TECHNICAL REPORT

ISO/TR 17671-7

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Welding — Recommendations for welding of metallic materials —

Part 7: Electron beam welding

Soudage — Recommandations pour le soudage des matériaux métalliques —

Partie 7: Soudage par faisceau d'électrons

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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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 2.

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.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

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.

ISO/TR 17671-7 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 10, *Unification of requirements in the field of metal welding*.

ISO/TR 17671 consists of the following parts, under the general title *Welding — Recommendations for welding of metallic materials*:

— *Part 1: General guidance for arc welding*

— *Part 2: Arc welding of ferritic steels*

— *Part 3: Arc welding of stainless steels*

— *Part 4: Arc welding of aluminium and aluminium alloys*

— *Part 5: Welding of clad steels*

— *Part 6: Laser beam welding*

— *Part 7: Electron beam welding*

Introduction

This part of ISO/TR 17671 contains special recommendations for the electron beam welding of metallic materials and should be observed in connection with the general recommendations for welding in accordance with ISO/TR 17671-1. It includes details on quality requirements, production welding facilities as well as the weldability of some materials and contains information on welding procedures.

The special properties of electron beam welding derive from the high power and power density in the beam spot, the resulting "deep welding effect" and the unique controllability of the process.

Electron beam welding is recommended for welding metallic materials which require low heat input, low shrinkage, low distortion, and for welding dissimilar or reactive metals. It allows high welding speeds and flexibility of design by joining simple components. The electron beam is able to join very thin and very thick sections and the combination of both. It is also suited to automation and quality control.

Requests for official interpretations of any aspect of this Technical Report should be directed to the Secretariat of ISO/TC 44/SC 10 via your national standards body, a complete listing of which can be found at www.iso.org.

Welding — Recommendations for welding of metallic materials —

Part 7:
Electron beam welding

1 Scope

This part of ISO/TR 17671 may be used for the electron beam welding (process No. 51 in accordance with ISO 4063) of weldable metallic materials in accordance with ISO/TR 15608 (see Annexes A and B). It does not contain data on permissible stresses on weld seams or on the testing and evaluation of weld seams. Such data can either be seen from the relevant user standards or should be separately agreed upon between the contracting parties.

A requirement for the application of this part of ISO/TR 17671 is that the recommendations be used by appropriately trained and experienced personnel.

2 Normative references

The following referenced documents are indispensable for the application 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 3834-1, *Quality requirements for fusion welding of metallic materials — Part 1: Guidelines for selection and use*

ISO 3834-2, *Quality requirements for fusion welding of metallic materials — Part 2: Comprehensive quality requirements*

ISO 3834-3, *Quality requirements for fusion welding of metallic materials — Part 3: Standard quality requirements*

ISO 3834-4, *Quality requirements for fusion welding of metallic materials — Part 4: Elementary quality requirements*

ISO 4063, *Welding and allied processes — Nomenclature of processes and reference numbers*

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

ISO 13919-1, *Welding — Electron and laser-beam welded joints — Guidance on quality levels for imperfections — Part 1: Steel*

ISO 13919-2, *Welding — Electron and laser beam welded joints — Guidance on quality levels for imperfections — Part 2: Aluminium and its weldable alloys*

ISO 14732, *Welding personnel — Approval testing of welding operators for fusion welding and of resistance weld setters for fully mechanized and automatic welding of metallic materials*

ISO 14744-1, *Welding — Acceptance inspection of electron beam welding machines — Part 1: Principles and acceptance conditions*

ISO 14744-2, *Welding — Acceptance inspection of electron beam welding machines — Part 2: Measurement of accelerating voltage characteristics*

ISO 14744-3, *Welding — Acceptance inspection of electron beam welding machines — Part 3: Measurement of beam current characteristics*

ISO 14744-4, *Welding — Acceptance inspection of electron beam welding machines — Part 4: Measurement of welding speed*

ISO 14744-5, *Welding — Acceptance inspection of electron beam welding machines — Part 5: Measurement of run-out accuracy*

ISO 14744-6, *Welding — Acceptance inspection of electron beam welding machines — Part 6: Measurement of stability of spot position*

ISO/TR 15608:2000, *Welding — Guidelines for a metallic materials grouping system*

ISO 15609-3, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 3: Electron beam welding*

ISO 15614-11, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 11: Electron and laser beam welding*

ISO/TR 17671-1, *Welding — Recommendations for welding of metallic materials — Part 1: General guidance for arc welding*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13919-1, ISO 13919-2, ISO 14744-1, ISO 15609-3, ISO 15614-11 and the following apply.

3.1
accelerating voltage
electric potential difference, U_A, between cathode and anode

3.2
beam current
the value, I_B, of the electric current in the beam

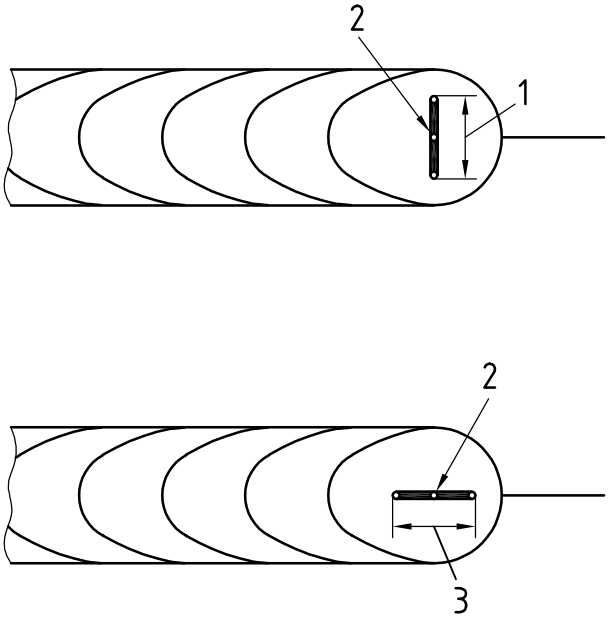
3.3
beam oscillation
periodic deflection of the electron beam from the initial position defined in terms of pattern, dimensions and frequency

See Figure 1.

3.4
cosmetic pass
superficial remelting of the weld in order to enhance its appearance

NOTE This pass is usually made with a defocused or oscillating beam.

3.5
defocusing
deviation from the normal focus position (e.g. focus on work-piece surface)



Key

1 oscillation width
2 initial position of the beam
3 oscillation length

Figure 1 — Terms of electron beam oscillation

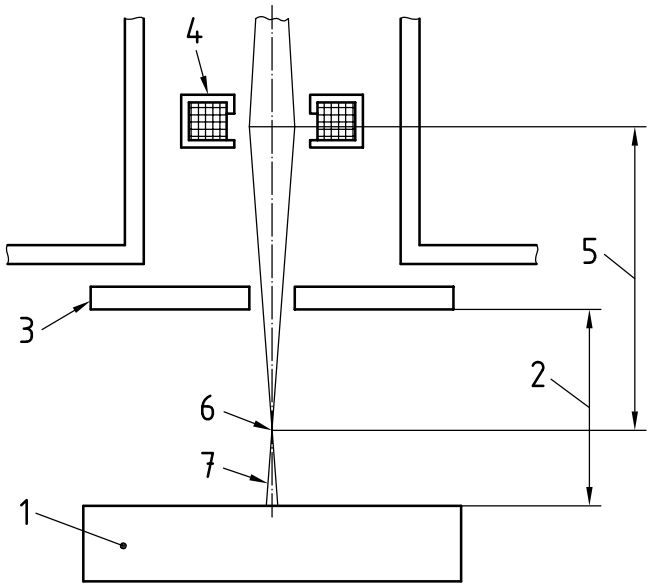
3.6
focusing distance
distance between the focusing lens plane and beam focus position

See Figure 2.

3.7
working distance
distance between the surface of the work-piece and a standard reference point on the equipment which is traceable to the true focusing lens plane

See Figure 2.

3.8
lens current
current, I_L, which flows through the electromagnetic focusing lens



Key

1	work-piece	5	focusing distance
2	working distance	6	beam focus
3	heat protection	7	beam spot
4	focusing lens		

Figure 2 — Definition of working distance and focusing distance

3.9
slope-down
controlled decrease of the beam power at the end of welding

The slope-down region is the region on the work-piece in which the effects of slope-down occur. See Figure 3.

The slope-down region can consist of one or two areas, depending on the selected welding mode:

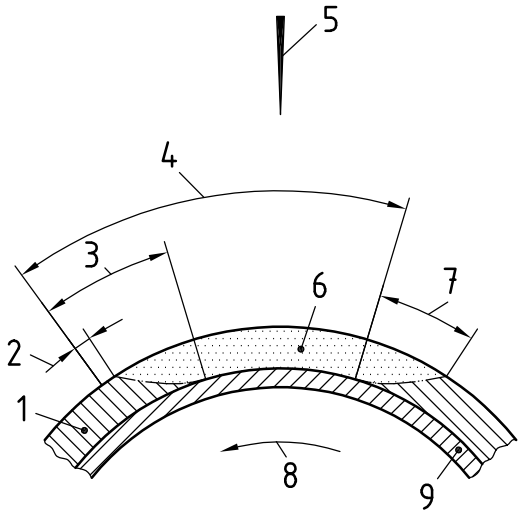
a) in partial penetration welding:

— a region where penetration decreases continuously.

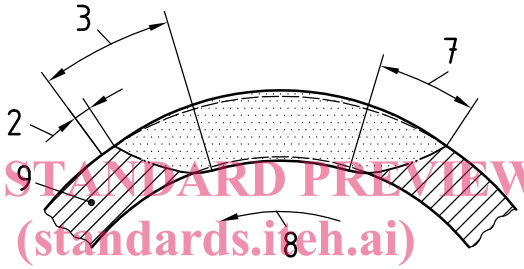
b) in full penetration welding:

— a region where beam penetration is still complete;

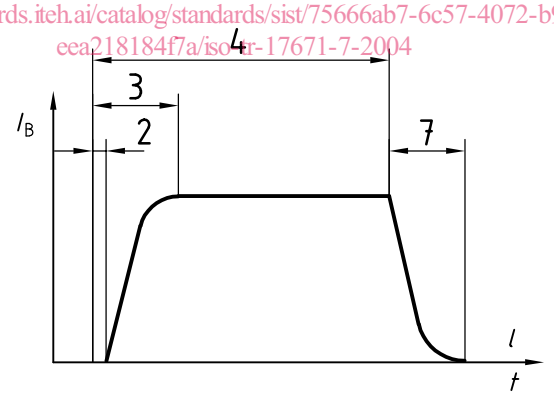
— a region where penetration is partial or decreasing.



a) Partial penetration welding (with overlap)



b) Full penetration welding (without overlap)



c) Typical beam current, I_B, profile for a circular weld with overlap

Key

1	work-piece (welded zone)	7	slope-down region
2	delay between control starting and weld beginning	8	direction of work-piece motion
3	slope-up region	9	work-piece (unwelded zone)
4	overlapping region	I_B	beam current
5	electron beam	l	weld length
6	remelted zone	t	weld time

Figure 3 — Definition for termination of circular seams

3.10
slope-up
controlled increase of the beam power at the beginning of welding

See Figure 3.

3.11
spiking
local variation of fusion zone depths as a consequence of instabilities in the beam penetration mechanism

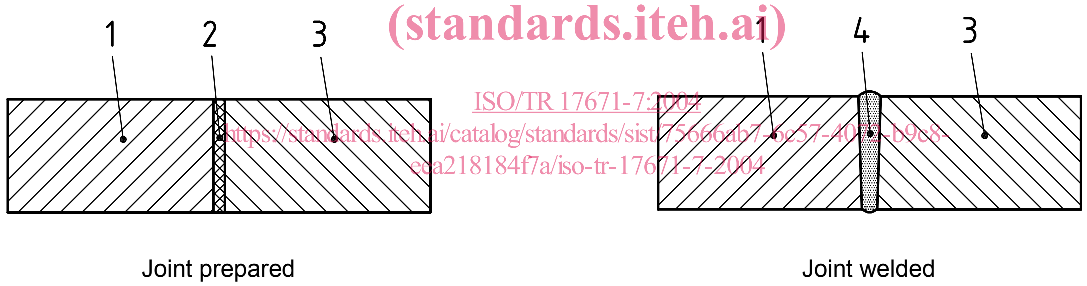
3.12
evacuation hole
hole for evacuating cavities in work-pieces

See Figure 12.

3.13
working pressure
pressure measured in the welding enclosure in the vicinity of the work-piece

3.14
interlayer material
alloy addition introduced by means of pre-placed foil at the joint interface, to modify the weld fusion zone composition, in order to improve weldability or weld performance

See Figure 4.



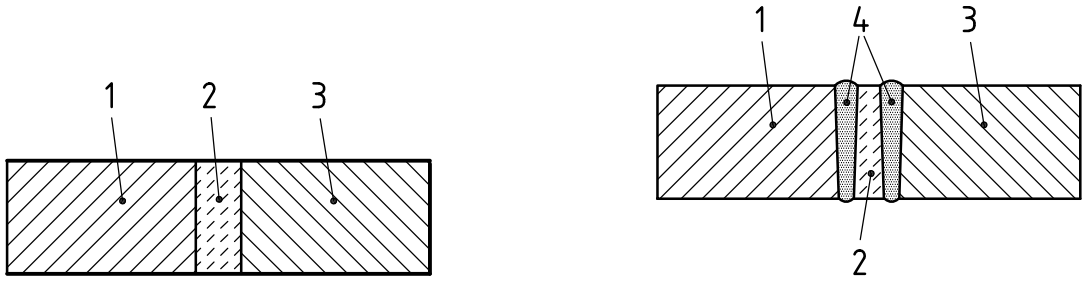
Key

1 parent material A
2 interlayer material
3 parent material A or B
4 fusion zone

Figure 4 — Welding with interlayer material

3.15
transition material
buffer material insert used to allow welding of metallurgically incompatible materials

See Figure 5.



Joint prepared Joint welded

Key

1 parent material A
2 transition material
3 parent material B
4 fusion zone

Figure 5 — Welding of dissimilar metals with transition material

4 Quality requirements

The quality requirements should be given in the design specification prior to the beginning of welding work. They should be based on ISO 3834-1 and ISO 3834-2 or ISO 3834-3 or ISO 3834-4 and ISO 13919-1 or ISO 13919-2, unless relevant user standards are available.

5 Storage and handling of parent metals and consumables

In order to avoid contact corrosion, foreign metal inclusions etc., parent metals and consumables of dissimilar classes of materials, in accordance with ISO/TR 15608, should not be stored and processed jointly.

6 Welding facilities

Welding facilities include the electron beam welding machine, workshop, tools, clamping devices, demagnetisation devices and cleaning facilities. In this clause, only those facilities which are of particular significance for electron beam welding will be described in more detail.

The electron beam welding machine should be installed so that environmental conditions, such as mechanical vibrations, noise and dirt from neighbouring machines, electric and magnetic fields do not influence the quality of welds. Moreover, noise control regulations pursuant to the equipment safety act should be observed for the vacuum pumps. In larger workshops, the machine operators' and machine setters' workplaces should be shielded against disturbances from manufacturing operations (e.g. by means of partition walls). The exhaust gases generated during evacuation of the working chamber shall only be released into the environment in accordance with the relevant emission regulations. Where particularly high demands are placed on weld quality, it is recommended that filtered air or inert gas be used to ventilate the working chamber.

The supply voltage for the electron beam welding machine shall not vary by more than ± 10 % and care should be taken to ensure that the welding machine has a satisfactory earth connection.

Upon commissioning or in the case of displacement, modifications and repairs of major welding machine components, the electron beam welding machine shall be subjected to an acceptance inspection in accordance with ISO 14744-1 to ISO 14744-6 (i.e. all parts of ISO 14744) as part of internal quality management. In this acceptance inspection, the short- and long-term consistency, as well as the reproducibility of the most important welding parameters and compliance with particular characteristic data deviations, is measured and verified according to given deviation limits.