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**Welding — Electron and laser beam welded  
joints — Guidance on quality levels for  
imperfections —**

Part 2:  
**Aluminium and its weldable alloys**

*Soudage — Assemblages soudés par faisceau d'électrons et par faisceau  
laser — Guide des niveaux de qualité des défauts —*

*Partie 2: Aluminium et ses alliages soudables*



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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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.

Attention is drawn to the possibility that some of the elements of this part of ISO 13919 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 13919-2 was prepared by the European Committee for Standardization (CEN) in collaboration with Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 10, *Unification of requirements in the field of metal welding*, 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...".

ISO 13919 consists of the following parts, under the general title *Welding — Electron and laser beam welded joints — Guidance on quality levels for imperfections*:

- *Part 1: Steel*
- *Part 2: Aluminium and its weldable alloys*

Annex A of this part of ISO 13919 is for information only.

For the purposes of this part of ISO 13919, the CEN annex regarding fulfilment of European Council Directives has been removed.

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## Foreword

The text of EN ISO 13919-2:2001 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 shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2002, and conflicting national standards shall be withdrawn at the latest by March 2002.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

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.

## Introduction

This European standard should be used as a reference in the drafting of application codes and/or for other application standards. It may be used within a total quality system for the production of satisfactory welded joints. It provides three sets of dimensional values from which a selection can be made for a particular application. The quality level necessary in each case should be defined by the application standard or the responsible designer in conjunction with the manufacturer, user and/or other parties concerned. The level should be prescribed before the start of production, preferably at the inquiry or order stage. For special purposes, additional details may need to be prescribed.

The quality levels given in this standard are intended to provide basic reference data and are not specifically related to any particular application. They refer to welded joints and not the complete product or component itself. It is possible, therefore, for different quality levels to be applied to individual welded joints in the same product or component. Quality levels are listed in table 1.

**Table 1 — Quality levels for weld 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.

If higher requirements are made on welds than compatible with the above levels (e.g. for dynamic loading) such welds may be machined or ground after welding in order to remove surface imperfections.

It would normally be hoped that for a particular welded joint the dimensional limits for imperfections could all be covered by specifying one quality level. In some cases, however, e.g. for certain types of aluminium or aluminium alloys and structures as well as for fatigue loading or leak tightness applications it may be necessary to specify different quality levels for different imperfections in the same welded joint or to include additional requirements.

The choice of quality level for any application should take account of design considerations, subsequent processing, e.g. surfacing, mode of stressing (e.g. static, dynamic), service conditions (e.g. temperature, environment), and

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consequences of failure. Economic factors are also important and should include not only the cost of welding but also that of inspection, test and repair.

Although this standard includes types of imperfections relevant to the electron and laser beam welding processes, only those which are applicable to the process and application in question need to be considered.

Imperfections are quoted in terms of their actual dimensions, and their detection and evaluation may require the use of one or more methods of non-destructive testing. The detection and sizing of imperfections is dependent on the inspection methods and the extent of testing specified in the application standard or contract.

This standard does not include details of recommended methods of detection and sizing and, therefore, it needs to be supplemented by requirements for examination, inspection and testing. It should be appreciated that methods of non-destructive examination may not be able to give the detection, characterisation and sizing necessary for use within certain types of imperfections shown in table 2.

Although this standard covers material thicknesses (penetration depths) from 1 mm and above for electron and laser beam welding, it should be noted that the permitted size for all types of imperfection has an absolute, upper limit.

Application for thicknesses above 50 mm for electron beam welding and 12 mm for laser beam welding is, for that reason, usually safe, but may be overly conservative and may require special precautions, such as weld bead dressing in order to comply with the limits for reinforcement and undercut. Attention should be paid to such precautions during approval testing of the welding procedure and alternative requirements may have to be specified, if necessary.

Application for thicknesses below 1 mm is possible, but the requirements may be overly conservative for certain types of imperfections.

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## 1 Scope

This standard provides guidance on levels of imperfections in electron and laser beam welded joints in aluminium and its alloys. Three levels are given in such a way as to permit application for a wide range of welded fabrications. The levels refer to production quality and not to the fitness-for-purpose of the product manufactured.

This standard applies to electron and laser beam welding of:

- aluminium and its alloys;
- all types of welds welded with or without additional filler wire;
- materials equal to or above 1 mm thickness for electron and laser beam welding.

When significant deviations from the joint geometries and dimensions stated in this standard are present in the welded product, it is necessary to evaluate to what extent the provisions of this standard can apply.

NOTE For circular welds, a lower quality level e.g., may be specified for the fade-out zone.

Metallurgical aspects, e.g. grain size, hardness are not covered by this standard.

## 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 here after. 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.

EN ISO 6520-1, *Welding and allied processes — Classification of geometric imperfections in metallic materials — Part 1: Fusion welding (ISO 6520-1:1998)*

EN 30042, *Arc-welded joints in aluminium and its weldable alloys — Guidance on quality levels for imperfections (ISO 10042 : 1992)*

### 3 Symbols

The following symbols are used in table 2:

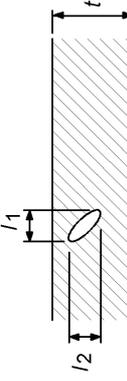
$\Delta L$	distance between two imperfections (pore, cavity)
$b$	width of weld
$b_r$	width of weld root
$d$	maximum size of an imperfection (pore, cavity)
$f$	projected areas of pores or cavities
$g$	distance from center line in T-joint
$h$	size of the imperfection (height, width)
$h_1; h_2$	deviation from the weld penetration
$l$	length of imperfection (measured in any direction)
$L$	weld length under consideration (weld length examined)
$L_c$	length of combined porosity (affected weld length)
$s$	weld penetration
$s_1$	weld penetration in T-joint
$t$	work-piece thickness

### 4 Evaluation of welds

Limits for imperfections are given in table 2.

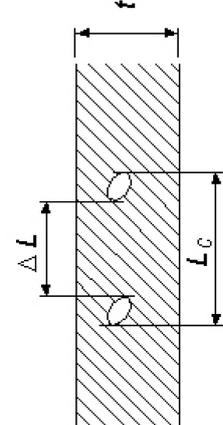
A welded joint should normally be evaluated separately for each individual type of imperfection. Different types of imperfection occurring at any cross-section of the joint may need special consideration.

Table 2 — Imperfections

No	Imperfection, designation	EN ISO 6520-1 reference	Remarks	Limits for imperfections for quality levels:		
				moderate D	intermediate C	stringent B
1	Cracks	100	All types of cracks except micro cracks (less than 1 mm <sup>2</sup> crack area). For crater cracks see No 2.	Not permitted	Not permitted	Not permitted
2	Crater cracks	104		Local crater cracks permitted	Local crater cracks Permitted	Not permitted
3	Porosity and gas pores	200	<p>The following conditions and limits for imperfections shall be fulfilled:</p> <p>a) Maximum dimension <math>l</math> (<math>l_1</math>, <math>l_2</math> or <math>h</math>) for a single pore;</p> <p>b) Maximum dimension of the summation of the projected area of the imperfections.</p> <p>Projection is in a direction parallel to the surface and perpendicular to the weld axis. It relates to an area <math>t</math> multiplied by weld length, where weld length is the actual length of the weld or 100 mm, whichever is the smaller.</p> 	<p><math>l</math> or <math>h \leq 0,5 t</math> max. 6 mm</p> <p>Electron beam welding: <math>f \leq 6 \%</math> Laser beam welding: <math>f \leq 10 \%</math></p>	<p><math>l</math> or <math>h \leq 0,4 t</math> max. 5 mm</p> <p>Electron beam welding: <math>f \leq 3 \%</math> Laser beam welding: <math>f \leq 6 \%</math></p>	<p><math>l</math> or <math>h \leq 0,3 t</math> max. 4 mm</p> <p>Electron beam welding: <math>f \leq 1,5 \%</math> Laser beam welding: <math>f \leq 3 \%</math></p>

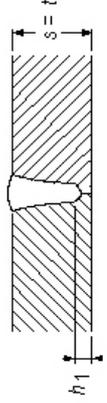
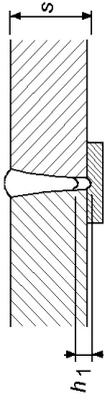
(continued)

Table 2 (continued)

		Limits for imperfections for quality levels:			
No	Imperfection, designation	EN ISO 6520-1 reference	moderate D	intermediate C	stringent B
4	Localised (clustered) and linear porosity	2013 and 2014	<p>The following conditions and limits for imperfections shall be fulfilled:</p> <p>a) Maximum dimension <math>l</math> (<math>l_1</math>, <math>l_2</math> or <math>h</math>) for a single pore;</p> <p>b) Maximum dimension of the summation of the projected area of the imperfections. Projection is in a direction parallel to the surface and perpendicular to the weld axis. It relates to an area <math>t</math> multiplied by weld length, where weld length is the actual length of the weld or 100 mm, whichever is the smaller.</p> <p>In addition:</p> <p>c) The distances <math>\Delta L</math> between the individual pores in clustered or linear porosity shall be assessed. Any two pores closer than:</p> <p style="text-align: center;">shall be considered a combined porosity.</p> <p>d) Combined porosity is permitted, provided the affected weld length <math>L_c</math> is less than:</p>	<p><math>l</math> or <math>h \leq 0,4 t</math> max. 5 mm</p> <p><math>f \leq 5 \%</math></p> <p>0,5 <math>t</math> max. 10 mm</p> <p><math>L_c \leq t</math></p>	<p><math>l</math> or <math>h \leq 0,3 t</math> max. 4 mm</p> <p><math>f \leq 2 \%</math></p> <p>0,5 <math>t</math> max. 15 mm</p> <p><math>L_c \leq t</math></p>
			<p><math>l</math> or <math>h \leq 0,5 t</math> max. 6 mm</p> <p><math>f \leq 15 \%</math></p> <p>0,25 <math>t</math> max. 5 mm</p> <p><math>L_c \leq 2 t</math></p>	 <p>Affected weld length <math>L_c</math> for combined porosity. Use d) acceptance limit.</p>	

(continued)

Table 2 (continued)

No	Imperfection, designation	EN ISO 6520-1 reference	Remarks	Limits for imperfections for quality levels:		
				moderate D	intermediate C	stringent B
5	Shrinkage cavity	202		Use limits for porosity		
6	Crater pipe	204		$h \leq 0,15 t$ max. 2 mm	$h \leq 0,1 t$ max. 1,5 mm	$h \leq 0,05 t$ max. 1 mm
7	Solid inclusions	300	Only oxide inclusions permitted	Use limits for porosity		
8	Lack of fusion	401		$h \leq 0,25 s$ max. 1 mm	Not permitted	Not permitted
9	Incomplete penetration	402	<p>Lack of penetration <math>h_1</math> for full penetration welds shall be less than:</p>  <p>Welding into backing:</p>  <p>Partial penetration may be specified for certain applications. Figures below show examples. The limits relate to deviations <math>h_1</math>, resulting in penetrations less than specified. Max. deviation <math>h_1</math>:</p>	$h_1 \leq 0,25 s$ max. 1 mm	Not permitted	Not permitted
				$h_1 \leq 0,25 s$ max. 1 mm	$h_1 \leq 0,2 s$ max. 0,7 mm	$h_1 \leq 0,15 s$ max. 0,5 mm

(continued)

Table 2 (continued)

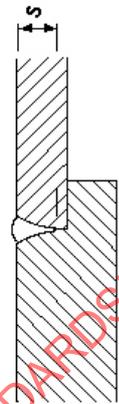
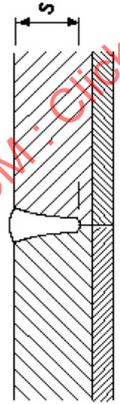
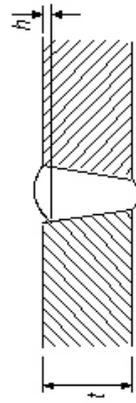
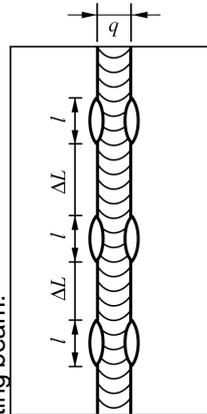
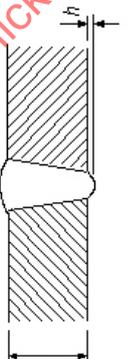
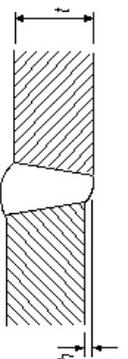
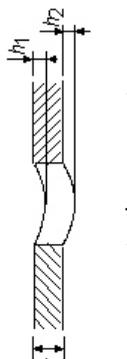
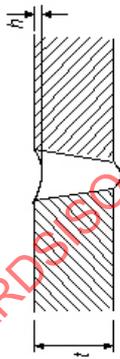
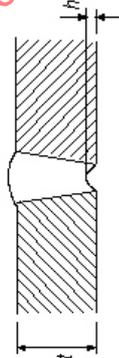
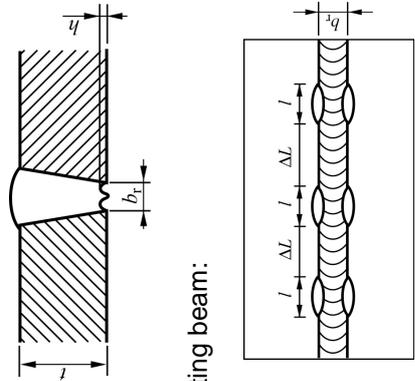
No	Imperfection, designation	EN ISO 6520-1 reference	Remarks	Limits for imperfections for quality levels:		
				moderate D	intermediate C	stringent B
9			<p>Sealing run:</p>  <p>Welding of clad materials. Followed by back gouging and arc welding from clad side.</p> 			
10	Imperfections specific to fillet welds	—	Applicable only for welding with filler materials. Imperfections Nos 12, 14, 16, 17, 18 and 22 according to EN 30042. Limits for imperfection No 13 according to EN 30042 depend on the application and shall be specified individually for each particular case.	Use limits for arc welding, see EN 30042, level D.	Use limits for arc welding, see EN 30042, level C.	Use limits for arc welding, see EN 30042, level B.
11	Undercut	5011 5012	 <p>Pulsating beam:</p> 	$h \leq 0,15 t$ max. 2 mm	$h \leq 0,1 t$ max. 1,5 mm	$h \leq 0,05 t$ max. 1 mm  $h \leq 0,1 t$ max. 1,5 mm if $l \leq 2 b$ and $\Delta L \geq 5 b$

Table 2 (continued)

No	Imperfection, designation	EN ISO reference	Remarks	Limits for imperfections for quality levels:		
				moderate D	intermediate C	stringent B
12	Excess weld metal	502	 <p>To be applied for reinforcement on weld side.</p>	$h \leq 0,2 \text{ mm} + 0,3 t$ max. 5 mm	$h \leq 0,2 \text{ mm} + 0,2 t$ max. 5 mm	$h \leq 0,2 \text{ mm} + 0,15 t$ max. 5 mm
13	Excessive penetration	504		$h \leq 0,2 \text{ mm} + 0,3 t$ max. 5 mm	$h \leq 0,2 \text{ mm} + 0,2 t$ max. 5 mm	$h \leq 0,2 \text{ mm} + 0,15 t$ max. 5 mm
14	Linear misalignment	507	 <p>The limits relate to deviations from the correct position. Unless otherwise specified, the correct position is that when the centerlines coincide.</p>	$h \leq 0,25 t$ max. 3 mm	$h \leq 0,15 t$ max. 2 mm	$h \leq 0,1 t$ max. 1 mm
15	Sagging	509	 <p>The excess penetration may, to some extent, compensate for the sagging. Only for welding of thin plate materials where <math>b \geq 0,5 t</math> and <math>t \leq 2 \text{ mm}</math>.</p>	$h_1 \leq 0,3 t + h_2$ max. 0,5 t	$h_1 \leq 0,2 t + h_2$ max. 0,3 t	$h_1 \leq 0,1 t + h_2$ max. 0,2 t

(continued)

Table 2 (continued)

		Limits for imperfections for quality levels:			
		moderate D	intermediate C	stringent B	
No	Imperfection, designation	Remarks			
16	Incompletely filled groove		$h \leq 0,15 t$ max. 2 mm	$h \leq 0,1 t$ max. 1,5 mm	$h \leq 0,05 t$ max. 1 mm
17	Root concavity		$h \leq 0,3 t$ max. 1 mm	$h \leq 0,2 t$ max. 0,5 mm	$h \leq 0,1 t$ max. 0,5 mm
18	Shrinkage groove	 <p>Pulsating beam:</p>	$h \leq 0,15 t$ max. 2 mm	$h \leq 0,1 t$ max. 1,5 mm	$h \leq 0,05 t$ max. 1 mm
			$h \leq 0,3 t$ max. 2,5 mm if $l \leq 2 b_r$ and $\Delta L \geq 5 b_r$	$h \leq 0,2 t$ max. 2 mm if $l \leq 2 b_r$ and $\Delta L \geq 5 b_r$	$h \leq 0,1 t$ max. 1,5 mm if $l \leq 2 b_r$ and $\Delta L \geq 5 b_r$

(continued)