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Railway infrastructure — Rail welding —

Part 1: General requirements and test methods for rail welding

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Foreword

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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).

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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 269, *Railway applications*, Subcommittee SC 1, *Infrastructure*.

A list of all parts in the ISO 23300 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.

Introduction

Rail welding is an essential technology in the railway track domain for reducing noise and vibration on rail joints, improving ride comfort and reducing maintenance costs.

Since environments (e.g. geography, deployable resources and energy affairs) differ by region and railway line, rail welding processes have been developed to meet the requirements and conditions of each environment. As a result, various rail welding processes exist, e.g. flash butt welding (FBW), gas pressure welding (GPW), aluminothermic welding (ATW) and enclosed arc welding (EAW).

For this reason, a general rail welding standard on an international level covering conventional rail welding processes was deemed necessary. This document contributes to the development of railways by ensuring the quality of welded joints in terms of enhancing the reliability of train operation, improving the welding work efficiency and facilitating the introduction of new procedures.

This document covers the general requirements for rail welding and is used in conjunction with the subsequent parts of the ISO 23300 series, which cover the specific requirements for each welding process (such as FBW, GPW, ATW and EAW).

Railway infrastructure — Rail welding —

Part 1: General requirements and test methods for rail welding

1 Scope

This document specifies requirements concerning the approval and/or homologation of welding processes, contractors, welders, inspectors and acceptance of welded joints in the factory and/or track.

This document is applicable to the following rail welding processes:

a) flash butt welding (FBW);

b) gas pressure welding (GPW);

c) aluminothermic welding (ATW);

d) enclosed arc welding (EAW).

In this document, 43 kg/m to 75 kg/m new flat-bottomed rails of the same profiles and same steel grades are used as the subject of welding.

This document does not specify requirements or test methods specific to each welding process. These are to be prescribed in the subsequent parts of the ISO 23300 series.

Concerning butt welding, this document is restricted to connecting rail ends.

This document does not cover the welding for construction of crossings, railway switches, signal bond installation or restoration of rails.

This document does not cover any safety regulations for welding operations.

In this document, the qualifications of individuals and organizations that are approved by the railway authority for rail welding are not specified.

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 6507-1, *Metallic materials — Vickers hardness test — Part 1: Test method*

ISO 6508-1, *Metallic materials — Rockwell hardness test — Part 1: Test method*

ISO 7500-1, *Metallic materials — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Calibration and verification of the force-measuring system*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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/

3.1
railway authority
either the railway regulator or the owner of a railway infrastructure or the custodian with a delegated responsibility for a railway infrastructure

3.2
process supplier
company which provides a rail welding process which is approved by the *railway authority* (3.1) to supply machines, consumables and tools for the making of *welded joints* (3.13)

3.3
training centre
organization or centre responsible for training *welders* (3.5) and which is approved by the *railway authority* (3.1), and, in the case of aluminothermic welding, by the *process supplier* (3.2)

3.4
contractor
company approved by the *railway authority* (3.1) to provide staff and machinery in order to execute the *production* (3.8) of *welded joints* (3.13)

3.5
welder
person who is trained and competent to undertake the appropriate welding process

3.6
operator
person who is trained and competent to undertake the appropriate welding machine operation

3.7
inspector
person who is trained, qualified, approved and competent to carry out inspection of *welded joints* (3.13) by observation and judgement, accompanied as appropriate by measurement and testing techniques

3.8
production
butt welding work to connect rails for rail transport operation, whether performed in-factory or on-site

3.9
fixed plant
stationary production line for solid phased welding of rails

3.10
profile finishing
operation by which the rail head or relevant part of the rail head at the *welded joint* (3.13) is returned to rail profile

Note 1 to entry: Operation can be carried out by grinding, milling, planing or any other suitable means.

3.11
post-weld heat treatment
application of heating and cooling control to a *welded joint* (3.13) after welding

3.12
heat-affected zone
HAZ
part of the unmelted base metal where the metal structure, metallurgical properties, mechanical properties are transformed due to heat input during the welding process such as welding, *post-weld heat treatment* (3.11) and flame cutting

3.13
welded joint
rail joints bonded by welding, which includes the weld metal and the *heat-affected zone* (3.12)

3.14
finished condition
welded, trimmed, dressed and *profile finished* (3.10)

3.15
non-destructive testing
NDT
application of technical methods to examine materials or components in ways that do not impair their future usefulness and serviceability, in order to detect, locate and evaluate defects, to assess integrity, properties, composition and geometrical characteristics

3.16
acceptance in factory/track
acceptance inspection conducted from the viewpoint of quality control targeting *welded joints* (3.13) which will be used in track

4 Rail welding processes

The following processes are currently applied for butt welding connecting rail ends:

a) FBW: Hot pressure welding process using electric current and axial force to produce a welded joint (there are two types: fixed plant and mobile).

b) GPW: Hot pressure welding process using gas flame and axial force to produce a welded joint.

c) ATW: Cast fusion welding process using aluminothermic reaction to generate liquid steel.

d) EAW: Electric arc welding process performed by surrounding rails with copper or ceramic block.

5 General process of rail welding

The rail welding process generally consists of the following stages:

a) Preparatory stage: Including provision of information from the railway authority or delegated company and arrangement of conditions.

b) Working stage: Including rail end preparation, alignment, step treatment, welding work and post-weld heat treatment.

c) Finishing stage: Including profile finishing and welded joint identification.

d) Verification/acceptance stage: Including the tests/inspections classified in Clauses 6 and 7.

NOTE Further details on each stage of each applied process will be prescribed in the subsequent parts of the ISO 23300 series.

6 Approval/homologation of welding processes

6.1 General

Initial approval/homologation tests shall be carried out for every application of each rail welding process. Approval/homologation tests are used to confirm the reliability of the welding process and do not reflect quality control in production. Approval/homologation tests shall be carried out for a particular rail profile and grade, using a specific welding machine or specific type of welding consumable material.

NOTE The series and sequence of tests for each welding process, together with the number of specimens for each test item, are specified in the subsequent parts of the ISO 23300 series.

The specification requirements of each approval/homologation test shall be provided to the contractor from the railway authority before conducting the test.

6.2 Non-destructive testing (NDT)

In this document, NDT methods include:

a) visual testing (VT);

b) ultrasonic testing (UT);

c) magnetic particle testing (MT);

d) dye penetrant testing (PT).

After the VT, further appropriate NDT methods shall be applied in accordance with the relevant annexes of this document and the subsequent parts of the ISO 23300 series, and shall be used to inspect the welded joint in finished condition.

The NDT methods for sectioned and full-size samples are dependent upon the welding process being used.

NOTE The NDT methods for sectioned and full-size samples are described in the subsequent parts of the ISO 23300 series.

6.3 Slow-bending test

The slow-bending test for a welded joint is a practical and efficient test method that can simply evaluate the performance of the welded joint on whether the load and the deflection satisfy the specified value. However, the original purpose of the test is to force failure of the welded joint and to observe the existence or non-existence of weld defects on the fracture face.

In this test, two loading modes are applied as appropriate:

a) one with the rail head upwards in which tensile stress is applied to the rail foot;

b) one with the rail head downwards in which tensile stress is applied to the rail head.

Each slow-bending test shall also be continued until the load or deflection reaches the specified value or fracture occurs.

For applying the slow-bending test in which tensile stress is applied to the rail foot, the requirements and the test method given in Annex A shall be followed.

For applying the slow-bending test in which tensile stress is applied to the rail head, the requirements and the test method given in Annex B shall be followed.

6.4 Past-the-post fatigue test

The straightness of the welded joint in finished condition shall not affect the execution of a past-the-post fatigue test.

The test sample shall be subject to NDT, which shall include VT and UT, MT or PT as appropriate. Only those samples that have been qualified by NDT can be used for the fatigue test.

The test shall be conducted in three-point or four-point bending with the rail foot in tension. Each test type is sufficient for approval.

The requirements for the three-point bending test and the test method given in Annex C shall be followed.

The requirements for the four-point bending test and the test method given in Annex D shall be followed.

6.5 Macro examination

Macro examination shall be performed to investigate the presence or absence of defects in the relevant sections, or on a fracture face following bend, fatigue or drop-hammer testing that is not identified as a surface breaking defect in the welded joint and to confirm that the appropriate heat input has been achieved. The macro structures depend on each welding process.

The macro examination described in Annex E shall be followed.

6.6 Micro examination

Micro examination shall be performed to investigate the presence or absence of an abnormal metallographic structure in the welded joint. The micro structures depend on each welding process.

The micro examination described in Annex F shall be followed.

6.7 Hardness test

A hardness test shall be performed to evaluate wear resistance and to confirm accordance with specification. The hardness values depend on each welding process.

The hardness test described in Annex G shall be followed.

6.8 Drop-hammer test (optional)

A railway authority may demand a drop-hammer test to assess the welded joint's performance.

If applied, the drop-hammer test described in Annex H shall be followed.

6.9 Recording of defects

The details of weld defects shall be recorded.

The recording of defects described in Annex I shall be followed.

6.10 Test result reports

Test result reports shall contain, as a minimum, items in accordance with the relevant annexes and shall reference this document.

7 Acceptance in factory/track

7.1 General

Documentation and records relating to traceability shall be made available upon request by the railway authority.

7.2 Weld inspection

Prior to any inspection, the welded joint shall be completed and the traceability shall be identified. The welded joint shall be in the finished condition.

Joints welded in a fixed plant shall be inspected in the plant. Based on the inspection, the welded joint shall be deemed as accepted or rejected.

Joints welded on-site shall be inspected on the railway track. Based on the inspection, the welded joint shall be deemed as accepted or rejected. This is applicable to FBW using a mobile machine, GPW, ATW and EAW.

The equipment used for inspection shall be calibrated and shall meet the requirements of the relevant equipment supplier and the railway authority.

The inspector shall be competent and shall meet the requirements of the railway authority.

A weld inspection report containing the result and details of the weld inspection shall be completed. When the inspection results do not conform to this document or the subsequent parts of the ISO 23300 series, the welded joint shall be treated as unqualified products.

Items to be inspected for the acceptance of welded joints shall include:

a) straightness (see 7.3);

b) NDT (VT shall be applied to find the surface breaking defect about the welded joint. Other inspection items are optional, and shall be defined by the railway authority. If applicable, Annexes J, K and L shall be followed).

7.3 Straightness inspection

The straightness of the welded joint in finished condition shall be measured, vertically and horizontally over a 1 m span. The error of 1 m straight edge shall not exceed 0,05 mm.

The straightness shall be measured while the welded joint is at ambient temperature. In some specific cases (i.e. immediately following profiling, insufficient cooling times for site-made welded joints), any measurement of alignment can be made while the welded joint is hot. The effect of temperature on the welded joint shall be taken into consideration.

Straightness across the welded joint shall be measured as follows (see Figure 1):

a) The vertical straightness of the running surface shall be measured along the longitudinal surface of the rail. Measurement points are shown in Figures 1 a) and b). For negative tolerance, see Figure 1 a). For positive tolerance, see Figure 1 b).

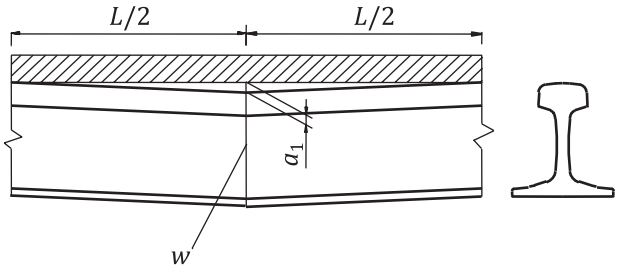
b) The horizontal straightness of the welded joint at the running edge shall be measured on one or both faces at a gauge measuring point below the running surface. Measurement points are shown in Figures 1 c) and d). For negative tolerance which widens the gauge, see Figure 1 c). For positive tolerance which tightens the gauge, see Figure 1 d).

c) The necessity of measurement on the field side shall be confirmed by the railway authority with the contractor.

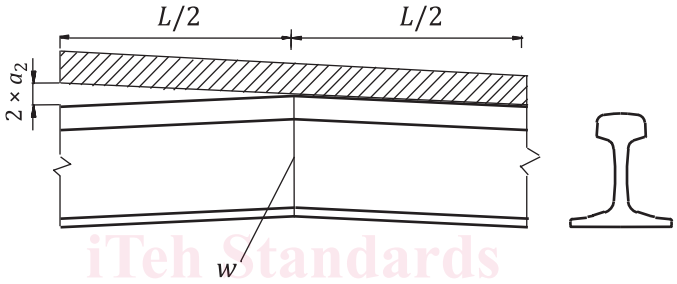
d) The means of measuring the straightness of the welded joint as described shall be the choice of the contractor, but in the case of acceptance inspection a calibrated straight edge shall be used.

Acceptance criteria for straightness shall be specified by the railway authority.

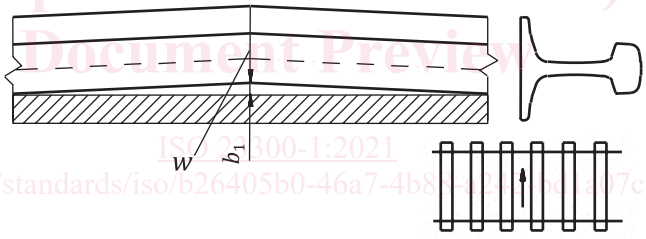
Examples of acceptance criteria for straightness are given in Annex M.



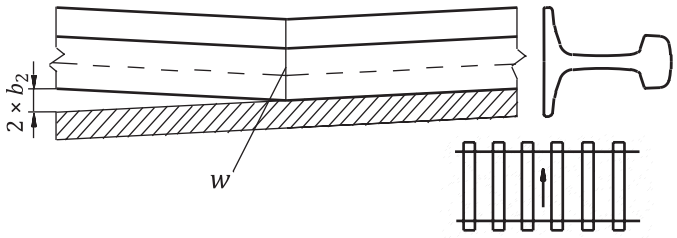
a) running surface straightness (negative tolerance)



b) running surface straightness (positive tolerance)



c) running edge straightness (widens gauge)



d) running edge straightness (tightens gauge)

Key

w weld centre

L measurement span, L = 1 m

a_1 vertical straightness tolerance on the running surface (a_1 is negative tolerance)

a_2 vertical straightness tolerance on the running surface (a_2 is positive tolerance)

b_1 horizontal straightness tolerance (tolerance widens gauge)

b_2 horizontal straightness tolerance (tightens gauge)

Figure 1 — Schematic of straightness measurement

7.4 Documentation

Documentation shall contain traceability of the welded joint and inspection reports in accordance with the relevant annexes and shall reference this document.

8 Requirement on contractor/welder/inspector

8.1 Contractor

The welding contractor shall maintain a management system of rail welding that complies with the requirements of the railway authority.

The welding contractor shall maintain a system that ensures the competence of employed welders, welding operators and inspectors through appropriate training, assessment and authorization, and which shall include:

a) welder/operator training and competences;

b) weld records;

c) number of welded joints produced in a given period;

d) number of welded joints rejected;

e) notified number of welded joints failed in service.

The welding contractor shall maintain a system of weld inspection according to the relevant railway authority requirements. Nonconformities found during these inspections shall be recorded in the traceability system.

Welding equipment and welding consumable materials shall be approved by the relevant railway authority. Equipment shall comply with the manual of the welding process.

Inspection and calibration equipment shall comply with those requirements as agreed between the contractor and the relevant railway authority.

8.2 Welder, operator and inspector

The welder, operator and inspector shall be trained at an approved training centre.

Training shall include both practical and theoretical elements.

All training shall conclude with a practical and theoretical examination to confirm the trainee's ability to carry out the welding of rails in accordance with the requirements of the relevant welding process.

The qualification to work in track shall be provided by the railway authority.

The knowledge acquired by the trainee should contain, but is not limited to:

a) basic safety;

b) rails;

c) operating equipment;

d) specific information to the welding process (FBW, GPW, ATW, EAW);

e) abnormalities, causes and effects;

f) grinding and finishing;

g) NDT of welded joints;