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Brazing — Imperfections in brazed joints

Brasage fort — Défauts dans les assemblages réalisés par brasage fort



Reference number
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Foreword

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 18279 was prepared by the European Committee for Standardization (CEN) in collaboration with Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 12, *Soldering and brazing materials*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Throughout the text of this document, read “...this European Standard...” to mean “...this International Standard...”.

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Foreword

This document (EN ISO 18279:2003) has been prepared by Technical Committee CEN/TC 121 "Welding", the secretariat of which is held by DS, in collaboration with Technical Committee ISO/TC 44 "Welding and allied processes".

This European Standard EN ISO 18279:2003 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of an identical text or by endorsement, at the latest by June 2004 and conflicting national standards shall be withdrawn at the latest by June 2004.

Annexes A and B are informative.

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.

Introduction

Brazed joints usually contain imperfections of various types, some of which will be detrimental in almost every case but others may be detrimental or harmless, depending entirely on the service requirements of the joint in question. Therefore it will frequently be 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 but 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 standard 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 may be of help where detailed information is not available. It has to be emphasized that the use of quality levels can only be successful if the imperfections that are relevant to the application of the brazed joint are determined.

1 Scope

This European Standard 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 standard, reference is to be made to other sources, e.g. statutory regulations, codes of practice and technical delivery conditions.

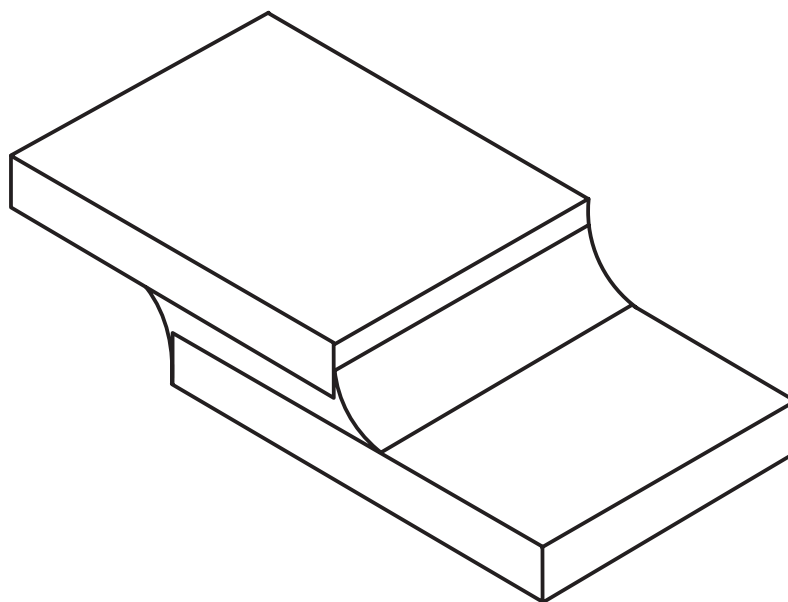
No information is given on how imperfections are to be assessed in individual cases because this depends on the requirements for the particular brazed joint. These imperfections are not always detectable by the use of non-destructive testing alone.

The standard 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.

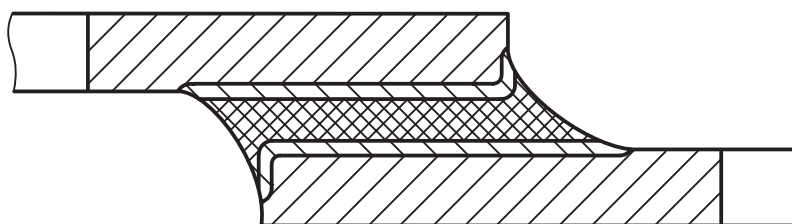
For requirements for brazed joints which are relevant and essential to the particular function of the component, reference should be made to the relevant documentation, e.g. manufacturing documents or procedure sheets.

NOTE It is important that these requirements be precisely prescribed and that compliance with them be verifiable. Compliance may be established by testing either the brazed assembly itself or a test piece produced under comparable conditions. The requirements should be established and fully documented before any classification is undertaken.





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



a) Simple brazed assembly



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.

b) Section through assembly in a)

Figure 1 — Schematic of brazed assembly

2 Terms and definitions

For the purposes of this European Standard the areas of a brazed assembly are defined as shown schematically in Figure 1. In addition the following term and definition apply.

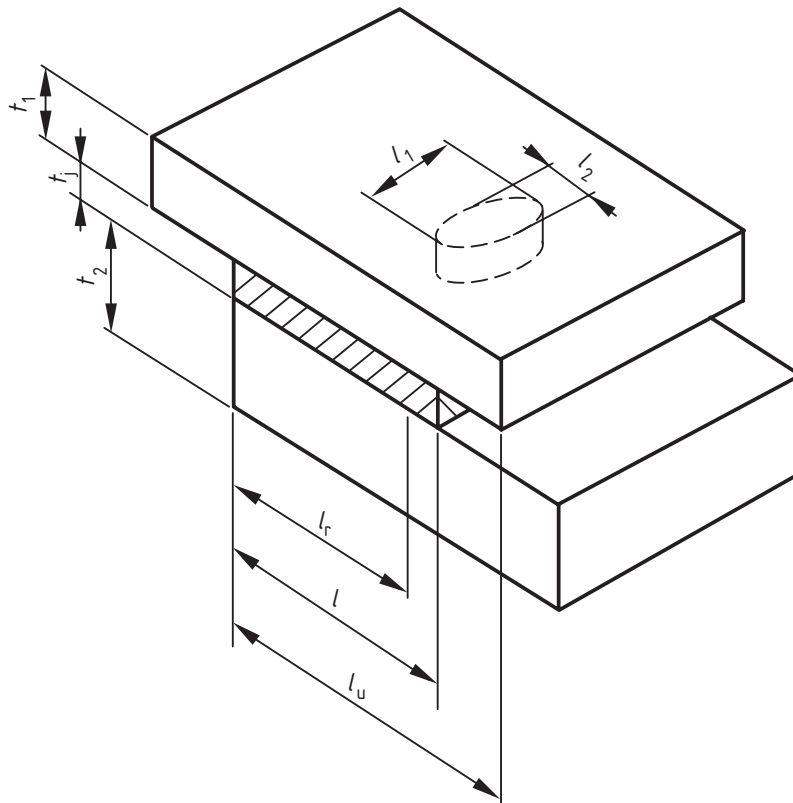
2.1 imperfections

irregularities in the brazed joint, deviations 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

3 Symbols

The following symbols are used:

- 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.



NOTE This figure illustrates a planar imperfection.

Figure 2 — Symbols used for dimensions

4 Classification

4.1 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.

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

4.2 External imperfections

External imperfections in brazed joints include:

- underfill;
- cracks;
- surface-breaking porosity;
- incomplete fillet;
- overlap;
- localized melting;
- rough surface of seam;
- flux seepage;
- discoloration;
- spatter;
- residual flux;
- surface erosion of parent material.

4.3 Internal imperfections

Internal imperfections in brazed joints include:

- cracks;
- filling imperfections;

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

Table 1 — Classification of imperfections

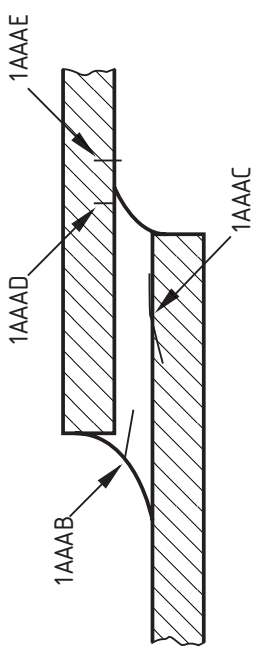
| Designation | Description | Remarks | Drawing |
|--|-------------|--|---|
| I Cracks | | | |
| 1A ^a AAA | crack | Limited separation of the material, predominantly two-dimensional extension. A crack may be longitudinal or transverse | |
| 1A ^a AAB | | It can lie in one or more of the following : in the braze metal | |
| 1A ^a AAC | | at the interface and including the diffusion zone | |
| 1A ^a AAD | | In the HAZ | |
| 1A ^a AEE | | in the unaffected parent material |  |
| ^a - 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'. | | | |

Table 1 — Classification of imperfections (continued)

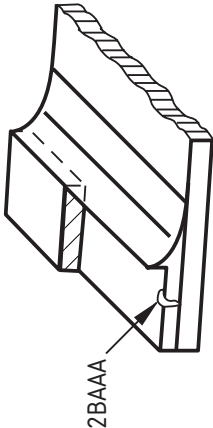
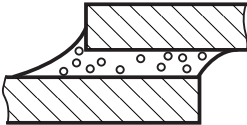

| Designation | Description | Remarks | Drawing |
|--------------------|-------------------|---|---|
| II Cavities | | | |
| 2AAAA | cavity | | |
| 2BAAA | gas cavity | Gas-filled cavity |  |
| 2BGAA | gas pore | Spheroidal gas inclusion. It can occur as : uniformly distributed porosity localized (clustered) porosity linear porosity |  |
| 2BGGA | | | |
| 2BGMA | | | |
| 2BGHA | | | |
| 2LIAA | large gas pockets | Large voids may be the width of the joint with elongated shape |  |

Table 1 — Classification of imperfections (continued)

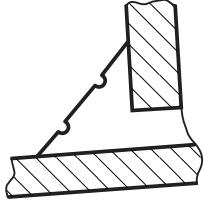
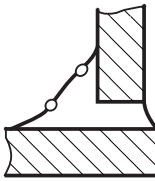
| Designation | Description | Remarks | Drawing |
|--|----------------|---|---|
| 2BALF ^b | surface pore | Gas pore breaking the surface. |  |
| 2MGAF ^b | surface bubble | Gas pore near the surface which results in swelling |  |
| ^b These imperfections often occur together. | | | |

Table 1 — Classification of imperfections (continued)

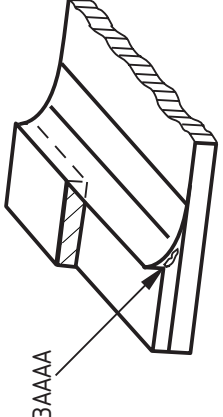
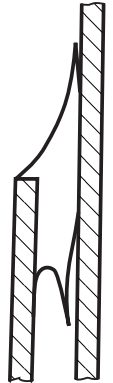
| Designation | Description | Remarks | Drawing |
|---------------------------------|----------------------|--|--|
| III. Solid inclusions | | | |
| 3A AAA | solid inclusion | Inclusion of foreign metal or non-metallic particles in the braze metal May be possible to divide into : oxide inclusion metallic inclusion flux inclusion |  |
| 3D AAA | | | |
| 3F AAA | | | |
| 3C AAA | | | |
| IV Bonding imperfections | | | |
| 4B AAA | bonding imperfection | No bonding or inadequate bonding between the braze metal and the parent material |  |

Table 1 — Classification of imperfections (continued)

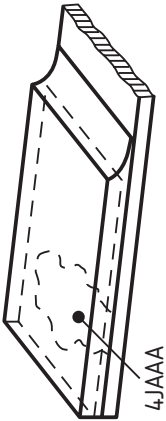
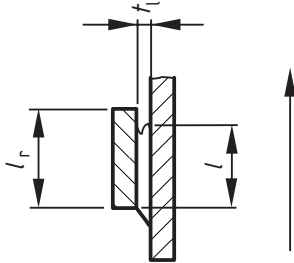
| Designation | Description | Remarks | Drawing |
|-------------|------------------------|---|---|
| 4JAAA | filling imperfection | Incomplete filling of the gap |  <p>A 3D perspective drawing of a joint between two plates. The joint is filled with a material, but there is a visible gap or void in the center. The drawing is labeled '4JAAA'.</p> |
| 4CAAA | incomplete penetration | The braze metal has failed to flow through the required length of the joint |  <p>A cross-sectional drawing of a joint between two plates. The joint is filled with braze metal. The drawing shows the required length of the joint, l_r, and the actual length of the braze metal, l. The braze metal has failed to flow through the required length of the joint. The drawing is labeled '4CAAA'. An arrow indicates the direction of flow through the joint.</p> <p>The arrow indicates the direction of flow through the joint.</p> |

Table 1 — Classification of imperfections (continued)

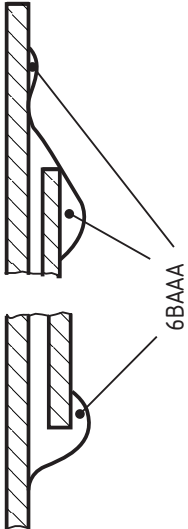


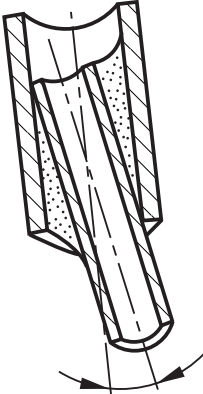
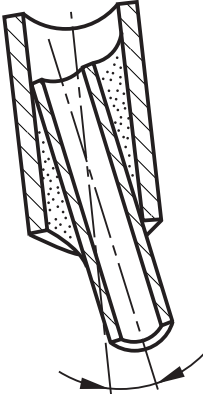
| Designation | Description | Remarks | Drawing |
|---------------------------------------|-------------------------------------|--|--|
| V Shape and size imperfections | | | |
| 6BAAA | excess braze metal | Braze metal has spilled over onto parent material solidifying as a bead or a thick layer |  |
| 5A AAA | imperfect shape | Departure from the prescribed shape of the brazed joint |  |
| 5E IAA | linear misalignment (linear offset) | The components are parallel but offset |  |
| 5E JAA | angular misalignment | The components form an angle deviating from the required value. |  |
| 5BAAA | distortion | Unwanted change in the shape of the brazed assembly |  |

Table 1 — Classification of imperfections (continued)

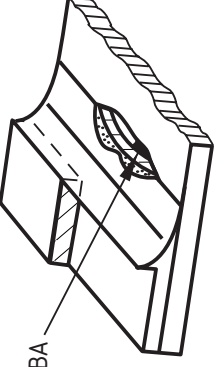
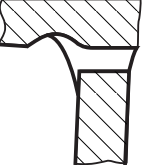
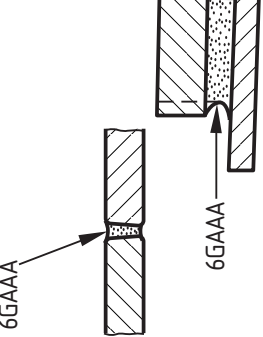
| Designation | Description | Remarks | Drawing |
|-------------|--|---|---|
| 5FABA | localized melting (or melt-through) | Through-going hole in the brazed joint or next to it |  |
| 7NABD | fused parent material surface | Fused surface of the brazed assembly in the region of the joint | |
| 7OABP | erosion by filler metal | Erosive damage to the surface of the brazed assembly. |  |
| 6GAAA | recessed braze metal (recessed fillet) | <p>The surface of the braze metal in the brazed joint is below the required dimension</p> <p>The surface of the braze metal has sunk below the surface of the parent material</p> |  |

Table 1 — Classification of imperfections (continued)

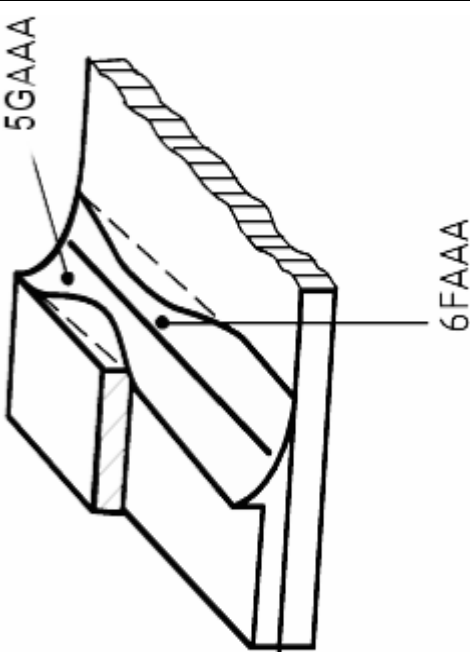
| Designation | Description | Remarks | Drawing |
|---------------------------------------|----------------------------|--|--|
| 5HAAA | rough surface | Irregular solidification, liquation, etc. | |
| 6FAAA | insufficient fillet | Fillet below specified size has formed |  |
| 5GAAA | irregular fillet | Appearance of fillet variable | |
| VI Miscellaneous imperfections | | | |
| 7AAAA | miscellaneous imperfection | Imperfection that cannot be classified into groups I to V of this table. | |

Table 1 — Classification of imperfections (continued)

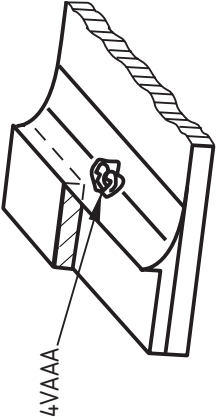

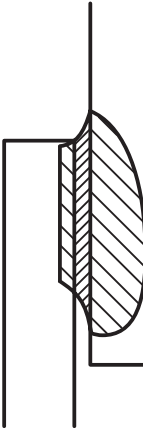
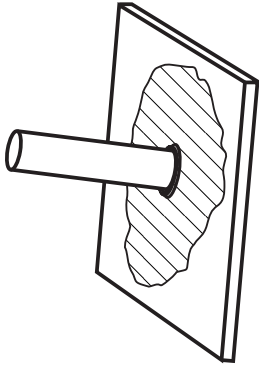
| Designation | Description | Remarks | Drawing |
|-------------|---|---|--|
| 4VAAA | flux seepage | Emergence of flux residues at surface pores |  <p>A 3D perspective drawing of a joint between two metal plates. A small circular hole is shown in the joint, with a shaded area representing flux residue emerging from it. The label '4VAAA' is positioned to the left of the drawing.</p> |
| 7CAAA | spatter | Drops of braze metal adhering to the surface of the brazed assembly. |  <p>A 3D perspective drawing of a metal plate with several small, irregular droplets of braze metal adhering to its surface. The label '7CAAA' is positioned to the left of the drawing.</p> |
| 7SAAA | discoloration/oxidation | Oxidation/flux action/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 |  <p>A 3D perspective drawing of a joint between two metal plates. The joint area is shaded with diagonal lines, indicating excessive alloying of the parent and filler materials. The label '7UAAC' is positioned to the left of the drawing.</p> |
| 9FAAA | flux residue | Flux that has not been removed | |

Table 1 — Classification of imperfections (continued)

| Designation | Description | Remarks | Drawing |
|-------------|----------------------------|---|---|
| 7QAAA | excessive braze metal flow | excessive braze metal flow |  |
| 9KAAA | etch marking | Reaction with flux on the parent material surface | |

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 standard, this review also needs to cover the requirements for applicable test methods, e.g. those in EN 12797 and EN 12799.

It is essential to recognize the importance of carrying out a realistic view of relevant imperfections, e.g. 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 have to 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 an example of this, in general terms a fill proportion of about 60 % in a brazed tube joint is sufficient in a large range of applications. As a consequence of factors such as these, in certain instances it will be necessary to carry out a realistic choice of tests on actual-sized brazed assemblies. A consequence of this is that extraordinary testing may at best be merely a waste of money and at worst dangerously misleading.

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 three quality levels with the symbol 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 | Stringent |

The three quality levels are arbitrarily identified as D, C and B and are intended to cover the majority of practical applications. Level symbol A is intended to relate to especially stringent applications and for these the limits for imperfections are to 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.

It is permitted to specify that certain imperfections be in compliance with 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 re-design may 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.

Table B.2 — Suggested limits for imperfections

| Designation | Description | Suggested limits for imperfections for quality levels | | |
|-------------|---|---|---|---|
| | | Moderate D | Intermediate C | Stringent B |
| I Cracks | | | | |
| 1AAAA | crack | Permissible where component function is not adversely affected | Not permissible | Not permissible |
| 1AAAB | | | | |
| 1AAAC | | | | |
| 1AAAD | | | | |
| 1AAAE | | | | |
| II Cavities | | | | |
| 2AAAA | cavity | | | |
| 2BAAA | gas cavity | Max. 40 % of the projected area. | Max. 30 % of the projected area. | Max. 20 % of the projected area. |
| 2BGAA | gas pore | Max. 40 % of the projected area. | Max. 30 % of the projected area. | Max. 20 % of the projected area. |
| 2BGGA | Max. permissible pore diameter or pore area may be defined for special applications | Max. permissible pore diameter or pore area may be defined for special applications | Max. permissible pore diameter or pore area may be defined for special applications | Max. permissible pore diameter or pore area may be defined for special applications |
| 2BGMA | | | | |
| 2BGHA | | | | |

Table B.2 — Suggested limits for imperfections (continued)

| Designation | Description | Suggested limits for imperfections for quality levels | | |
|----------------------|-------------------|---|---|---|
| | | Moderate D | Intermediate C | Stringent B |
| 2LIAA | large gas pockets | Max. 40 % of the projected area. Max. permissible pore diameter or pore area may be defined for special applications | Max. 30 % of the projected area. Max. permissible pore diameter or pore area may be defined for special applications | Max. 20 % of the projected area. Max. permissible pore diameter or pore area may be defined for special applications |
| 2BALF | surface pore | Permissible where component function is not adversely affected | Max. 20 % of the projected area permissible where component function is not adversely affected | Not permissible |
| 2MGAF | surface bubble | Permissible | Permissible | Not permissible |
| III Solid inclusions | | | | |
| 3AAAA | solid inclusion | Max. 40 % of the projected area. | Max. 30 % of the projected area. | Max. 20 % of the projected area. |
| 3DAAA | | Max. permissible diameter or area of solid inclusion may be defined for special applications | Max. permissible diameter or area of solid inclusion may be defined for special applications | Max. permissible diameter or area of solid inclusion may be defined for special applications |
| 3FAAA | | | | |
| 3CAAA | | | | |

Table B.2 — Suggested limits for imperfections (continued)

| Designation | Description | Suggested limits for imperfections for quality levels | | |
|--------------------------|------------------------|--|--|--|
| | | Moderate D | Intermediate C | Stringent B |
| IV Bonding imperfections | | | | |
| 4BAAA | bonding imperfection | Max. 25 % of nominal brazed area. Permissible where component function is not adversely affected and not breaking the surface | Max. 15 % of nominal brazed area. Permissible where component function is not adversely affected and not breaking the surface | Max. 10 % of nominal brazed area. Permissible where component function is not adversely affected and not breaking the surface |
| 4JAAA | filling imperfection | 60 % or more of the projected area to be filled with braze metal. Permissible where component function is not adversely affected and not breaking the surface | 70 % or more of the projected area to be filled with braze metal. Permissible where component function is not adversely affected and not breaking the surface | 80 % or more of the projected area to be filled with braze metal. Permissible where component function is not adversely affected and not breaking the surface |
| 4CAAA | incomplete penetration | Permissible where component function is not adversely affected and not breaking the surface | Permissible where component function is not adversely affected and not breaking the surface | Not permissible |
| V Imperfect shape | | | | |
| 6BAAA | excess braze metal | Permissible | Permissible | Not permissible |
| 5AAAA | imperfect shape | | | |

Table B.2 — Suggested limits for imperfections (continued)

| Designation | Description | Suggested limits for imperfections for quality levels | | |
|-------------|--|--|--|--|
| | | Moderate D | Intermediate C | Stringent B |
| 5EIAA | linear misalignment (linear offset) | Permissible where component function is not adversely affected | Permissible where component function is not adversely affected | Permissible where component function is not adversely affected |
| 5EJAA | angular misalignment | Permissible where component function is not adversely affected | Permissible where component function is not adversely affected | Permissible where component function is not adversely affected |
| 5BAAA | distortion | Permissible where component function is not adversely affected | Permissible where component function is not adversely affected | Permissible where component function is not adversely affected |
| 5FABA | localized melting (or melt-through) | Not permissible. | Not permissible | Not permissible |
| 7NABD | fused parent material surface | Permissible where component function is not adversely affected | Not permissible | Not permissible |
| 7OABP | erosion by filler metal | Nominal material thickness not to be reduced by more than 20 % | Nominal material thickness not to be reduced by more than 15 % | Nominal material thickness not to be reduced by more than 10 % |
| 6GAAA | recessed braze metal (recessed fillet) | Permissible where component function is not adversely affected | Permissible where component function is not adversely affected | Permissible where component function is not adversely affected |
| 5HAAA | rough surface | Permissible | Permissible | Not permissible. Rough areas to be machined smooth. |
| 6FAAA | insufficient fillet | Permissible where component function is not adversely affected | Permissible where component function is not adversely affected | Not permissible |

Table B.2 — Suggested limits for imperfections (continued)

| Designation | Description | Suggested limits for imperfections for quality levels | | |
|--------------------------------|---|--|--|--|
| | | Moderate D | Intermediate C | Stringent B |
| 5GAAA | irregular fillet | Permissible where component function is not adversely affected | Permissible where component function is not adversely affected | Not permissible |
| VI Miscellaneous imperfections | | | | |
| 7AAAA | miscellaneous imperfection | | | |
| 4VAAA | flux seepage | Permissible where component function is not adversely affected | Permissible where component function is not adversely affected | Not permissible |
| 7CAAA | spatter | Permissible | Permissible where component function is not adversely affected | Permissible where component function is not adversely affected |
| 7SAAA | discoloration/oxidation | Permissible | Permissible | Permissible ; however discoloured areas are to be removed |
| 7UAAC | excessive alloying of parent and filler materials | Permissible where component function is not adversely affected | Permissible where component function is not adversely affected | Permissible where component function is not adversely affected |
| 9FAAA | flux residue | Permissible where component function is not adversely affected | Permissible where component function is not adversely affected | Not permissible |

Table B.2 — Suggested limits for imperfections (concluded)

| Designation | Description | Suggested limits for imperfections for quality levels | | |
|-------------|----------------------------|---|-------------------|--|
| | | Moderate D | Intermediate C | Stringent B |
| 7QAAA | excessive braze metal flow | Permissible | Permissible | Permissible where component function is not adversely affected |
| 9KAAA | etch marking | Permissible | Permissible | Permissible where component function is not adversely affected |

Bibliography

- 1) EN 12797:2000, *Brazing — Destructive tests of brazed joints*
- 2) EN 12799:2000, *Brazing — Non-destructive examination of brazed joints*

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