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Electron and laser-beam welded joints — Requirements and recommendations on quality levels for imperfections —

Part 2: Aluminium, magnesium and their alloys and pure copper

Assemblages soudés par faisceau d'électrons et par faisceau laser — Exigences et recommandations sur les niveaux de qualité des défauts —

Partie 2: Aluminium, magnésium et leurs alliages et cuivre pur

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 10, *Quality management in the field of welding*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 121, *Welding*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 13919-2:2001), which has been technically revised.

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

— Clause 2 has been updated;

— reference to ISO 6520-1 has been added to bring the document in line with ISO 5817.

A list of all parts in the ISO 13919 series can be found on the ISO website.

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.

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

This document is intended to be used as a reference in drafting application codes and/or other application standards. It contains a simplified selection of laser and electron beam welding imperfections based on the designations given in ISO 6520-1.

Some imperfections described in ISO 6520-1 have been used directly and some have been grouped together. The basic numerical referencing system from ISO 6520-1 has been used.

The purpose of this document is to define the dimensions of typical imperfections which can be expected in normal fabrication. It can be used within a quality system for the production of 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 is defined by the application standard or the responsible designer in conjunction with the manufacturer, user and/or other parties concerned. The quality level is expected to be prescribed prior to the start of production, preferably at the enquiry or order stage. For special purposes, additional details can be prescribed.

The quality levels given in this document provide basic reference data and are not specifically related to any particular application. They refer to the types of welded joint in fabrication and not to the complete product or component itself. Therefore, it is possible that different quality levels are applied to individual welded joints in the same product or component.

It would normally be expected that, for a particular welded joint, the dimensional limits for imperfections can all be covered by specifying one quality level. In some cases, it can be necessary to specify different quality levels for different imperfections in the same welded joint.

The choice of quality level for any application is expected to take account of design considerations, subsequent processing (e.g. surfacing), mode of stressing (e.g. static, dynamic), service conditions (e.g. temperature, environment) and consequences of failure. Economic factors are also important and are intended to include not only the cost of welding, but also of inspection, test and repair.

Although this document includes types of imperfection relevant to the beam welding processes given in the Scope, 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 can require the use of one or more methods of non-destructive testing. The detection and sizing of imperfections are dependent on the inspection methods and the extent of testing specified in the application standard or contract.

This document does not address the methods used for the detection of imperfections.

The values given for imperfections are for welds produced using normal welding practice. More stringent requirements as stated in quality level B can include additional manufacturing processes, e.g. grinding, dressing.

Electron and laser-beam welded joints — Requirements and recommendations on quality levels for imperfections —

Part 2: **Aluminium, magnesium and their alloys and pure copper**

1 Scope

This document gives guidance on levels of imperfections in electron and laser beam welded joints in aluminium, magnesium and their alloys and pure copper. 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 document applies to electron and laser beam welding of:

— aluminium and its alloys;

— magnesium and its alloys;

— pure copper (e.g. Cu-ETP1 CW003A, Cu-ETP CW004A, Cu-FRHC CW005A, Cu-FRTP CW006A, Cu-OF1 CW007A, Cu-OF CW008A, Cu-OFE CW009A, Cu-PHC CW020A, Cu-HCP CW021A, Cu-PHCE CW022A, Cu-DLP CW023A, Cu-DHP CW024A);

— all types of welds welded with or without additional filler wire;

— materials equal to or above 0,5 mm thickness for electron and laser beam welding.

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

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

Metallurgical aspects, e.g. grain size, hardness, hydrogen embrittlement (pure copper) are not covered by this document.

This document is directly applicable to visual examination of welds and does not include details of recommended methods of detection or sizing by other non-destructive means. There are difficulties in using these limits to establish appropriate criteria applicable to non-destructive testing methods, such as ultrasonic, radiographic and penetrant testing, and they can need to be supplemented by requirements for inspection, examination and testing.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 10042, *Welding — Arc-welded joints in aluminium and its alloys — Quality levels for imperfections*

3 Terms and definitions

No terms and definitions are listed in this document.

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Symbols and abbreviated terms

ΔL	distance between two imperfections (pore, cavity)
b	width of weld
b_1	required width of weld
b_r	width of weld root
d	maximum size of an imperfection (pore, cavity)
f	projected areas of pores or cavities
h	size of the imperfection (height, width)
h_1	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
β	angle of angular misalignment

5 Evaluation of welds

Limits for imperfections are given in Table 1. These limits apply to the finished weld and may also be applied to an intermediate stage of fabrication.

If a method other than macro examination is used for the detection of imperfections, only those imperfections which can be detected with a maximum magnification of tenfold shall be considered. Cracks (see Table 1, No 1.1, No 1.2, No 2.1 and No. 2.2) and micro lack of fusion (see Table 1, No 1.5 and No 2.7) are excluded.

A welded joint should normally be evaluated separately for each individual type of imperfection.

Any two adjacent imperfections separated by a distance lesser than the major dimension of the smaller imperfection shall be considered a single imperfection.

For joints made of base materials having different thicknesses, the evaluation of the defects shall be based on the thickness of the thinnest base material. For stake welds made in parallel joints and lap

joints, the evaluation of the defects shall be based on the sum of the thickness of the base materials for full penetration welds, and on the designed fusion penetration for partial penetration welds.

Annex A includes examples of determination of percentage (%) porosity and Annex B includes additional information for the use of this document.

Table 1 — Imperfections

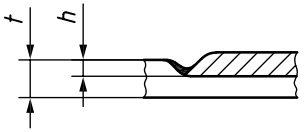
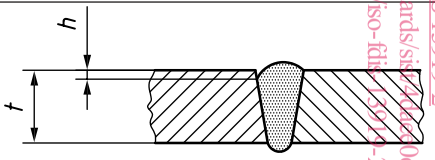
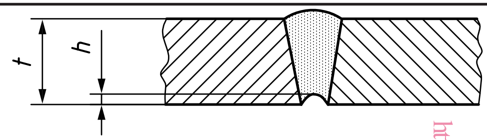
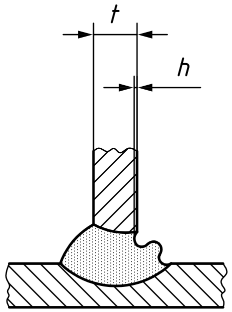
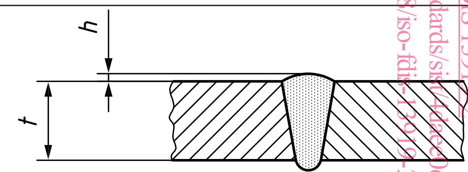
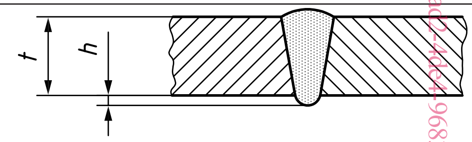
No.	ISO 6520-1 reference	Imperfection, designation	Remarks	t mm	Limits for imperfections for quality levels: D	C	B
1 Surface imperfections							
1.1	100	Cracks	All types of cracks except crater cracks (magnification less than 10×)	≥0,5	Not permitted	Not permitted	Not permitted
1.2	104	Crater cracks	Magnification less than 10×	≥0,5	permitted	Local crater cracks permitted	Not permitted
1.3	2017 516	Surface pore Root porosity	Maximum dimension of a single pore for spongy formation at the root of a weld due to bubbling of the weld metal at the moment of solidification (e.g. lack of gas backing)	≥0,5	$d \le 0,5\ s$, but max. 3 mm	$d \le 0,3\ s$, but max. 2 mm	Not permitted
1.4	2025	End crater pipe		≥0,5	$h \le 0,4\ t$	$h \le 0,3\ t$	$h \le 0,2\ t$
				>3	$h \le 0,4\ t + 0,3$ mm	$h \le 0,3\ t + 0,3$ mm	$h \le 0,2\ t + 0,3$ mm
1.5	401	Lack of fusion (incomplete fusion)	All types of lack of fusions (magnification less than 50×)	≥0,5	$l \le 0,25$ s or 1 mm, whichever is smaller	Not permitted	Not permitted
1.6	4021	Incomplete root penetration		≥0,5	$l \le 0,25$ s or 1 mm, whichever is smaller	Not permitted	Not permitted
1.7	5011 5012	Continuous undercut Intermittent undercut		≥0,5	$h \le 0,15\ t$ max. 2 mm	$h \le 0,1\ t$ max. 1,5 mm	$h \le 0,05\ t$ max. 1 mm

Table 1 *(continued)*

No.	ISO 6520-1 reference	Imperfection, designation	Remarks	t mm	Limits for imperfections for quality levels: D	C	B
1.8	515 5013	Root concavity Shrinkage groove (butt weld) Shrinkage groove (T-joint, full penetration)	 	≥0,5	$h \leq 0{,}4\ t$, but max. 4 mm	$h \leq 0{,}3\ t$, but max. 3 mm	$h \leq 0{,}2\ t$, but max. 2 mm
1.9	502	Excess weld metal (butt weld, parallel joint, overlap joint)	 To be applied for reinforcement on weld side.	≥0,5	$h \leq 0{,}4$ mm + $0{,}4\ t$ or 10 mm, whichever is smaller	$h \leq 0{,}4$ mm + $0{,}3\ t$ or 10 mm, whichever is smaller	$h \leq 0{,}4$ mm + $0{,}2\ t$ or 10 mm, whichever is smaller
1.10	504	Excessive penetration		≥0,5	$h \leq 0{,}4$ mm + $0{,}4\ t$ or 5 mm, whichever is smaller	$h \leq 0{,}4$ mm + $0{,}3\ t$ or 5 mm, whichever is smaller	$h \leq 0{,}4$ mm + $0{,}2\ t$ or 5 mm, whichever is smaller