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

Part 1: Steel, nickel, titanium and their alloys

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

Partie 1: Acier, nickel, titane et leurs alliages

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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*.

This second edition cancels and replaces the first edition (ISO 13919-1:1996) which has been technically revised.

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

— the text has been editorial revised;

— the normative references have 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 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.

Limits on some of the individual imperfections described in ISO 6520-1 have been prescribed directly whereas some have been grouped together. The basic numerical referencing system from ISO 6520-1 has been used.

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 requirements and conditions (e.g. temperature, pressure or vacuum levels, environment) and consequences of failure. These considerations may lead to the need to include additional requirements on weld quality outside of those referred to in this document. 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.

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

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

Part 1: Steel, nickel, titanium and their alloys

1 Scope

This document gives requirements and recommendations on levels of imperfections in electron and laser-beam welded joints in steel, nickel, titanium and their alloys. Three levels are given in such a way as to permit application for a wide range of welded fabrications. Quality level B corresponds to the highest requirement of the finished weld. 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:

— steel, nickel, titanium and their alloys;

— 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.

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 may need to be prescribed.

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.

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

This document does not address the methods used for the detection of imperfections. 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 additional requirements for inspection, examination and testing.

2 Normative references

There are no normative references in this document.

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)

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

ΔL	distance between two imperfections (pore, cavity)
b	width of weld
b_1	required width of weld
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 required weld penetration
l	length of imperfection (measured in maximum size 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	workpiece thickness
β	angle of angular misalignment

5 Assessment of imperfections (adapted to ISO 5817 and ISO 12932)

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

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

Any two adjacent imperfections separated by a distance less 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.

Annexes A and B include examples and additional informations for using this document.

Table 1 — Imperfections

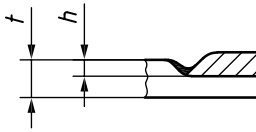
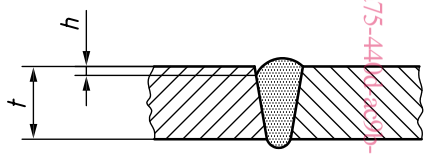
No.	ISO 6520-1 reference	Imperfection designation	Remarks	t mm	Limits for imperfections for quality levels		
					D	C	B
1 Surface imperfections							
1.1	100	Crack	All types of cracks except crater cracks (magnification less than 10×)	≥ 0,5	Not permitted	Not permitted	Not permitted
1.2	104	Crater crack	Magnification less than 10×	≥ 0,5	Permitted	Not 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	$d \le 0{,}3\ s$, but max. 3 mm	Not permitted	Not permitted
1.4	2025	End crater pipe	 (longitudinal section)	≥ 0,5 ≤ 3	$h \le 0{,}4\ t$	$h \le 0{,}3\ t$	$h \le 0{,}2\ t$
				> 3	$h \le 0{,}3\ t + 0{,}3$ mm	$h \le 0{,}2\ t + 0{,}3$ mm	$h \le 0{,}1\ t + 0{,}3$ mm
1.5	401	Lack of fusion (incomplete fusion)	All types of lack of fusions (magnification less than 10×)	≥ 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	Short imperfections: $l \le 0{,}25\ s$ or 1 mm, whichever is smaller	Not permitted	Not permitted
1.7	5011 5012	Continuous undercut Intermittent undercut	This is not regarded as a systematic imperfection. 	≥ 0,5	$h \le 0{,}15\ t$, but max. 1 mm	$h \le 0{,}1\ t$, but max. 0,5 mm	$h \le 0{,}05\ t$, but max. 0,5 mm

Table 1 *(continued)*

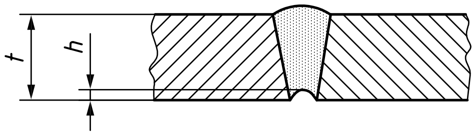
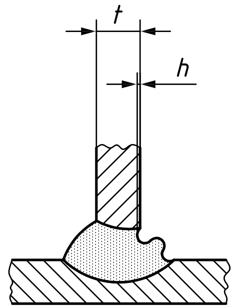
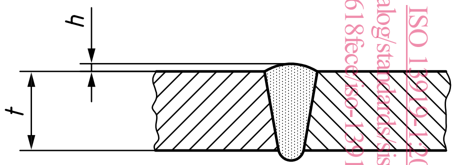
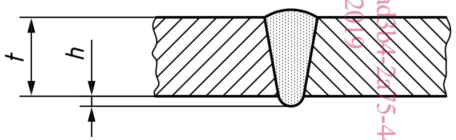
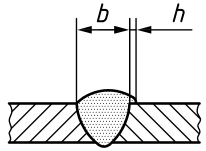
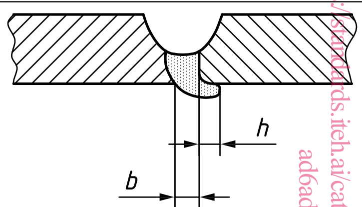
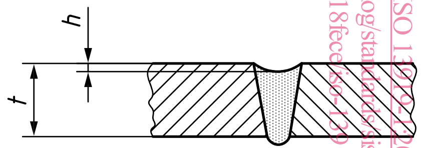
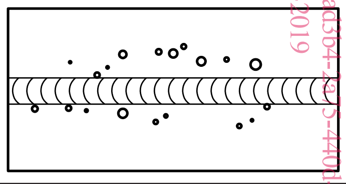
No.	ISO 6520-1 reference	Imperfection designation	Remarks	t mm	Limits for imperfections for quality levels D	C	B
1.8	515	Root concavity Shrinkage groove (butt weld)		≥ 0,5	$h \leq 0{,}3\ t$, but max. 1 mm	$h \leq 0{,}2\ t$, but max. 0,5 mm	$h \leq 0{,}1\ t$, but max. 0,5 mm
	5013	Shrinkage groove (T-joint, full penetration)					
1.9	502	Excess weld metal (butt weld, parallel joint, overlap joint)	 To be applied for reinforcement on weld side.	≥ 0,5	$h \leq 0{,}2$ mm + $0{,}3\ t$ or 5 mm, whichever is smaller	$h \leq 0{,}2$ mm + $0{,}2\ t$ or 5 mm, whichever is smaller	$h \leq 0{,}2$ mm + $0{,}15\ t$ or 5 mm, whichever is smaller
1.10	504	Excessive penetration	 Used for root run for joints welded from one side.	≥ 0,5	$h \leq 0{,}2$ mm + $0{,}3\ t$ or 5 mm, whichever is smaller	$h \leq 0{,}2$ mm + $0{,}2\ t$ or 5 mm, whichever is smaller	$h \leq 0{,}2$ mm + $0{,}15\ t$ or 5 mm, whichever is smaller

Table 1 *(continued)*

No.	ISO 6520-1 reference	Imperfection designation	Remarks	t mm	Limits for imperfections for quality levels D	C	B
1.11	5061	Toe overlap		≥ 0,5	$h \leq 0{,}2\ b$	Not permitted	Not permitted
	5062	Root overlap					
1.12	509 511	Sagging Incompletely filled groove		≥ 0,5	$h \leq 0{,}3\ t$ or 1 mm, whichever is smaller	$h \leq 0{,}2\ t$ or 0,5 mm, whichever is smaller	$h \leq 0{,}1\ t$ or 0,5 mm, whichever is smaller
1.13	510	Burn through	—	≥ 0,5	Not permitted	Not permitted	Not permitted
1.14	602	Spatter		≥ 0,5	Acceptance depends on application, e.g. material, corrosion protection		
1.15	—	Imperfections specific to fillet welds with filler wire	—	≥ 0,5	Use limits for arc welding, see ISO 5817, level D.	Use limits for arc welding, see ISO 5817, level C.	Use limits for arc welding, see ISO 5817, level B.