application	Range of qualification
Manually or mechanically fed (MF)	Manually or mechanically fed and preplaced
Preplaced (PP)	Preplaced

Table 2 — Range of qualification for brazing filler material liquidus temperatures

Test piece brazing filler material liquidus temperature	Range of qualification
< 850 °C (LT)	< 850 °C

Table 2 (continued)

Test piece brazing filler material liquidus temperature	Range of qualification
≥ 850 °C (HT)	All

7 Special qualification tests

7.1 General requirements

Any changes to the requirements defined in this document are classified as special qualification tests.

As required by actual production, the brazing coordinator specifies test pieces with defined brazing processes and material thickness. A special qualification test only qualifies for brazing under the specific conditions represented by the qualification test.

If test methods are not in accordance with this document, they shall be defined by the brazing coordinator. The brazing coordinator shall define additional test methods and also increase the quality requirements as defined by the design authority.

A special qualification test shall be marked in the designation with an "X".

7.2 Special qualification tests for brazers

Examples include qualifications for:

- a) brazing with a special condition for restricted accessibility;
- b) brazing on dissimilar material groups;
- c) brazing on plated surfaces;
- d) brazing performed on actual production parts;
- e) application of filler material different to that specified for standard test pieces.

7.3 Special qualification tests for brazing operators

Examples include:

- a) qualification for brazing on dissimilar material groups;
- b) restriction to braze assembly work only;
- c) restriction to brazing operation only (i.e. excluding braze assembly work);
- d) brazing operator qualification performed on actual production parts.

8 Designation for qualification test

The designation of a brazer qualification test or brazing operator qualification test is composed as follows:

- a) "brazer qualification test" or "brazing operator qualification test" (as applicable);
- b) the number of this document, i.e. ISO 11745;
- c) brazing process code number in accordance with ISO 4063;
- d) material group;

- e) test piece thickness combination;
- f) brazing filler material application;
- g) brazing filler material liquidus temperature.

EXAMPLE 1 Qualification test for manual torch brazing (912) of steel, material group B, test piece thickness combination of t_1 with 1 mm and t_2 with 4 mm, manually or mechanically fed brazing filler material with liquidus temperature < 850 °C. This test qualifies for any thickness combination between 0,9 mm and 4,4 mm with brazing filler material liquidus temperature < 850 °C, see [6.3](#):

Brazer qualification test ISO 11745-912-B-1-4-MF-LT

EXAMPLE 2 Qualification test for manual torch brazing (912) of steel, material group B, test piece thickness combination of t_1 with 1 mm and t_2 with 4 mm, preplaced filler material with liquidus temperature ≥ 850 °C. This test qualifies for any thickness combination between 0,9 mm and 4,4 mm with preplaced brazing filler material with any liquidus temperature, see [6.3](#). X indicates a special test (for examples, see [7.2](#)):

Brazer qualification test ISO 11745-912-B-1-4-PP-HT-X

EXAMPLE 3 Qualification test for brazing operator, furnace brazing (921), material group B:

Brazing operator qualification test ISO 11745-921-B

9 Performing the brazer and brazing operator qualification test

9.1 General

In the qualification test, the brazer or brazing operator shall demonstrate job knowledge in accordance with [9.2](#) and practical skills in accordance with [9.3](#).

All limitations or extensions to the conditions specified in this document shall be considered as special qualification tests.

9.2 Theory test

A theory test is required. The content of the theoretical test and the grading shall be at the discretion of the person responsible for the conduction of brazer or brazing operator qualification tests. See [Annex E](#) for guidelines.

9.3 Practical testing

9.3.1 General

All practical testing shall be conducted under the surveillance of an authorized person (see [Clause 4](#)).

9.3.2 Brazer

The brazer shall braze the test pieces according to [9.3.4](#) (TP1, TP2 and TP3) or according to a special qualification test(s) (see [Clause 7](#)), in accordance with the brazing procedure specification (BPS) in EN 13134 or ANSI/AWS B2.2 or a technically equivalent standard. All test pieces shall be clearly identified and traceable to the brazer.

The brazing coordinator shall choose a representative material from the material group used for production brazing.

Brazing filler material, heat source and type of flux shall be as used in production work for the respective material group and as defined in the BPS.

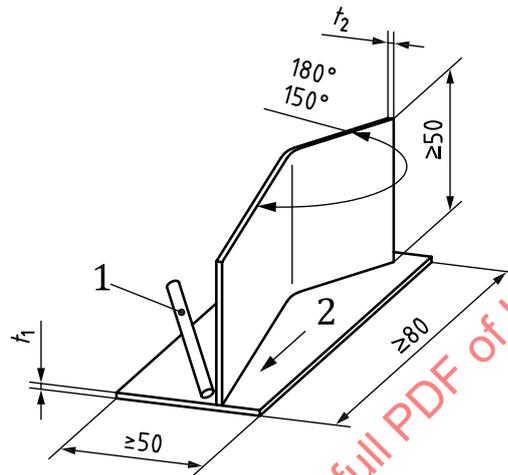
9.3.3 Brazing operator

The brazing operator shall demonstrate compliance with the BPS of a typical production part or the BPS of a specific brazing test piece representative of production parts.

9.3.4 Test pieces

Test pieces TP1, TP2 and TP3 are illustrated in [Figures 1, 2](#) and [3](#), respectively.

Dimensions in millimetres



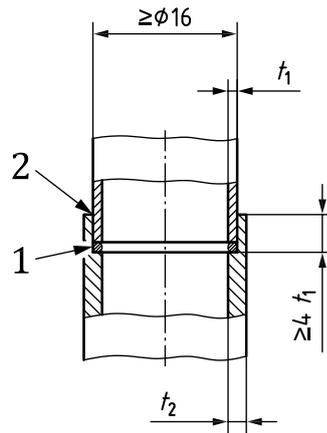
Key

- 1 rod (filler material applied)
- 2 heat supply
- t_1 material thickness of horizontal plate
- t_2 material thickness of vertical plate

NOTE Before bending, the vertical sheet has the same size as the horizontal sheet.

Figure 1 — Test piece TP1: modified T-joint

Dimensions in millimetres

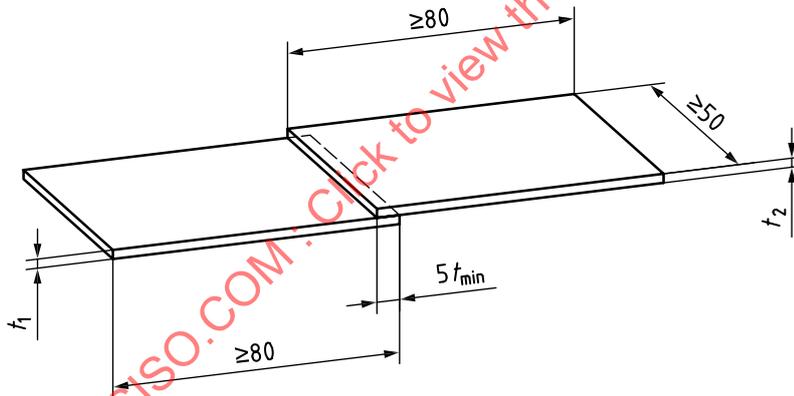


Key

- 1 preplaced filler material
- 2 joint gap (material groups A, B, C, E: 0,10 mm to 0,15 mm, material group D: 0,2 mm to 0,3 mm)
- t_1 material thickness of inserted tube (0,8 mm to 2 mm)
- t_2 material thickness of recessed tube (1,2 mm to 3 mm)

Figure 2 — Test piece TP2: tube lap joint

Dimensions in millimetres



Key

- t_1 thickness of lower sheet
- t_2 thickness of upper sheet
- t_{min} thickness of thinner sheet

Figure 3 — Test piece TP3: lap joint with manually fed filler material

10 Examination and testing

10.1 General

For the brazer qualification test, the test pieces shall be examined and tested according to [Table 3](#). The test results shall be documented in the brazer qualification test record, see [Annex A](#).

Table 3 — Method of inspection or testing

Method of inspection or testing	Test piece		
	TP1	TP2	TP3
Visual examination	x	x	x
Peel test	—	—	x ^a
Radiographic examination	—	x ^a	x ^a
Metallographic examination	x	x ^a	—
Key x required inspection method — method not required ^a Only one of these methods is required for each test piece as determined by the brazing coordinator.			

For the brazing operator qualification test, the assessment according to the applicable engineering document for the production part shall apply. The test results shall be documented.

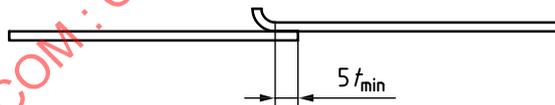
10.2 Visual and dimensional examination

Visual examination for external imperfections or features shall be performed at up to 10 times magnification and with an angled mirror, if required. Examination results shall be recorded.

Compliance with the specified test piece dimensions shall be checked.

10.3 Peel test

The objective of this test is to examine the internal quality of the joint (see ISO 18279). In order to do this, any suitable separation technique as authorized by the brazing coordinator may be applied to separate parts. If desired, a curved geometry may be applied to test piece TP3, see Figure 4. After brazing, the test piece may be cut into sections with a minimum width of 15 mm, all of which shall be tested.



Key

t_{\min} thickness of the thinner sheet

Figure 4 — Optional modification of test piece TP3 for the peel test

10.4 Radiographic examination

The objective of this test is to examine the internal quality of the joint (see ISO 18279). Radiographic examinations shall be defined in accordance with EN 4179, approved level 3 or equivalent, carried out in accordance with EN 12799 or equivalent.

10.5 Metallographic examination

When metallographic examination is required (see Table 3), a minimum of two cross-sections shall be prepared. Cross-sections at 90° to the longitudinal direction of the brazed joint shall be ground and polished until the brazed joint is clearly visible. The sections shall be examined at a minimum of 10 times magnification for internal imperfections.

11 Acceptance criteria

11.1 General

The test pieces shall be checked for internal and external imperfections or features in accordance with ISO 18279:2003, acceptance level B.

11.2 Brazer qualification test

If a test piece fails to meet the acceptance criteria (according to ISO 18279), one substitute test piece may be brazed. If this test piece also fails to meet the acceptance criteria, the test has been failed. The extent of inspection or testing is specified in [Table 3](#). The test results shall be assessed by the inspecting authority and shall be recorded on a brazer qualification test record, see [Annex A](#).

If the brazer fails the test, the brazing coordinator shall decide if and when a new test can be allowed, provided that the brazer has had further training or practice.

11.3 Brazing operator qualification test

If the brazing operator fails the test, the brazing coordinator shall decide if and when a new test can be allowed, provided that the brazing operator has had further training or practice.

12 Qualification test certificate

A brazer qualification test certificate (for an example of a form, see [Annex C](#)) or a brazing operator qualification test certificate (for an example of a form, see [Annex D](#)) shall be used to document that the brazer or brazing operator has passed the qualification test. The qualification test designations according to [Clause 8](#) shall be stated. Special conditions (see [Clause 7](#)) and limitations (e.g. for filler materials in [6.5](#)) shall be stated under "Notes".

The brazer or brazing operator qualification test certificate is only valid when supplied with a comprehensive brazer or brazing operator qualification test record (for examples, see [Annex A](#) and [Annex B](#)). The qualification test certificate and the qualification test record may be combined into a single document. The brazer or brazing operator qualification test record shall identify the materials used, test piece thicknesses, special qualification test data (if applicable) and test results.

If actual production parts have been used for the requalification, the parts shall be clearly defined and all test records, including but not limited to X-ray images, shall be retained and traceable until expiration of the brazer or brazing operator qualification.

Test documents and test pieces or test specimens shall be retained until expiration of the period of validity of the brazer or brazing operator qualification.

The brazer or brazing operator qualification test certificate shall be signed and dated by the brazing coordinator or the examining body. The qualification test record shall be signed and dated by either the examiner or the examining body.

In the case of a limited extent of qualification (e.g. preplaced filler material only), the qualification test shall be identified by an "X" (brazer qualification test ISO 11745 - B X). Any limitation shall be documented in the qualification test certificate and a short explanation about the limitation shall be added.

13 Period of validity of the qualification

The brazer or brazing operator qualification is valid for a period of two years, expiring at the end of the month of the qualification test. By way of a requalification test, the qualification for brazing with the corresponding processes, material groups and product or semi-finished product types can be extended for another period of two years.

At any time during the period of validity, a requalification test shall be requested if any of the following circumstances apply:

- a) if there is a reason to question the ability of the brazer or brazing operator to meet the requirements for qualification;
- b) the brazer or brazing operator has not been working for more than six months with the brazing process for which the brazer or brazing operator is qualified;
- c) unacceptable results of representative components.

14 Requalification test

For the requalification test, the same requirements as for the initial qualification tests apply.

Successful requalification tests shall be entered into the brazer or brazing operator qualification test certificate on the basis of the brazer or brazing operator qualification test record.

For the theoretical part of the test, see [Annex E](#).

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Annex A (informative)

Brazer qualification test record in accordance with this document

Name of brazer:

Date of birth:

Address:

Company or plant:

Identification of test piece(s):

Brazing process/BPS No.:

Liquidus temperature:

Filler material application:

Special test conditions, if applicable:

Test piece	Used for the test pieces				Assessment ^a			
	Material(s)	Dimensions	Filler material	Flux	Visual examination	Radiographic examination	Metallographic examination	Peel test
TP1								
TP2								
TP3								

^a p: pass; f: fail.

Signed:

Date:

Examiner or examining body

(The user is allowed to copy this form.)

Annex B (informative)

Brazing operator qualification test record in accordance with this document

Name of brazing operator:

Date of birth:

Address:

Company or plant:

Identification of test piece(s):

Brazing process/BPS No.:

Special test conditions, if applicable:

Illustration of joint configuration (sketch or attached drawing number or photograph):

Part number or test piece	Used for the test pieces				Assessment ^a			
	Material(s)	Dimensions	Filler material	Flux	Visual examination	Radiographic examination	Metallographic examination	Peel test

^a p: pass; f: fail.

Signed:

Date:

Examiner or examining body

(The user is allowed to copy this form.)

Annex C
(informative)

Brazer qualification test certificate

Examiner or examining body

Certification of brazer qualification test in accordance with ISO 11745

Qualification test certificate no.: _____ Brazer's identity number: _____

Surname, first name: _____

Date of birth: _____

has successfully passed the qualification test for brazing on aerospace construction according to the brazer qualification designation:

- preplaced filler material
- manually or mechanically fed filler material
- liquidus temperature < 850 °C
- liquidus temperature ≥ 850 °C

Test date (yyyy-mm-dd): _____

Description of special test conditions or limitations, if applicable:

This certificate expires at the end of yyyy-mm (end of month of its date of test + two years), unless renewed by notation on the reverse side after passing a repeat test.

Place and date of issue: _____

Brazing coordinator or examining body

(The user is allowed to copy this form.)