Brazing — Destructive tests of brazed joints

The European Standard EN 12797:2000, with the incorporation of amendment A1:2003 has the status of a British Standard

ICS 25.160.50
National foreword


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Summary of pages

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Brazing – Destructive tests of brazed joints

(includes amendment A1:2003)
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Foreword

This European Standard has been prepared by Technical Committee CEN/TC 121 "Welding", the secretariat of which is held by DS.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by January 2001, and conflicting national standards shall be withdrawn at the latest by January 2001.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Foreword to amendment A1

This document EN 12797:2000/A1:2003 has been prepared by Technical Committee CEN/TC 121 "Welding", the secretariat of which is held by DS.

This Amendment to the European Standard EN 12797:2000 shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2004, and conflicting national standards shall be withdrawn at the latest by June 2004.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.
1 Scope

This European Standard describes destructive test procedures and test piece types necessary to perform the tests on brazed joints.

Brazed joints are used in a wide variety of assemblies and the design requirements placed upon these joints will also vary widely; there will usually be some level of strength required but this may not be explicitly stated and is frequently of minor importance compared to some other criterion, e.g. hermeticity. It follows that a test which measures strength may be totally irrelevant in assessing a joint for a particular application where strength is a minor consideration. This situation is made more complicated because brazed joints are almost invariably designed to be loaded in shear and the dimensions of the joint affect the shear strength to a much greater extent than they do the tensile strength. The tests described in this standard have been used successfully to give information on specific properties and where such information is needed, it is recommended that one of them be specified.

It is vital to recognize that for many fabrications none of these tests will be suitable and specific tests will have to be devised, which do yield the requisite information (which may be qualitative rather than quantitative). The destructive test methods described are as follows:

a) shear tests (see clause 4);
b) tensile tests (see clause 5);
c) metallographic examination (see clause 6);
d) hardness tests (see clause 7);
e) peel test (see clause 8);
f) bend tests (see clause 9).

Details of burst tests are not included as these are not commonly used on brazed joints.

The type of test piece described for each test can be quoted or incorporated in engineering applications standards that deal with brazed assemblies.

The results of the tests are used:

1) to determine basic data regarding filler metal performance;
2) to arrive at optimum brazing designs (including gaps) and brazing procedures;
3) to relate production results to results achieved in development.

This European Standard does not recommend the number of samples to be tested or the repeat tests allowed. Neither does it specify methods of sampling brazed joints, except to give guidance regarding the precautions necessary, nor does it comment on the acceptance criteria applicable to any of the tests.

No attempt is made to define which test or tests, if any, should be applied in any situation. This is a matter to be established before any particular method of test is selected.
2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

- EN 910 Destructive tests on welds in metallic materials - Bend tests.
- EN 10002-1 Metallic materials - Tensile testing - Part 1: Method of test (at ambient temperature).
- ISO 5187 Welding and allied processes - Assemblies made with soft solders and brazing filler metals - Mechanical test methods.
- ISO 7438 Metallic materials - Bend test.

3 General principles

Imperfections may be observed when joints are examined by destructive tests. They may reduce the quality and performance characteristics of the joint or the brazed assembly.

Destructive tests may be needed to determine the effects of the brazing process or any subsequent heat treatment on the properties of the joint (e.g. parent materials, filler metals, internal stresses).

This European Standard does not give guidance regarding the cause of the imperfection or its effect upon the joint quality or the effects of single or multiple defects upon the performance characteristics of the brazed assembly. This will depend upon the life-limiting processes to which the joint is subjected and the life requirements and performance specific to the brazed assembly.

The majority of brazed joints are designed with the component parts in a lap configuration. Because of the capillary nature of a brazed joint, most imperfections will be contained within the joint region, with the principal axes parallel to the plane of the joint. Any other imperfections are likely to
have been caused by stresses in the brazing metal or the parent materials, or were already present before brazing. Guidance is given regarding the types of imperfection that are observed when destructive tests are applied; these are defined diagrammatically in annex A.

NOTE 1 The importance of tolerance to typical imperfections, the cause for rejection, the method of imperfection interpretation and the method of presentation of observations have to be established before a specific method of test is selected.

The use of any method should always be considered in relation to testing as a whole. The benefits of using any particular method can only be obtained by consideration of results in conjunction with results obtained by using other test methods. The most appropriate method or methods of testing should be selected.

The methods of destructive examination are not associated with any particular type of test piece but lay down the general principles of the types of testing described. It is emphasized that a satisfactory examination method can only be developed and used after taking into account all the relevant factors regarding the equipment to be used and the characteristics of the test pieces being examined.

The use of the methods of test described enables results from different organizations to have a greater validity when compared, and their use provides designers with basic data on the performance of brazing filler metals and brazed constructions. However, it is essential to appreciate that the results achieved, as with all mechanical tests, are not fundamental, and that the values obtained depend upon the conditions of the test, the condition of the brazing filler metal, the design of the joint and the quality achieved by the brazing process. The brazing process produces joints that are not homogeneous as they are made up of parent materials and a filler metal.

Many factors (such as the joint gap, brazing cycle, diffusion of the filler into the parent material, etc.) will affect the mechanical properties of the joint. Therefore expert knowledge is required to assess whether it is possible to repeat in production the mechanical properties achieved in test pieces.

4 Shear tests

4.1 General

Many designs of test specimen have been used to produce shear data for brazed joints. The great majority of brazed joints are designed to be stressed in shear, and it is not possible to convert the results obtained from butt brazed joints into shear strengths. Test pieces detached from brazed assemblies may be difficult to manufacture into standard shear test specimens; multi-jointed assemblies produce similar problems, where the presence of one defective joint may not reduce the overall strength but can cause failure in service. The shear specimen should essentially be simple in design and economic to manufacture and test.

In all cases, particularly if there is a wide scatter in the results, the effect of non-bonded areas and other imperfections observed by non-destructive examination and the visual examination of the fracture surfaces should be considered.
4.2 Principle

The principle of the test is to subject the test specimen to mechanical loading in shear to fracture and assess its mechanical properties when subjected to these methods of loading.

4.3 Test pieces and specimens

The details of the test pieces and specimens to be used shall be established before any testing is undertaken, and may be, for example, one of the following types.

a) Type I as shown in Figure 1;
b) Type II as shown in Figure 2.

The dimensions shown in Figures 1 and 2 are those typically used but it may be necessary to vary these to reflect specific applications.

4.4 Procedure

The test shall be conducted generally in accordance with the principles of ISO 5187.

4.5 Test results and information to be reported

The test results and information to be reported shall include the following.

a) Test piece and details including dimensions, tolerances and brazed joint gap and method of preparation;
b) References, e.g. contract number, part number, location on brazed structure, as applicable;
c) Date of test;
d) Brazing filler metal;
e) Parent materials;
f) Brazing process details;
g) Test specimen type;
h) Number of test specimens;
i) Type of test machine;
j) Temperature of test;
k) Numerical results;
l) Position of fracture;
m) Appearance of fracture surface (imperfections if failure is in the brazed joint);
n) Name of laboratory and authorizing signature.
Dimensions in millimetres, surface roughness values in micrometres

For the classification of filler metals, a value of \( a = 4 \) is recommended.

a) Test piece before brazing

b) Test piece

c) Test specimen after details machining

**Key**

1. X: According to the gap required
2. Filler metal

**Figure 1 - Type I shear test piece and specimen dimensions**
Dimensions in millimetres, surface roughness values in micrometres

For the classification of filler metals, a value of $a = 4$ is recommended

**a) Test piece details**

**b) Test piece before brazing**

**c) Test specimen after brazing and machining**

**Key**

1. $Y$: According to the jig used
2. $X$: According to the gap required
3. Gas outlet
4. Filler metal

**Figure 2 - Type II shear test piece and specimen dimensions**
5 Tensile tests

5.1 General

Many designs of test specimen have been used to produce tensile data for brazed joints. The tensile specimen should essentially be simple to design and economic to manufacture and test.

The test results should be evaluated taking into consideration the requirements of EN 10002-1 and the requirements of each specific test. In all cases, and particularly if there is a wide scatter in the results, the effects of non-bonded areas and other imperfections observed by non-destructive examination and the visual examination of the fracture surfaces should be considered.

5.2 Principle

The principle of the test is to subject the test specimen to mechanical loading in tension, to fracture and to assess its mechanical properties when subjected to this method of loading.

5.3 Test pieces and specimens

The details of the test pieces and specimens to be used shall be established before any testing is undertaken, and may be, for example, one of the following types.

a) Type I as shown in Figure 3;
b) Type II as shown in Figure 4;
c) Type III as shown in Figure 5.

The dimensions shown in Figures 3, 4 and 5 are those typically used but it may be necessary to vary these to reflect specific applications.

5.4 Procedure

The test shall be conducted generally in accordance with the principles of ISO 5187 and EN 10002-1.

Tensile tests shall be carried out normally on a fixture on a machine possessing adjustable clamps, in order to avoid unintentional bending stresses in the specimens causing spurious results.
Dimensions in millimetres

a) Test piece details b) Test piece before razing c) Test specimen

**Key**
1 Filler metal
2 Chamfer at 45° (on 0.5 radius)
3 Joint gap
4 Location of brazed joint

**Figure 3 - Type I tensile test piece and specimen dimensions**
Dimensions in millimetres

a) Test piece as brazed

b) Test specimen

Key
1 Gauge length

Figure 4 - Type II tensile test piece and specimen dimensions
Dimensions in millimetres

Key
1 Stand
2 Round bar
3 Upper grip
4 Section of brazing wire
5 Lower grip
6 Four-burner blow pipe
7 Burner support
8 Base plate

c) Brazing jig

Figure 4 - Type II tensile test piece and specimen dimensions (concluded)
The position mark on either end of the finished specimen identifies the orientation of the sample when brazed.

a) Test piece half

Key
1 Spacer foil (thickness = brazing gap width)  5 Shims
2 Groove receiving filler metal  6 V-block support
3 Test piece cross-section for testing  7 Test piece half
4 Clamping device  8 TIG tack weld

b) Test piece clamping device and positioner of spacer foils, shown schematically
c) Tensile specimen

Figure 5 - Type III tensile test piece and specimen dimensions

5.5 Test results and information to be reported

The test results and information to be reported shall include the following.

a) Test piece and method of preparation;
b) Reference, e.g. contract number, part number, location on brazed structure, as applicable;
c) Date of test;
d) Brazing filler metal;
e) Parent materials;
f) Brazing process details;
g) Test specimen type;
h) Number of test specimens;
i) Testing method;
j) Type of testing machine;
k) Temperature of test;
l) Numerical results;
m) Position of fracture;
n) Appearance of fracture surface (imperfections if failure is in the brazed joint);
o) Name of laboratory and authorizing signature.
6 Metallographic examination

6.1 General

The quality of brazed joints and fundamental information about parent material/filler metal reactions, diffusional characteristics and other aspects can be investigated by macro- and micro-examination of the brazed joint. Consideration should be given to the manufacture of test pieces specifically intended to assist metallographic examination, e.g. variable gap test pieces. This technique only gives information about the sectioned surfaces that are the subject of examination. It is also useful for investigating the cause of failures and production quality, and to confirm the data produced by non-destructive examination methods.

The operator can, if necessary, be supplied with sketches or photographs of the type of imperfection that may be present.

6.2 Principle

The macro- and micro-structures of the brazed joint are examined to investigate its quality.

6.3 Preparation of the test specimen

Particular care shall be taken when sectioning to ensure that the structure is not modified. The sections and their relative positions shall be unequivocally recorded and marked.

The section shall be ground and polished to achieve the surface finish required for macro- and micro-examination. For more sophisticated methods, such as micro-probe analysis, scanning electron microscopy and similar methods, the sections shall be prepared by methods specific to the method of examination being used. The sections prepared for macro- and micro-examination, shall be flat and free from scratches, pits and stains, so that they can be examined with or without etching.

NOTE 1 Because of the different materials present in nearly all brazed joints, etching may be difficult and sometimes impossible.

6.4 Procedure

The procedure used shall be one of the following.

a) Macroscopic examination. The section shall be examined at a low magnification, up to x25. The joint shall be examined for lack of flow, flux entrapment, porosity, cracks and any other imperfections;

b) Microscopic examination. The sections shall be examined by means of a metallurgical microscope at suitable magnifications. The joint shall be examined for detail not revealed by macro-examination, the structure of the brazed joint, erosion, parent metal/filler metal reactions, grain boundary phenomena and any other metallurgical requirement;

c) Sophisticated techniques. These techniques shall be used for detailed examination of filler metal compositions, as-brazed and after heat treatment, diffusion of filler metal into parent materials, and any other data relevant to the investigation of the quality of the brazed joint.
The details of the processing of the data from the tests shall be established before any testing is undertaken.

6.5 Test results and information to be reported

The test results and information to be reported shall include the following.

a) Test piece and method of preparation;
b) Reference, e.g. contract number, part number, location on brazed structure, as applicable;
c) Date of test;
d) Brazing filler metal;
e) Parent materials;
f) Brazing process details;
g) Test method;
h) Number of sections examined;
i) Surface preparation, including any etching;
j) Numerical results where applicable;
k) Photographs, if a permanent record is required;
l) Any observations that are required by the contractual agreement;
m) Name of laboratory and authorizing signature.

7 Hardness testing

7.1 General

Different methods of hardness testing give different results which are not always directly comparable. By use of empirically determined tables, the results from one type of test can be approximately converted into those of others for various materials.

When applied to brazed joints, a hardness test is useful as a production method for checking the metallurgical condition of the parent materials and, in the case of heat treatable parent materials, will give guidance regarding the efficiency of the heat treatment process. It is frequently used in research and development to investigate the diffusional characteristics of the filler metal, for example when investigating the behaviour of nickel-based filler metals. In such cases consideration should be given to making a traverse across the braze.

7.2 Principle

An indentation is made in the surface of the test specimen, the size of which, in conjunction with the applied load, gives the hardness of the surface layer.
Micro-hardness tests are normally recommended when it is required to measure the hardness of the 
filler metal within the brazed joint and the hardness of the adjacent parent metal.

7.3 Preparation of the test specimen

To measure hardness in the brazed joint filler metal and adjacent regions, the test piece shall be 
sectioned. The position of the sections shall be established before any testing is undertaken.

The surface preparation shall be appropriate to the type of test being applied and shall not influence 
the results of the test. The smaller the size of the impression, the better the surface preparation needs 
to be. For micro-hardness tests, the surface shall be prepared as described in 6.3.

NOTE 1 Care should be taken when sectioning and preparing the sections to ensure that the 
surface to be examined is not modified by the method of preparation.

7.4 Procedure

7.4.1 Macro-hardness test The appropriate test shall be carried out as follows:

a) Vickers hardness test in accordance with EN ISO 6507-1;

b) Brinell test in accordance with EN 10003-1;

c) Rockwell test in accordance with EN 10109-1.

The operator shall be made aware of the possible hardness variations that may occur over the 
surface of the test specimen. The test specimen shall be suitably supported during the test so that it 
does not move when the load is applied by the indentor.

7.4.2 Low-force hardness test A Vickers hardness test shall be carried out in accordance with 
EN ISO 6507-1.

7.4.3 Micro-hardness test The appropriate test shall be carried out as follows:

a) Vickers hardness test in accordance with EN ISO 6507-1;

b) Knoop diamond hardness test in accordance with ISO 4545.

7.5 Test results and information to be reported

The test results and information to be reported shall include the following.

a) Test piece and method of preparation;

b) Reference, e.g. contract number, part number, location on brazed structure, as applicable;

c) Date of test;

d) Brazing filler metal;

e) Parent materials;

f) Brazing process details;

g) Number of test specimens;
h) Testing method;
i) Method of sectioning;
j) Surface preparation;
k) Numerical results;
l) Name of laboratory and authorizing signature;
m) Summary of results.

8 Peel tests

8.1 General

There are two typical uses of peel testing.

a) A simple test used as a method of on-line quality control when the nature of the work piece permits;
b) A semi-quantitative test applied specifically to a suitable test piece (see Figure 6). Because of the nature of the test it is not usually possible to achieve a numerical result for the load required to peel the component parts of the joint except by averaging the results from a large number of test specimens.

NOTE 1 In some cases, because of the basic strength of the bond between the parent materials and the filler metal, the failure may occur through the parent material.

8.2 Principle

The components of the brazed joint are peeled apart to determine the quality by visual examination.

8.3 Preparation of the test specimen

The test specimen shall be either:

a) detached from a brazed assembly;
b) the test piece used without further preparation (see Figure 6).

In batch and continuous processes it shall be brazed concurrently with the brazed assemblies.

8.4 Procedure

One member of the test specimen shall be held in a vice or by some similar method, and the other member shall be peeled away to enable the separated faces to be visually examined.

Useful information can also be obtained from an impression of the forces required for hand peeling.
The separated faces of the joint shall be visually examined in accordance with clause 3 of EN 12799:2000. The objective of the examination shall be to determine the general quality of the bond, the presence of unbonded areas, voids and flux inclusions in the joint.

In addition, test specimens (see Figure 6) may be peeled in a tensile machine to obtain semi-quantitative data.

**Key**

1. Brazed joint
2. The presence and size of this fillet will influence the measurement of any peel strength

**Figure 6 - Peel test specimen**

**8.5 Test results and information to be reported**

The test results and information to be reported shall include the following.

a) Test piece and method of preparation;
b) Reference, e.g. contract number, part number, location on brazed construction, as applicable;
c) Date of test;
d) Filler metal;
e) Parent materials;
f) Brazing process details;
g) Number of test specimens;
h) Method of peeling;
i) Position of fracture;
j) Appearance of fracture surface including percentage of bond;
k) Name of laboratory and authorizing signature.
The results of the visual examination shall be assessed and compared with the maximum permissible size, number and distribution of imperfections, which shall be established before any testing is undertaken and will depend upon the service conditions or the quality specification.

9 Bend tests

9.1 General

Bend tests are not often applied to brazed joints but, when used, can give some indication of the ability of a brazed joint to be deformed as part of the general manufacturing process or its ability to be flexed during its life as an engineering component or assembly.

The acceptance or rejection of the test specimen which contains minor cracking rather than exhibits total failure depends upon the life-limiting process to which the brazed assembly is subjected.

9.2 Principle

The brazed joint is deformed by bending to determine the ductility and resistance to cracking of the brazed joint, the heat affected zone, the parent materials and the brazed assembly

9.3 Preparation of the test specimen

The test specimen shall be prepared as specified in ISO 7438. The configuration of the test specimen shall be either:

a) as detailed in Figure 7; or
b) another test configuration, the details of which shall be established before any testing is undertaken.

NOTE 1 In the case of tubular test pieces, it is common practice to take a longitudinal section to produce the test specimens.

9.4 Procedure

The test specimen shall be deformed by bending either in the free mode as shown in Figure 8 or by a controlled bend test around a suitable predetermined radius as shown in Figure 9.

NOTE 1 The controlled bend test is most suitable for materials incorporating brazed joints.

Bend testing is also a method of applying a proof load and shall be carried out as demonstrated in Figure 10. Loads up to the limiting proof strain shall be applied to the test piece.

NOTE 2 The loading of the test specimen may also be increased until failure occurs, or the test specimen deforms until it passes through the support blocks.

An arrangement for a constant moment bend test is shown in Figure 11.
Methods of testing shall be either:

a) as described in EN 910; or

b) another test procedure using another test specimen, the details of which shall be established before any testing is undertaken.

NOTE 3 The test procedures can be used for both lap and butt brazed test specimens.

WARNING In some cases when brittle materials or brittle brazed joints are being tested, the fracture materials may be ejected from the test machine in a dangerous manner. It is essential to protect the operator and other persons in the vicinity of the test machine.

9.5 Test results and information to be reported

The test results shall be reported as described in EN 910.

The test results and information to be reported shall include the following.

a) Test piece and method of preparation;

b) Reference, e.g. contract number, part number, location on brazed structure, as applicable;

c) Date of test;

d) Brazing filler metals;

e) Parent materials;

f) Brazing process details;

g) Test specimen type;

h) Number of test specimens;

i) Testing method;

j) Radius of former;

k) Position and appearance of fracture;

l) Name of laboratory and authorizing signature.
a) Lap joint in sheet materials

b) Butt brazed joint in round materials

c) Scarf joint in round materials

Figure 7 - Test pieces for bend test
Key
1 Load
2 Brazed lap joint
3 Test specimen
4 Vice
5 Round nosed mandrel plate

a) Arrangement to give test specimen preliminary bend

b) Intermediate stage
c) Final stage

NOTE 1 These test procedures can be used for both lap and butt configurations.
NOTE 2 See warning in 9.4.

Figure 8 - Free bend test
a) Using a special forming rig  
b) Using a U block and former  

c) Using a soft metal bed  
d) Using a hand lever  

NOTE 1 These test procedures can be used for both lap and butt configurations.

Key  
1 Test specimen  
2 Clearance  
3 Brazed butt joint  
4 U block  
5 Lead block  
6 Clamp

Figure 9 - Supported bend tests for lap and butt joints
Key
1 Test specimen
2 Loading adaptor
3 Butt braze
4 Support
5 Dial gauge

Figure 10 - Simple bend or flexing test
Key
1 Joint gap
2 Filler metal
3 Zone subjected to constant moment test
4 Direction of force
5 2 screws per head
6 Pin joint

Figure 11 - Constant moment bend test
Annex A (informative)

Imperfections in brazed joints

Figures A.1 to A.7 illustrate imperfections in brazed joints.

Key
1  Filler metal melts, no flow
2  Lack of flow into capillary gap

Figure A.1 - Incomplete flow at fillet and in capillary

Key
1  Crack in filler metal
2  Crack in parent material (ceramic failure)
3  Interfacial crack

Figure A.2 - Longitudinal cracks
Key
1  In brazed joint
2  Propagating into parent material (liquid metal attack)

Figure A.3 - Transverse cracks

Key
1  Large pores
2  Linear porosity
3  Cluster of small pores
4  Gas pore or flux inclusion

Figure A.4 - Porosity and inclusions
Considerable reaction between parent metal and filler metal with consequent erosion of former.

Key
1  Vertical when brazed
2  Original face of parent metal

Figure A.5 - Erosion

Figure A.6 - Excessive filler metal flow
Figure A.7 - Incorrect component assembly
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