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Railway applications - Welding of railway vehicles and components - Part 3: Design requirements

Bahnanwendungen - Schweißen von Schienenfahrzeugen und -fahrzeugteilen - Teil 3: Konstruktionsvorgaben

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Applications ferroviaires - Soudage des véhicules ferroviaires et des pièces - Partie 3 : Exigences de conception

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Foreword

This document (EN 15085-3:2007) has been prepared by Technical Committee CEN/TC 256 "Railway applications", the secretariat of which is held by DIN.

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of an identical text or by endorsement, at the latest by April 2008, and conflicting national standards shall be withdrawn at the latest by April 2008.

This series of European Standards EN 15085 "Railway applications — Welding of railway vehicles and components" consists of the following parts:

- Part 1: General
- Part 2: Quality requirements and certification of welding manufacturer
- Part 3: Design requirements
- Part 4: Production requirements
- Part 5: Inspection, testing and documentation

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Introduction

Welding is a special process in the manufacture of railway vehicles and their parts. The required provisions for this process are laid down in the standards series EN ISO 3834. The basis of these provisions is the basic technical welding standards in respect of the special requirements for the construction of railway vehicles.

This European Standard is aimed at defining the terms of enforcement applicable to European Standards; it is not construed as a substitute to these standards.

This European Standard can also be used by internal and external parties, including certification bodies, to assess the organisation's ability to meet customer, regulatory and the organisation's own requirements.

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1 Scope

This series of standards applies to welding of metallic materials in the manufacture and maintenance of railway vehicles and their parts.

This part of the series specifies design and classification rules applicable to the manufacture and maintenance of railway vehicles and their parts. Upon agreement with the customer, drawings issued prior to this European Standard may be subject to the provisions of this European Standard.

This European Standard does not define parameters for the dimensioning (refer to other standards e.g. on fatigue testing).

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.

EN 1011-2, *Welding — Recommendations for welding of metallic materials — Part 2: Arc welding of ferritic steels*

EN 1708-2, *Welding — Basic weld joint details in steel — Part 2: Non internal pressurized components*

EN 10025-2, *Hot rolled products of structural steels — Part 2: Technical delivery conditions for non-alloy structural steels*

EN 12663, *Railway applications — Structural requirements of railway vehicle bodies*

EN 13749, *Railway applications — Wheelsets and bogies — Methods of specifying structural requirements of bogie frames*

EN 15085-1:2007, *Railway applications — Welding of railway vehicles and components — Part 1: General*

EN 15085-2:2007, *Railway applications — Welding of railway vehicles and components — Part 2: Quality requirements and certification of welding manufacturer*

EN 15085-4:2007, *Railway applications — Welding of railway vehicles and components — Part 4: Production requirements*

EN 15085-5:2007, *Railway applications — Welding of railway vehicles and components — Part 5: Inspection, testing and documentation*

EN 22553, *Welded, brazed and soldered joints — Symbolic representation on drawings (ISO 2553:1992)*

EN ISO 4063, *Welding and allied processes — Nomenclature of processes and reference numbers (ISO 4063:1998)*

EN ISO 5817, *Welding — Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) — Quality levels for imperfections (ISO 5817:2003)*

EN ISO 6520-1, *Welding and allied processes — Classification of geometric imperfections in metallic materials — Part 1: Fusion welding (ISO 6520-1:2007)*

EN ISO 6520-2, *Welding and allied processes — Classification of geometric imperfections in metallic materials — Part 2: Welding with pressure (ISO 6520-2:2001)*

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EN ISO 9692-1, *Welding and allied processes — Recommendation for joint preparation — Part 1: Manual metal-arc welding, gas-shielded metal-arc welding, gas welding, TIG welding and beam welding of steels (ISO 9692-1:2003)*

EN ISO 9692-2, *Welding and allied processes — Joint preparation — Part 2: Submerged arc welding of steels (ISO 9692-2:1998)*

EN ISO 9692-3, *Welding and allied processes — Recommendation for joint preparation — Part 3: Metal inert gas welding and tungsten inert gas welding of aluminium and its alloys (ISO 9692-3:2000)*

EN ISO 10042, *Welding — Arc-welded joints in aluminium and its alloys — Quality levels for imperfections (ISO 10042:2005)*

EN ISO 13919-1, *Welding — Electrons and laser beam welded joints — Guidance on quality levels for imperfections — Part 1: Steel (ISO 13919-1:1996)*

EN ISO 13919-2, *Welding — Electron and laser beam welded joints — Guidance on quality levels for imperfections — Part 2: Aluminium and its weldable alloys (ISO 13919-2:2001)*

EN ISO 14555, *Welding — Arc stud welding of metallic materials (ISO 14555:2006)*

EN ISO 15614-1, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys (ISO 15614-1:2004)*

EN ISO 15614-12, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 12: Spot, seam and projection welding (ISO 15614-12:2004)*

EN ISO 17653, *Destructive tests on welds in metallic materials — Torsion test of resistance spot welds (ISO 17653:2003)*

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ISO 10447, *Resistance welding — Peel and chisel testing of resistance spot, projection and seam welds*

CEN ISO/TR 15608, *Welding — Guidelines for a metallic materials grouping system (ISO/TR 15608:2005)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 15085-1:2007 apply.

4 Design requirements

4.1 General

As regards welds forming an integral part of items of rolling stock, except for specific provisions laid down within the framework of the project or in the product specification, design and requirements shall be defined as follows.

4.2 Joint static dimensioning

Calculated stresses shall be less than or equal to the admissible strength of the assembly considered which are proposed in the specification or by the manufacturer and accepted by the acceptance authority.

Examples of welding bead static dimensioning: “effective cross-sections a_R ” are given in Annex B and Annex C.

Calculation on local areas shall be performed to ensure that the cross section of the weld is both required and sufficient to withstand static stresses.

4.3 Joint fatigue dimensioning

Joints shall be designed according to stress and safety categories.

The admissible fatigue strength, which are defined by standards, codes, methods, guidelines or by stress/cycle diagrams, are proposed in the specification or by the manufacturer and shall be accepted by the acceptance authority or the responsible national safety authority.

The reference curve shall either be laid down in specifications or proposed by the manufacturer and approved by the customer. Usually, this curve applies to a given type of joint (butt weld, fillet weld etc.).

4.4 Stress categories and stress factors

The stress category is determined by the stress factor according to Table 1. The stress factor is the ratio of the calculated fatigue stress to the admissible fatigue stress of the joint type, adjusted by the appropriate safety factor. The standard or source of data for the admissible stress shall be agreed between the customer and the manufacturer and, if required with the national safety authority. In this context the European Standards on railway vehicle manufacturing shall be applied, e.g. EN 12663, EN 13749. In addition to this the application of national standards is also possible.

Alternatively, the admissible fatigue stress can be obtained from fatigue tests on representative joint samples. The statistical evaluation of the fatigue tests shall be done according to a standard or a guideline agreed with the national safety authority. European Standards for structural requirements of railway vehicles shall also be applied, e.g. EN 12663. Furthermore the application of national standards is also possible.

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Table 1 — Stress categories

| Stress category | Stress factor (S) | | |
|-----------------|---|---|-----------------------|
| | Fatigue strength values from calculation standard | Fatigue test values for representative joint sample | |
| | | Option 1 | Option 2 ^a |
| High | $\geq 0,9$ | $\geq 0,8$ | $\geq 0,9$ |
| Medium | $0,75 \leq S < 0,9$ | $0,5 \leq S < 0,8$ | $0,75 \leq S < 0,9$ |
| Low | $< 0,75$ | $< 0,5$ | $< 0,75$ |

^a The decisive limiting value shall be agreed with customer or acceptance authority.

4.5 Safety categories

The safety category defines the consequences of failure of the single welded joint in respect to the effects on persons, facilities and the environment.

The safety categories are differentiated as follows:

- Low:** Failure of the welded joint does not lead to any direct impairment of the overall function. Consequential events with personal injuries are unlikely.
- Medium:** Failure of the welded joint leads to an impairment of the overall function or can lead to consequential events with personal injuries.
- High:** Failure of the welded joint leads to consequential events with personal injuries and breakdown of the overall function.

If required in the contract, the acceptance of the safety categories defined by the designer for each weld shall be subjected to the approval of the customer and/or the national safety authority.

For the determination of the safety category, also Annex G should be considered.

4.6 Weld performance classes

Weld performance classes shall be defined in the design phase depending on the safety category and the stress category. The responsible welding coordinator should be consulted with respect to practicability and feasibility.

Welded joints of railway vehicles are divided into six weld performance classes (see Table 2).

Table 2 — Weld performance classes

| Stress categories | Safety categories | | |
|-------------------|--------------------|-------------------|-------|
| | High | Medium | Low |
| High | CP A ^a | CP B ^c | CP C2 |
| Medium | CP B ^b | CP C2 | CP C3 |
| Low | CP C1 ^d | CP C3 | CP D |

^a Weld performance class CP A is a special class which applies only for welds with full penetration and full accessibility for inspection in production and maintenance.

^b Weld performance class CP B:
CP B for safety category „high“: is only valid for welds with full penetration and full accessibility for inspection in production and maintenance.

^c CP B for safety category „medium“: is also valid for welds without the possibility for a volumetric test; in this case a special remark “medium safety category/increase of surface test is required” shall be indicated on the drawing and the tests according to Table 1 of EN15085-5:2007 shall be carried out.

^d Weld performance class CP C1:
CP C 1 is also valid for welds without the possibility for volumetric testing. In this case a special remark “surface test necessary” shall be indicated on the drawing and the tests according to Table 1 of EN 15085-5:2007 shall be carried out.

Joint with weld performance class CP A, CP B and CP C1, which can be inspected during production but cannot be inspected and repaired in maintenance, shall be allocated to the next higher inspection class according to Table 3 or the stress level shall be reduced.

If it is not possible to fulfil the requirements of a weld performance class, the designer shall reduce the stress category or change the design, see Annex D and Annex E.

Finishing-up a weld is one of the possible ways of increasing the admissible fatigue stresses of an assembly and may consequently lead to a downscaling of the weld performance class.

Weld performance classes and inspection classes shall be shown on drawings or in other documents, e.g. parts lists.

4.7 Weld inspection classes

The inspection class applicable to each welded joint is defined depending on the weld performance class defined formerly, see Table 3.

These inspection classes are used to identify the various types and minimum levels of inspections on the welded joints.

Table 3 — Correspondence between weld performance classes and inspection classes

| Weld performance class | Inspection class Minimum requirement |
|------------------------|---|
| CP A | CT 1 |
| CP B | CT 2 |
| CP C1 | CT 2 |
| CP C2 | CT 3 |
| CP C3 | CT 4 |
| CP D | CT 4 |

The tests applicable to these inspection classes shall be at minimum the same as described in EN 15085-5.

4.8 Relationship between stress category, safety category, weld performance class, quality levels for imperfections, inspection class and testing

Table 4 shows a summary of the relationship between stress category, safety category, weld performance class, quality levels for imperfections, inspection class and testing according to Table 1, Table 2, Table 3, Table 5 and Table 6 as well as EN 15085-5:2007, Table 1.

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Table 4 — Relationship between stress category, safety category, weld performance class, quality levels for imperfections, inspection class and testing

| Stress category | Safety category | Weld performance class | Quality levels for imperfections EN ISO 5817 EN ISO 10042 | Inspection class | Volumetric tests RT or UT | Surface tests MT or PT | Visual examination VT |
|-----------------|-----------------|------------------------|---|------------------|------------------------------|---------------------------|--------------------------|
| High | High | CP A | see Table 5 or Table 6 | CT 1 | 100% | 100 % | 100 % |
| High | Medium | CP B | B | CT 2 | 10% | 10 % | 100 % |
| High | Low | CP C2 | C | CT 3 | Not required | Not required | 100 % |
| Medium | High | CP B | B | CT 2 | 10% | 10 % | 100 % |
| Medium | Medium | CP C2 | C | CT 3 | Not required | Not required | 100 % |
| Medium | Low | CP C3 | C | CT 4 | Not required | Not required | 100 % |
| Low | High | CP C1 | C | CT 2 | 10 % | 10 % | 100 % |
| Low | Medium | CP C3 | C | CT 4 | Not required | Not required | 100 % |
| Low | Low | CP D | D | CT 4 | Not required | Not required | 100 % |

5 Quality levels for imperfections

5.1 General

Weld imperfections shall be as defined in accordance with EN ISO 6520-1 and EN ISO 6520-2.

5.2 Quality levels for imperfections

Quality levels for imperfections related to the weld performance class shall be as listed in Table 5 and Table 6 in accordance with EN ISO 5817 and EN ISO 10042.

5.2.1 Quality levels for imperfections for fusion welded joints (beam welding excluded)

5.2.1.1 Steel

Quality levels for imperfections according to EN ISO 5817 are given in Table 5.

Table 5 — Quality levels for imperfections for steel related to weld performance class

| Imperfections according to EN ISO 5817 | Weld performance classes | | | |
|--|--------------------------------------|------|-----------------------|------|
| | CP A | CP B | CP C1 / CP C2 / CP C3 | CP D |
| 1.1 to 1.6, 1.13, 1.15, 1.18, 1.19, 1.22, 2.1, 2.7, 2.8, 2.11 to 2.13, | B | B | C | D |
| 1.7, 1.8, 1.9, 1.11, 1.14, 1.17, 1.23, 2.2, 2.3 to 2.6, 2.9, 2.10, 3.1 | Not permitted | B | C | D |
| 1.10, 1.16, 1.20, 1.21, 3.2 | Not applicable | B | C | D |
| 1.12 ^a , 4.1, 4.2 | These imperfections are not assessed | | | |

^a For CPA, see also 7.3.15.