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Brazing — Qualification testing of brazers and brazing operators

Brasage fort — Essais de qualification des braseurs et des opérateurs braseurs en brasage fort

Reference number
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Foreword

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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).

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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 11, *Qualification requirements for welding and allied processes personnel*.

This second edition cancels and replaces the first edition (ISO 13585:2012), which has been technically revised.

The main changes compared to the previous edition are as follows:

— brazing processes, in accordance with ISO 4063:2009, covered by this document, have been moved to the scope;

— Clause 3 has been updated and additional terms have been defined;

— additional symbols and abbreviated terms have been added to Clause 4;

— Clause 5 has been significantly revised and updated including clarifications on brazing operator qualification;

— material grouping has been moved to new Annex E;

— Clause 6 has been updated to refer to ISO or technically equivalent standards;

— the period of validity and prolongation of qualifications has been revised to 5 years in Clause 9.

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.

Brazing — Qualification testing of brazers and brazing operators

1 Scope

This document specifies requirements for qualification testing of brazers and brazing operators for metallic materials.

This document gives general provisions on quality requirements for brazing (see Annex A).

This document applies to the following brazing processes according to ISO 857-2 and ISO 4063:2009 with local and global heating:

— 911 Infrared brazing;

— 912 Flame brazing, torch brazing;

— 913 Laser beam brazing;

— 914 Electron beam brazing;

— 916 Induction brazing;

— 918 Resistance brazing;

— 919 Diffusion brazing;

— 921 Furnace brazing;

— 922 Vacuum brazing;

— 923 Dip-bath brazing;

— 924 Salt-bath brazing;

— 925 Flux bath brazing;

— 926 Immersion brazing;

— 972 Arc weld brazing.

This document is not applicable to personnel operating brazing equipment who do not have any direct influence on the quality of the brazed joint, for example, personnel performing exclusively loading/unloading the brazing unit or just initiating the brazing cycle in automatic brazing.

The principles of this document can be applied to other brazing processes and brazing of materials not listed.

This document does not apply to brazing for aerospace applications covered by ISO 11745.

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 857-2, *Welding and allied processes — Vocabulary — Part 2: Soldering and brazing processes and related terms*

ISO 4063:2009, *Welding and allied processes — Nomenclature of processes and reference numbers*

ISO 17672, *Brazing — Filler metals*

ISO 17779, *Brazing — Specification and qualification of brazing procedures for metallic materials*

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

ISO/TR 25901-1, *Welding and allied processes — Vocabulary — Part 1: General terms*

EN 12797, *Brazing — Destructive tests of brazed joints*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 857-2, ISO/TR 25901-1 and the following 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
brazing
joining process using *filler metal* (3.12) with a liquidus temperature above 450 °C

[SOURCE: ISO 857-2:2005, 3.1.2.]

3.2
brazer
person who holds and manipulates the device for heating the brazing area by hand

Note 1 to entry: The brazer verifies compliance with the pBPS or BPS prior to and during brazing.

3.3
brazing operator
person who controls or adjusts brazing parameters for *mechanized brazing* (3.5) or sets up brazing parameters for *automatic brazing* (3.6)

Note 1 to entry: The brazing operator verifies compliance with the pBPS or BPS prior to and during the brazing cycle.

3.4
manual brazing
brazing (3.1) where the required brazing conditions are maintained by hand

3.5
mechanized brazing
brazing (3.1) where the required brazing conditions are maintained by mechanical or electronic means but can be manually varied during the process

3.6
automatic brazing
brazing (3.1) in which all operations are performed without *brazing operator* (3.3) intervention during the process

Note 1 to entry: Manual adjustment of brazing variables by the brazing operator during brazing is not possible.

3.7
brazing procedure specification
BPS
document that has been qualified and provides the required variables of the brazing procedure to ensure repeatability during production brazing

3.8
preliminary brazing procedure specification
pBPS
document containing the required variables of the brazing procedure which is not yet qualified

3.9
manufacturer
workshop or site (or both) which is (are) under the same technical and quality management

3.10
examiner
person who has been appointed to verify compliance with 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]

3.11
examining body
organization that has been appointed to verify compliance with 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]

3.12
filler metal
added metal applied to brazed joints

Note 1 to entry: Filler metal can be in the form of wire, inserts, powder, pastes, foil, etc.

3.13
flux
non-metallic material which, when molten, promotes wetting by removing existing oxide or other detrimental films from the surfaces to be joined and prevents their re-formation during the joining operation

[SOURCE: ISO 857-2:2005, 3.2.2]

3.14
test piece
brazed assembly which is used for testing purposes

3.15
test specimen
part or portion cut from the *test piece* (3.14) in order to perform specified destructive testing

[SOURCE: ISO/TR 25901-1:2016, 2.2.1.6]

4 Symbols and abbreviated terms

t material thickness

L overlap length

D outside pipe diameter

T product type pipe

P product type plate

BJ butt joint

LJ lap joint

TJ T-joint

FF face fed

PP pre-placed

H horizontal flow

VU vertical up flow

VD vertical down flow

Where the full wording is not used, the symbols listed above and brazing process reference numbers in Clause 1 shall be used when completing the qualification test certificate (see Annexes B and C).

5 Essential variables and range of qualification

5.1 General

The qualification of brazers, (see 5.3) and brazing operators, (see 5.4) is based on essential variables in accordance with Table 1. For each essential variable, a range of qualification is defined and brazing outside that range of qualification requires a new qualification test.

Table 1 — Essential variables for brazer and brazing operator qualification

Essential variable	Brazer	Brazing operator
Brazing process number in accordance with ISO 4063:2009	X	X
Product type: T or P	X	—
Type of joint: BJ, LJ or TJ	X	—
Parent material group(s) in accordance with Annex E	X	—
Brazing filler metal classification in accordance with ISO 17672	X	—
Brazing filler application, FF or PP	X	X
Dimensions: *t*, *D*, *L*	X	—
Filler metal flow direction: H, VU or VD	X	—
Type of equipment	—	X

NOTE There can be other variables that the manufacturer deems to be essential in certain applications, e.g. constraint on access for the torch, purging gas, etc., which need separate qualification (see Annex D).

The brazer or brazing operator who undertakes the brazing procedure test satisfactorily in accordance with this document is qualified provided that the relevant testing requirements of this document are met.

5.2 Brazing process

Each qualification test qualifies only one brazing process (see Clause 1). A change of brazing process requires a new qualification test.

When applicable, the furnace atmosphere is limited to the same type of atmosphere, e.g. reducing or inert, carburizing or decarburizing, and hydrogen or disassociated ammonia, as used in the test.

For brazing processes where fuel gases apply, the qualification is limited to the same type of fuel gas and flame as used in the test.

5.3 Brazer qualification

5.3.1 Product type

Manual brazing of one product type qualifies for other product types in accordance with Table 2.

Table 2 — Range of qualification for product type

Dimensions in millimetres

Product type for test piece	Range of qualification
Plate	Plate and pipe
Pipe $D \leq 100$	Pipe
Pipe $D > 100$	Pipe and plate

5.3.2 Type of joint

Range of qualification for type of joint is given by Table 3.

Table 3 — Range of qualification for type of joint

Type of joint in test piece	Range of qualification
Butt joint	Butt joint
Lap joint	Lap joint
T-joint	T-joint

5.3.3 Parent material group(s)

In order to minimize the number of brazer qualification tests, parent materials are assigned to M-number groupings (see Annex E).

The parent material used in the brazer qualification test qualifies the brazer for brazing of all other parent materials within the same M-number grouping (see Table 4).

Parent materials that do not appear in Annex E, require separate qualification and only qualify that material.

Table 4 — Range of qualification for parent material

Test piece material (see Annex E)	Range of qualification[a,b]
100, 110, 120, 170	100, 110, 120, 170
130, 140, 150, 160, 180	130, 140, 150, 160, 180
200, 210, 220	200, 210, 220
300, 310, 320, 330, 340, 350, 360	300, 310, 320, 330, 340, 350, 360
400, 410, 420, 430	400, 410, 420, 430
500	500
600	600
700	700
800	800

[a] For a test piece material used for brazer qualification, the brazer is qualified to braze all materials and all combinations of materials given in the same row.

[b] When test piece material from two rows are used for brazer qualification, the brazer is qualified to braze all material combinations in each row and combinations between those rows.

5.3.4 Filler metals and brazing filler application

The brazing filler metal type, based on its class in accordance with ISO 17672 or other standards that provide equivalent technical conditions, qualifies other filler metal types within the same class.

One filler metal form (for example from preformed ring to paste) only qualifies for the same form.

A test with a flux classified in accordance with ISO 18496, or other standards that provide equivalent technical conditions, only qualifies for brazing within that same classification.

The brazing filler metal application qualifies for other filler metal applications in accordance with Table 5.

Table 5 — Range of qualification for brazing filler application

Test piece brazing filler application	Range of qualification
Face fed	Face fed, Pre-placed
Pre-placed	Pre-placed

NOTE Face fed", also known as "applied to the mouth of the joint", can be manually or mechanically fed while brazing.

5.3.5 Dimensions

The brazer qualification test of brazed joints is based on the material thickness, outside pipe diameter and overlap length. The ranges of qualification are specified in Table 6.

For dissimilar material thicknesses of test pieces, the range of qualification is based on the thickness of each plate (or pipe).

It is not intended that material thicknesses or outside pipe diameters should be measured precisely, but rather the general philosophy behind the values given in Table 6 should be applied.

For test pieces of different outside pipe diameters and parent material thicknesses, the brazer is qualified to:

— the larger diameter and below (see Table 6);

— twice the larger parent material thickness and below (see Table 6).

Table 6 — Range of qualification for dimensions

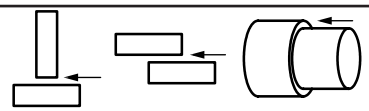
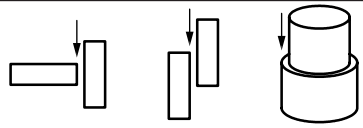
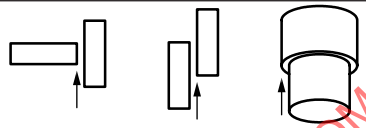
Dimensions	Test piece	Range of qualification
Material thickness, t (mm)	t	$\leq 2t$
Outside pipe diameter, D (mm)[a]	D	$\leq D$
Overlap length, L (mm)[a]	L	$\leq 1{,}25L$
NOTE If material thicknesses differ (see Figure F.5), the lower limit is based on the thinnest and the upper limit is based on the thickest thickness. [a] If applicable.		

5.3.6 Filler metal flow direction

The brazing of one filler metal flow direction qualifies for other flow directions in accordance with Table 7.

For personnel qualification, an angular deviation of maximum ±15° from filler metal flow positions applies.

Table 7 — Range of qualification for filler metal flow direction

Illustrations	Filler metal flow direction of the test piece	Range of qualification
	Horizontal flow	Horizontal flow and vertical down-flow
	Vertical down-flow	Vertical down-flow
	Vertical up-flow	All flow directions

5.4 Brazing operator qualification

5.4.1 Type of equipment

If mechanized or automatic brazing is used for the test, the range of qualification is limited to the brazing process and type of equipment only (see 6.2).

5.4.2 Filler metals and brazing filler application

If mechanized or automatic brazing is used for the test, the range of qualification is limited to the method of brazing filler application in accordance with Table 5.

6 Examination and testing

6.1 Supervision

The brazing of test pieces shall be witnessed by the examiner or examining body. The testing shall be verified by the examiner or examining body.

The test pieces shall be marked with the identification of the examiner and the brazer before brazing starts.

The examiner or examining body may stop the test if the brazing conditions are not correct or if it appears that the brazer or brazing operator does not have the skill to fulfil the requirements.

6.2 Brazing conditions

The qualification test of brazers and brazing operators shall follow a pBPS or BPS prepared in accordance with ISO 17779. The brazing time for the test piece shall correspond to the working time under usual production conditions.

The brazer or brazing operator shall prepare the parts (e.g. mechanical preparation, cleaning) or accept the preparation, set up the heating means and conduct the necessary verification to carry out the test in accordance with the pBPS or BPS.

NOTE It can be of value to otherwise imitate production conditions for the qualification test as far as possible.

6.3 Test piece

The test piece may be any design of joint which is relevant to the end work. Typically, this is a basic lap or butt joint in sheet material or a sleeve joint in tube (for examples of applicable joint configurations, see Annex F).

NOTE It is possible that requirements concerning test piece design are given in the applicable product standard.

6.4 Assessment of work pieces

When assembling the test piece, the brazer or brazing operator:

— shall assess the work pieces for:

  a) joint fit up;

  b) joint gap;

  c) degree or absence of local deformation; and

— is permitted to refuse the test piece components if the brazer or brazing operator considers that these are not in accordance with the written pBPS or BPS.

6.5 Extent of testing

Each test piece shall be tested by visual testing and one or more of the following tests:

a) ultrasonic test;

b) radiographic test;

c) peel test;

d) macroscopic examination;

e) bend test.

6.6 Visual testing

All joints shall be visually examined [see Annex A, item j)] in accordance with EN 12799 or technically equivalent standards. It can be necessary to cut open the brazed assembly to offer an internal examination. Therefore, the test may be destructive.

6.7 Non-destructive testing

Any non-destructive testing performed shall be carried out in accordance with EN 12799 or technically equivalent standards.

6.8 Destructive testing

Any destructive testing performed shall be carried out in accordance with EN 12797 or technically equivalent standards. The details of testing procedure and test specimen shall be established before any testing is undertaken.

6.9 Additional examination and testing

Additional testing may be carried out as appropriate or as agreed:

— non-destructive test methods, for example:

  a) penetrant testing;

  b) leak testing;

  c) proof testing;

  d) acoustic emission testing;

  e) thermography; or

— destructive test methods, for example:

  a) shear tests;

  b) tensile tests;

  c) metallographic examination;

  d) hardness testing.

NOTE Additional testing can be required in the product standard or by contract.

7 Acceptance requirements for test pieces

Unless otherwise specified, the acceptance requirements for imperfections found by test methods specified in this document shall be assessed in accordance with ISO 18279:2003.

A brazer or brazing operator is qualified if the imperfections are within quality level B of ISO 18279:2003 except for excess braze metal (6BAAA) where quality level C applies and no imperfections pass through the joint length.

8 Re-tests

If any test fails to comply with the requirements of this document, the brazer or brazing operator shall be given the opportunity to repeat the qualification test once without further training.

If it is established that failure is due to metallurgical or other extraneous causes that cannot be directly attributed to the lack of skill of the brazer or brazing operator, an additional test is required in order to assess the quality and integrity of the new test material and/or new test conditions.

9 Period of validity

9.1 Initial qualification

The period of validity of the brazer or brazing operator qualification starts at the date of brazing, or the date of prolongation (see 9.2). However, the brazer qualification is not valid until all required tests are completed and accepted.

The period of validity of the brazer or brazing operator qualification is 5 years. This is providing that all the following conditions are fulfilled and documented under the control of the manufacturer.

a) The brazer or brazing operator shall be engaged with reasonable continuity in brazing work within the range of qualification. An interruption for a period of no longer than 6 months is permitted.

b) The work of the brazer or brazing operator shall be in accordance with the technical conditions under which the qualification test is carried out.

c) There shall be no specific reason to question the skill and knowledge of the brazer or brazing operator.

If any of these conditions is not fulfilled, the qualification shall be cancelled.

The qualifications of a brazer or brazer operator shall be confirmed every six months by the person responsible for brazing activities or examiner/examining body. This confirms that the brazer or brazer operator has worked within the range of qualification and extends the validity of the qualification for a further six-month period.

9.2 Prolongation

The validity of the qualification on the certificate may be prolonged for further periods of 5 years provided that each of the following conditions, in addition to those specified in 9.1, are fulfilled.

a) The production brazed joints made by the brazer or brazing operator are continuously of the required quality.

b) Records of tests, e.g. documentation of volumetric non-destructive or destructive tests, from brazing within the original range of qualification during the 6-month period immediately previous shall be filed together with the qualification certificate of the brazer. Acceptance criteria for the production test piece are in accordance with Clause 7.

The examiner or examining body shall verify compliance with conditions a) and b), and sign or issue the prolongation of the qualification test certificate for the brazer.

10 Certificate

A certificate shall be issued to detail that the brazer or brazing operator has passed the performance qualification test. The relevant test conditions shall be recorded on the certificate.

If the brazer or brazing operator fails any of the prescribed tests, no certificate shall be issued.

The certificate shall be issued under the sole responsibility of the examiner or examining body.

The brazer or brazing operator qualification certificate shall contain the essential variables given in Table 1. Examples of recommended formats are given in Annex B and Annex C.

The pBPS or BPS of the manufacturer shall give information about materials, brazing processes, range of qualification, etc., in accordance with this document.

11 Designation

The designation of a brazer or brazing operator qualification test shall comprise the following items in the order given (the system is arranged so that it can be used for computerization):

a) a reference to this document (i.e. ISO 13585:2021);

b) the essential variables in accordance with Table 1.

The type of equipment for mechanized or automatic brazing shall not be incorporated in the designation, but shall be included in the brazing operator's qualification test certificate (see Annex C).

EXAMPLE 1

Qualification test for flame brazing (912) of pipe (T), lap joint (LJ), copper material group 310 (Annex E), face fed CuP281 filler metal (FF), 1,5 mm material thickness (t), 20 mm outside pipe diameter (D), 5 mm overlap length (L), horizontal flow direction (H):

ISO 13585:2021 - 912 T LJ 310 CuP281 FF t1,5 D20 L5 H

EXAMPLE 2

Qualification test for brazing operator, furnace brazing (921) with pre-placed brazing filler (PP):

ISO 13585:2021 – 921 PP

Annex A
(informative)

Quality requirements for brazing

The following information and requirements should be agreed and documented prior to the contract, when applicable:

a) the application standards to be used, if any, together with any supplementary requirements;

b) the BPS, including the brazing process and the brazing variables;

c) the joint design for the test pieces together with relevant tolerances and the number of test pieces required;

d) the specifications of the parent materials;

e) the specifications of the brazing consumables;

f) the handling of parent materials and brazing consumables;

g) the design and method of preparation of the test specimens and, where appropriate, the number to be taken from any test piece;

h) the acceptance criteria;

i) the principle of and procedure for retesting of a series of test pieces, including any additional requirements with regard to the number of test pieces/test specimens and any retraining and time delay conditions prior to reassessment;

j) the extent of visual testing and additional testing requirements for the non-destructive and/or destructive tests;

k) records and documentation.

Annex B
(informative)

Brazer qualification test certificate

Designation(s):

Manufacturer (name and address):

pBPS/BPS – Reference No.:

Brazer's name:

Identification:

Method of identification:

Employer:

Testing standard:

Job knowledge: Acceptable/Not tested (delete as necessary)

Photograph
(if required)

Variables	Test piece	Range of qualification
Brazing process		
Material thickness (mm)		
Outside pipe diameter (mm)		
Overlap length (mm)		
Parent material(s)		
Brazing filler type, work temperature		
Brazing filler application		
Product type		
Filler metal flow direction		
Other		

Further information is stated in the attached document or in the specification for brazing procedure No.:

Type of testing	Performed and accepted	Not tested
Visual Radiographic Ultrasonic Peel Other		

Name of examiner or examining body:

Place, date and signature of examiner or examining body:

Date of issue:

Qualification valid until:

Confirmation of qualification by employer or other responsible person (every six months), required for the validity of the certificate.			Prolongation of qualification by examiner or examining body (every five years).		
Date	**Signature**	**Position or title**	**Date**	**Signature**	**Position or title**

Annex C
(informative)

Brazing operator qualification test certificate

Designation(s):

Manufacturer (name and address):

Certificate reference No.:

pBPS/BPS – Reference No.:

Brazer's name:

Identification:

Method of identification:

Employer:

Testing standard:

Photograph
(if required)

Job knowledge: Acceptable/Not tested (delete as necessary)

Variables	Test piece	Range of qualification
Brazing process		
Type pf brazing equipment		

Further information is stated in the attached document or in the specification for brazing procedure No.:

Type of testing	Performed and accepted	Not tested
Visual Radiographic Ultrasonic Peel Other		

Name of examiner or examining body:

Place, date and signature of examiner or examining body:

Date of issue:

Qualification valid until:

Confirmation of qualification by employer or other responsible person (every six months), required for the validity of the certificate.			Prolongation of qualification by examiner or examining body (every three years).		
Date	**Signature**	**Position or title**	**Date**	**Signature**	**Position or title**

Annex D
(informative)

Other non-essential variables

D.1 Fuel/gases

Fuel/gases shall be selected to be relevant to the heating requirement. Typical examples include:

a) natural gas/air;

b) natural gas/oxygen;

c) propane/air;

d) propane/oxygen;

e) acetylene/air;

f) acetylene/oxygen.

D.2 Brazing torch

A torch similar to that used in production shall be used.

D.3 Joint location

On-site brazing can require a brazer to make joints in close proximity to walls, etc. Joints may be horizontal or vertical. Similar constraints on access for torches can also be encountered in mass production. Qualification tests shall be designed to reproduce these conditions.

D.4 Jigs and fixtures

If necessary, jigs and fixtures shall be used to position the components of a test piece.

D.5 Test location

The qualification test shall take place in a workshop but simulate the on-site limitations. It enables the ability of the brazer to perform on-site and workshop brazing operations in the selected jointing technique to be judged.