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## Brazing — Imperfections in brazed joints

*Brasage fort — Défauts dans les assemblages réalisés par brasage fort*

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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 document 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](http://www.iso.org/directives)).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at [www.iso.org/patents](http://www.iso.org/patents). ISO shall not be held responsible for identifying any or all such patent rights.

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](http://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*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 121, *Welding and allied processes*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 18279:2003), which has been technically revised.

The main changes are as follows:

- An additional quality level for brazed joint imperfections has been added in [Annex B](#) in order to reflect the technical progress that has been achieved over the past decade as well as the need for increased requirements regarding reliability of brazed joints for critical applications. Quality levels have been reevaluated.

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](http://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

Brazed joints usually contain imperfections of various types, some of which are detrimental in almost every case while others can be detrimental or harmless, depending entirely on the service requirements of the joint in question. Therefore, it is often necessary to classify the imperfections in a brazed joint and then try to assess the significance of their effects on the behaviour of the joint in service. The classification is relatively easy and [Table 1](#) describes the imperfections that most commonly occur. The assessment of significance is not easy (see also [Annex A](#)).

For welded joints, there has been extensive work carried out for many years on the significance of imperfections in service; however, such work has not been carried out on brazed joints. Moreover, the work on welded joints is only rarely relevant to brazed joints, mainly because of differences in geometry and stressing. Therefore, this document cannot give definitive quality levels for brazed joints. These can only be produced as experience is gained from industrial applications. However, [Annex B](#) gives some suggestions for quality levels for general applications, which can be of help where detailed information is not available. The use of quality levels can only be successful if the imperfections that are relevant to the application of the brazed joint are determined.

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# Brazing — Imperfections in brazed joints

## 1 Scope

This document details a classification of imperfections that can occur in brazing joints. In addition, guidance is provided on quality levels and suggested limits for imperfections are detailed.

For requirements not covered by this document, reference can be made to other sources, such as statutory regulations, codes of practice and technical delivery conditions.

No information is given on how imperfections are to be assessed in individual cases because this depends on the requirements for the particular brazed joint. These imperfections are not always detectable by the use of non-destructive testing alone.

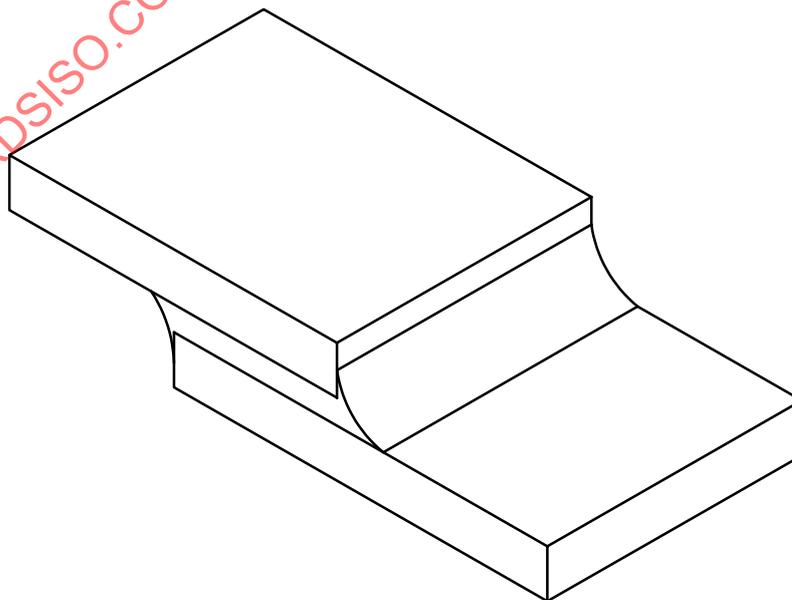
This document covers only imperfections that can occur in connection with brazing without the effect of any additional service loads. Only the type, shape and position of such imperfections are covered; no indication is given of the conditions of occurrence or causes.

For requirements for brazed joints which are relevant and essential to the particular function of the component, reference can be made to the relevant documentation, for example manufacturing documents or procedure sheets.

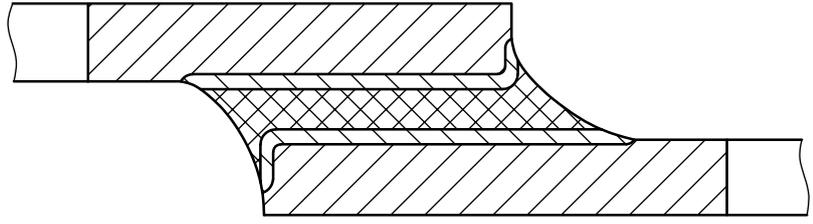
It is important that these requirements be precisely prescribed and that conformity with them be verifiable. Conformity can be established by testing either the brazed assembly itself or a test piece produced under comparable conditions.

This document does not specify requirements for acceptance levels for imperfections, since these will differ very markedly depending on the application, but it does suggest some quality levels which can be of value in the absence of more detailed information.

For the purposes of this document, the areas of a brazed assembly are designated as shown schematically in [Figure 1](#).



a) Simple brazed assembly



b) Section through assembly in a)

**Key**

-  parent material
-  parent material affected by brazing [heat-affected zone (HAZ)]
-  diffusion-transition zone
-  braze metal

NOTE Extent of HAZ will vary with materials and brazing process.

**Figure 1 — Schematic of brazed assembly**

**2 Normative references**

There are no normative references in this document.

**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 imperfection**

irregularity in the brazed joint or deviation from the intended relative positions of the parts joined by brazing and from the intended shape of the brazed component, where such deviations are dependent on the brazing

EXAMPLE For an example of an imperfection, see [Figure 2](#).

## 4 Symbols

For the purposes of this document, the following symbols apply.

- $l$  length of the brazed overlap
- $l_r$  required brazed length
- $l_u$  length of overlap before brazing
- $l_{1,2}$  dimensions of the brazed imperfection
- $t_j$  thickness of brazed joint
- $t_{1,2}$  wall or plate thickness or thicknesses

[Figure 2](#) illustrates a planar imperfection by using the symbols.

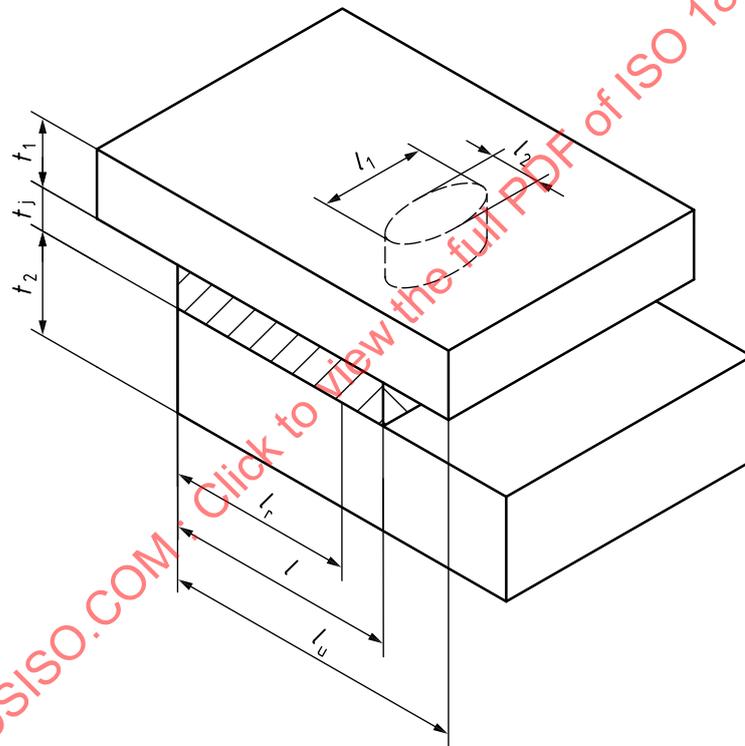


Figure 2 — Symbols used for dimensions

## 5 Classification

### 5.1 General

The imperfections are classified into six groups as follows:

- group I: cracks;
- group II: cavities;
- group III: solid inclusions;
- group IV: bonding imperfections;

- group V: shape and size imperfections;
- group VI: miscellaneous imperfections.

Imperfections are identified by designations which are given with descriptions in [Table 1](#).

A further distinction can be made between the external and internal imperfections that can occur in brazed joints.

## **5.2 External imperfections**

External imperfections in brazed joints include:

- underfill;
- crack(s);
- surface-breaking porosity;
- incomplete fillet;
- overlap;
- localized melting;
- rough surface of seam;
- flux seepage;
- discolouration;
- spatter;
- residual flux;
- surface erosion of parent material.

## **5.3 Internal imperfections**

Internal imperfections in brazed joints include:

- crack(s);
- filling imperfection;
- solid inclusion;
- gas entrapment;
- flux inclusion;
- lack of fusion;
- excessive alloying of filler material and parent material (sometimes called erosion).

Table 1 — Classification of imperfections

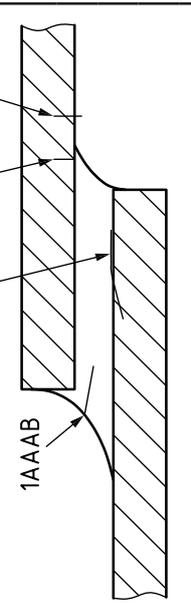
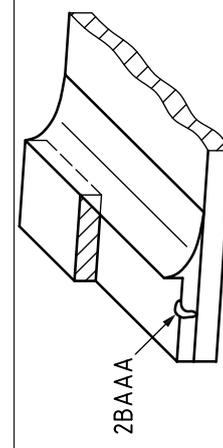
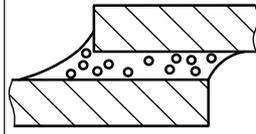
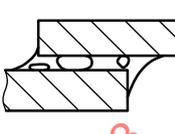
Designation	Description	Remarks	Drawing
<b>I Cracks</b>			
1A <sup>a</sup> AAA	Crack	Limited separation of the material, predominantly two-dimensional extension. A crack can be longitudinal or transverse. It can lie in one or more of the following:	
1A <sup>a</sup> AAB		— in the braze metal	
1A <sup>a</sup> AAC		— at the interface and including the diffusion zone	
1A <sup>a</sup> AAD		— in the HAZ	
1A <sup>a</sup> AAE		— in the unaffected parent material	
<b>II Cavities</b>			
2BAAA	Gas cavity	Gas-filled cavity	
2BGAA	Gas pore	Spheroidal gas inclusion It can occur as:	
2BGGA		— uniformly distributed porosity	
2BGMA		— localized (clustered) porosity	
2BGHA		— linear porosity	
2LIAA	Large gas pocket	Large voids may be the width of the joint with elongated shape	
<p><sup>a</sup> In the case of an intergranular crack, change this second symbol 'A' to the symbol 'F'. In the case of a transgranular crack, change this second symbol 'A' to the symbol 'H'.</p> <p><sup>b</sup> These imperfections often occur together.</p>			

Table 1 (continued)

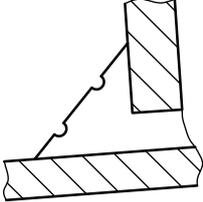
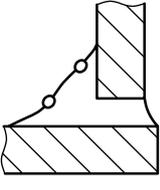
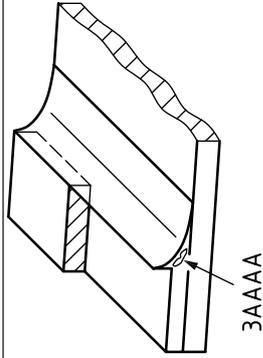
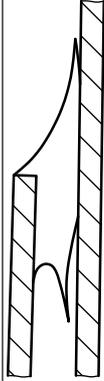
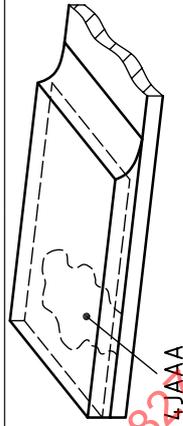
Designation	Description	Remarks	Drawing
2BALF <sup>b</sup>	Surface pore	Gas pore breaking the surface	
2MGAF <sup>b</sup>	Surface bubble	Gas pore near the surface, which results in swelling	
<b>III Solid inclusions</b>			
3AAAA	Solid inclusion	Inclusion of foreign metal or non-metallic particles in the braze metal. Could be possible to divide into: — oxide inclusion — metallic inclusion — flux inclusion	
3DAAA			
3FAAA			
3CAAA			
<b>IV Bonding imperfections</b>			
4BAAA	Bonding imperfection	No bonding or inadequate bonding between the braze metal and the parent material	
4JAAA	Filling imperfection	Incomplete filling of the gap	
<p><sup>a</sup> In the case of an intergranular crack, change this second symbol 'A' to the symbol 'F'. In the case of a transgranular crack, change this second symbol 'A' to the symbol 'H'.</p> <p><sup>b</sup> These imperfections often occur together.</p>			

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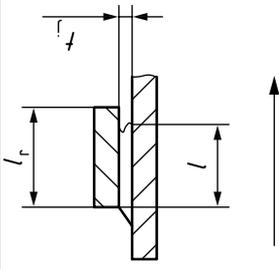
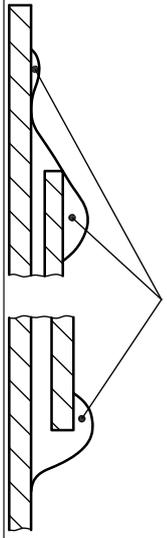
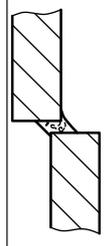
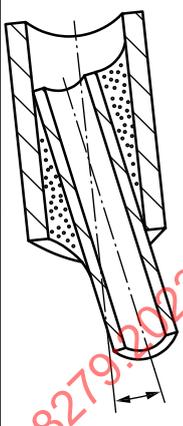
Designation	Description	Remarks	Drawing
4CAAA	Incomplete penetration	The braze metal has failed to flow through the required length of the joint	 <p>The arrow indicates the direction of flow through the joint</p>
<b>V Shape and size imperfections</b>			
6BAAA	Excess braze metal	Braze metal has spilled over onto parent material solidifying as a bead or a thick layer	 <p>6BAAA</p>
5AAAA	Imperfect shape	Departure from the prescribed shape of the brazed joint	
5EIAA	Linear misalignment (linear offset)	The components are parallel but offset	
5EJAA	Angular misalignment	The components form an angle deviating from the required value.	
5BAAA	Distortion	Unwanted change in the shape of the brazed assembly	
<p><sup>a</sup> In the case of an intergranular crack, change this second symbol 'A' to the symbol 'F'. In the case of a transgranular crack, change this second symbol 'A' to the symbol 'H'.</p> <p><sup>b</sup> These imperfections often occur together.</p>			

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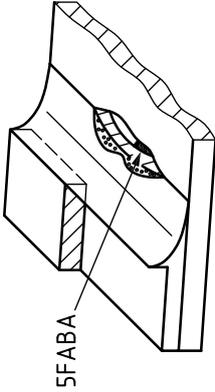
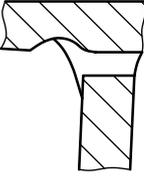
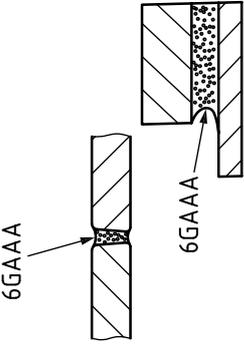
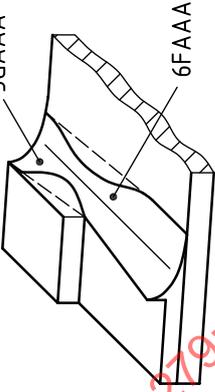
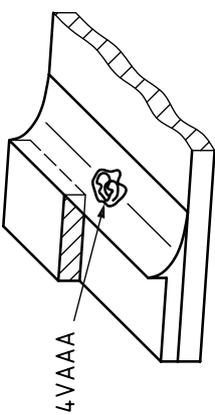
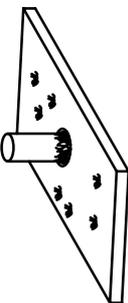
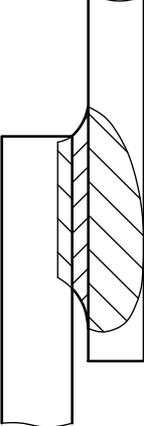
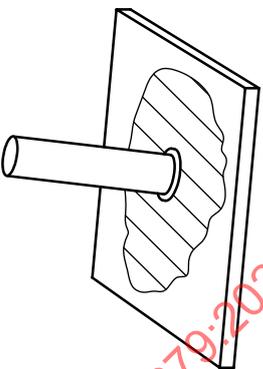
Designation	Description	Remarks	Drawing
5FABA	Localized melting (or melt-through)	Through-going hole in the brazed joint or next to it	
7NABD	Fused parent material surface	Fused surface of the brazed assembly in the region of the joint	
7OABP	Erosion by filler metal	Erosive damage to the surface of the brazed assembly	
6GAAA	Recessed braze metal (recessed fillet)	The surface of the filler metal in the brazed joint is below the level of the joint opening	
5HAAA	Rough surface	The surface of the braze metal has sunk below the surface of the parent material	
6FAAA	Insufficient or excessive fillet	Irregular solidification, liquation, etc.	
5GAAA	Irregular fillet	Filllet out of specified size has formed Appearance of fillet variable	
a	In the case of an intergranular crack, change this second symbol 'F' to the symbol 'A'. In the case of a transgranular crack, change this second symbol 'A' to the symbol 'H'.		
b	These imperfections often occur together.		

Table 1 (continued)

Designation	Description	Remarks	Drawing
<b>VI Miscellaneous imperfections</b>			
7AAAA	Miscellaneous imperfection	Imperfection that cannot be classified into groups I to V	
4VAAA	Flux seepage	Emergence of flux residues at surface pores	
7CAAA	Spatter	Drops of braze metal adhering to the surface of the brazed assembly	
7SAAA	Discolouration or oxidation	Oxidation, flux action or deposition of volatized filler metal or parent material on the surface.	
7UAAC	Excessive alloying of parent and filler materials	Associated with excess of heat, time and/or filler materials	
9FAAA	Flux residue	Flux that has not been removed	
7QAAA	Excessive braze metal flow	Excessive braze metal flow	
9KAAA	Etch marking	Reaction with flux on the parent material surface	
<sup>a</sup> In the case of an intergranular crack, change this second symbol 'A' to the symbol 'F'. In the case of a transgranular crack, change this second symbol 'A' to the symbol 'H'. <sup>b</sup> These imperfections often occur together.			

## Annex A (informative)

### Guidelines for practical evaluation of imperfections

Before undertaking an evaluation of imperfections, there is a crucial need for a carefully detailed review of all the relevant factors to avoid subsequent expensive errors. Although not specifically within the scope of this document, this review also needs to cover the requirements for applicable test methods, for example those in EN 12797 and EN 12799.

It is essential to recognize the importance of carrying out a realistic view of relevant imperfections, for example if the brazed assembly needs to hold a high internal vacuum, gas pores do not play an important role as long as the assembly is leak-proof. This applies equally to the choice of tests to prove the suggested imperfections. They shall be selected taking into account the requirements in service. The primary requirements have always to be borne in mind and given priority.

In brazing, imperfections typically found in welds do not occur. Furthermore, the occurrence of imperfections in brazing often has a different importance than it has in welding. As a consequence of factors such as these, in certain instances it is necessary to carry out a realistic choice of tests on actual-sized brazed assemblies. A consequence of this is that extraordinary testing can at best be merely a waste of money and at worst dangerously misleading.

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## Annex B (informative)

### Evaluation

The evaluation of brazed joints should account for each imperfection in [Table 1](#), the actual joint being assigned to one of four quality levels with the symbol A, B, C or D (see [Table B.1](#)). Joints should be examined after the application of any post-braze cleaning process.

**Table B.1 — Quality levels for brazed joint imperfections**

Level symbol	Quality level
D	Moderate
C	Intermediate
B	High
A	Stringent

The four quality levels are arbitrarily identified as D, C, B and A and are intended to cover the majority of practical applications. Level symbol A<sup>+</sup> is intended to relate to especially stringent applications and for these the limits for imperfections can be established for the specific application.

Where necessary, requirements may be more precisely defined. Combination of imperfections should be considered when setting the levels required.

Category A joints can meet the highest quality requirements, but not all brazing processes will be suitable to obtain this level. Where the wetting process between molten filler metal and base metal is influenced by additional effects, as for example with flux brazing, brazing of aluminium or sinter parts brazing, it is recommended that category A is not specified.

It is permitted to specify that certain imperfections conform to a different quality level, this being stated in the relevant documentation.

Assignment to a particular quality level should also take account of the component material and design, the brazing manufacturing methods used, the service conditions and the performance of the joint in service.

Suggested limits for imperfections are given in [Table B.2](#).

Extreme caution should be exercised in implementing the suggested limits for imperfections detailed in [Table B.2](#), particularly for existing designs that have proved satisfactory in service. Joint redesign can be found necessary to meet these limits but the need to do so should be seriously questioned if service experience has been satisfactory with the current design and standards of work.