
Investigation of brazeability with spreading and gap-filling test

*Étude de l'aptitude au brasage au moyen d'un essai de mouillage et
de capillarité*

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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 13, *Brazing materials and processes*.

This second edition cancels and replaces the first edition (ISO 5179:1983), which has been technically revised.

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

- the spreading test has been added;
- the T-joint test has been added.

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 <https://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

When designing and making a brazed joint, quite apart from the physical properties of the brazing alloy and the mechanical properties which can be expected from the joint, it is important to know the brazeability as a function of the operating conditions adopted. The determination of wettability has already been the subject of numerous investigations and proposals regarding testing methods. In carrying out these investigations, the most frequently used methods are based on the spreading of a drop, or on the measurement of surface tension, but they in fact only take one element of the problem into account. It is important to know not only the way in which the liquid filler metal wets the surface of the parent material but also how this same liquid filler metal behaves in a given gap between the joint components when diffusion takes place.

In this document, brazeability is defined as a total degree of joinability. The joinability consists of both wettability and fluidity to permit distribution into a joint, i.e. ability to fill a joint gap, although total brazeability includes performance of the physical, and mechanical properties in services.

As the tests to be designated for brazeability, three methods are introduced in this document. The traditional varying gap test is described for the most real ability to fill the gap, but it requires a private sample preparation and special evaluation technique with X-ray device. The T-joint test is newly developed to investigate ability to fill the gap in an easier manner. It can be easily operated at industrial laboratories. Moreover, a simple spreading test is designated for practical convenience.

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Investigation of brazeability with spreading and gap-filling test

1 Scope

This document specifies three test methods for investigating brazeability.

A spreading test shows testing method with measurement of the spread area of the filler metals.

A T-joint test describes a scheme to construct a T-shape design by the test pieces and a testing method.

A varying gap test describes a test piece and a testing method for assessing the influence of the various parameters which can influence brazing during manufacture as a function of clearances.

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*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 857-2 apply.

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

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

4 Description of the test piece

4.1 Spreading test piece

The design of the spreading test piece is shown in [Figure 1](#). By using this configuration, it is possible to investigate flow characteristics on the plate.

The test piece consists of a rectangular plate in the following dimensions:

- thickness, $(2,0 \pm 1,0)$ mm;
- width, (40 ± 10) mm;
- length, (40 ± 10) mm.

The filler metal (about 10 mm^3) is put on the centre of the plate.

If it requires fluxing at the temperature of the test, then the flux is also put on the plate.

4.2 Gap filling test

4.2.1 T-joint test piece

The design of the T-joint test piece is shown in [Figure 2](#).

- a) a plate set horizontally:
 - thickness, $(1,5 \pm 0,5)$ mm;
 - width, (25 ± 3) mm;
 - length, (60 ± 3) mm;
- b) another plate set vertically:
 - thickness, $(1,5 \pm 0,2)$ mm;
 - width, (25 ± 3) mm;
 - length, (60 ± 3) mm;

The plate should be prepared to have a perpendicular cross-section against the plate;

- c) a rod as a spacer to make a gap between the plates:
 - diameter $(0,50 \pm 0,01)$ mm;
 - length (30 ± 3) mm;
- d) construction of the test piece.

The two plates are placed perpendicularly, inserting the rod as shown in [Figure 2](#). Thin stainless wire with 0,8 mm in diameter are used to fix their shapes. Alternatively, the 2 plates can be fixed via welded spots at the connection area where no brazing filler metal flows on heating. Then, a brazing filler metal with 10 mm³ is introduced into the contacted point of the two plates. A piece of the brazing filler metal plate should be inserted into the contacting point, while the brazing filler metal rod should be put aside, and the brazing filler metal paste should be glued around the contacting point. It should be located near the contacted point, feasible to make it flow into the gap. If a flux is required at the temperature of the test, it should be smeared in line with the gap and the filler metal itself. The amount of applied brazing filler metal is weighed with conversion from volume to mass using its density, e.g. if the density is 10, 0,10 g should be weighed for introduction.

4.2.2 Varying gap test piece

The design of the varying gap test piece is shown in [Figure 3](#). By using this configuration, it is possible to investigate flow characteristics in the same specimen with capillary gaps varying from 0 mm to 0,5 mm.

The test piece consists of:

- a) an outer tube A:
 - exterior diameter, $(19 \pm 0,1)$ mm;
 - interior diameter, $(14 \pm 0,02)$ mm;
 - height, $(80 \pm 0,05)$ mm;
- The inner end of tube A is bevelled to 45°, while keeping a root face with a width of $(0,5 \pm 0,05)$ mm;
- b) an inner tube B:
 - exterior diameter, $(13,5 \pm 0,02)$ mm;

- interior diameter, $(9,5 \pm 0,1)$ mm;
- height, $(80 \pm 0,05)$ mm;

c) a cup C used as a bottom for the test piece;

NOTE A gap is necessary between the base of the inner tube B and the cup C to allow the filler metal to flow into the capillary gap between tubes A and B.

d) two adjustment screws press the inner cylinder B against the inner wall of the outer cylinder A in such a way that, on looking at a cross-section of the assembly, the gap varies from 0 mm to 0,5 mm over one half of the circumference.

The filler metal (cut in pieces of 15 mm to 20 mm) is introduced into the bore of the inner tube B. If it requires fluxing at the temperature of the test, then the flux is also introduced into the bore. The method of mixing filler metal and flux depends on their characteristics. It is suggested that about 1 400 mm³ of filler metal and the appropriate quantity of flux be used.

5 Purpose of the test

The variables that can be investigated by this test include:

- a) parent material including but not limited to: light metal alloys, copper and its alloys, steels with low levels of additional elements, and steel alloys such as stainless steels, or other brazeable materials;
- b) surface condition: various machine finishes, surface roughness, chemical and other cleaning, and plating, etc.;
- c) brazing filler metals of any kind including but not limited to the ones defined in ISO 17672;
- d) flux: various types of flux; boride, fluoride, chloride, and their mixtures partly included with silicon, fluorine, and borate
- e) atmosphere including but not limited to: air, hydrogen, nitrogen, vacuum, cracked ammonia;
- f) method of heating: torch, furnace, induction, infra-red, etc.;
- g) heating cycle: degree of superheat, time at temperature, time to reach temperature, cooling rate.

6 Preparation of test piece

The test piece is prepared according to a schedule, if methods of cleaning or surface preparation are part of the investigation, then these should be carefully applied.

7 Brazing cycle

The assembly is heated to the appropriate temperature. The method of measuring temperature shall be specified. An appropriate measuring device, such as the thermocouple, shall record the maximum temperature achieved by the sample. A temperature achieved over the whole of the sample shall be firmly recorded because the variability in temperature is the factor being investigated. The sample shall be instrumented sufficiently to give maximum information. Thus, factors on the temperature information, such as "heating rate" and "holding time", shall also be carefully recorded. Other important parameters such as atmosphere condition, gas flow rate, etc., shall be defined by the user and should also be recorded.

8 Examination

8.1 Spreading test piece

After heating, the area of the filler spread onto the material is measured with an appropriate visual imaging sensor to a unit of mm². The spreading test should be done 3 times in a separate manner to calculate the average value.

8.2 T-joint test piece

After brazing, the flow path of the brazing filler metal into the gap is measured with a vernier calliper or a suitable measuring device to 10⁻¹ mm. The T-joint test should be done 3 times in a separate manner to calculate the average value.

8.3 Varying gap test piece

After brazing, the specimen should be radiographed along two or more perpendicular axes (see [Figure 5](#)). The height of the liquid metal rise is then measured on the films and the values obtained are plotted against the angle on a developed diagram. Micrographic inspection of the top of the test piece enables accurate measurement of the rise of the filler metal at 80 mm up the test piece to be carried out.

9 Micrographic inspection for varying gap test

9.1 Varying gap test piece

Micrographic inspection is carried out on a section taken at right angles to the axis of the test piece at a point 30 mm up its length to assess the flow of filler metal at this point. Other sections can be taken at right angles to the axis at various distances from the base. This enables more data to be obtained. The width of the filler metal should be measured, and other features should be investigated such as filler metal alloying and grain boundary penetration into the parent material. Their relationship to the capillary joint gap should be noted. By carrying out several tests, the operator can study parameters such as:

- performance of the parent material;
- surface condition of the parts to be brazed;
- grade of the filler metal;
- type of flux or atmosphere;
- method and conditions of heating (rate of filling, temperature, time, rate of cooling, etc).

10 Results

The results can be conveniently collated on a separate test data sheet in a similar way to that shown in [Figure 7](#) and [Figure 8](#). The table can be extended to include other variables investigated.

Dimensions in millimetres

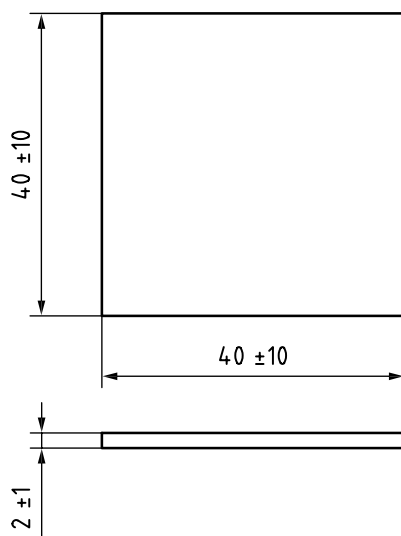


Figure 1 — Spreading test piece

Dimensions in millimetres

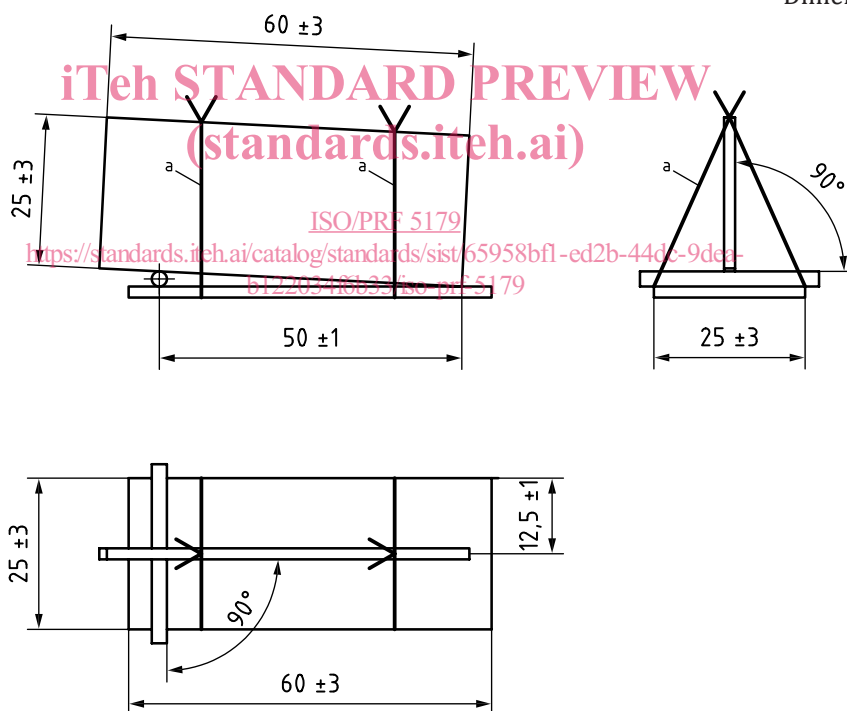


Figure 2 — Assembly of T-joint test piece, Clumping wire with $\phi = 0,8$