SLOVENSKI STANDARD
SIST EN 17149-3:2025

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Železniške naprave - Ocenjevanje odpornosti konstrukcije železniških vozil - 3. del: Ocena odpornosti proti utrujenosti na podlagi kumulativne škode

Railway applications - Strength assessment of rail vehicle structures - Part 3: Fatigue strength assessment based on cumulative damage

Bahnanwendungen - Festigkeitsnachweis von Schienenfahrzeugstrukturen - Teil 3: Betriebsfestigkeitsnachweis

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Applications ferroviaires - Évaluation de la résistance des structures de véhicule ferroviaire - Partie 3 : Évaluation de la résistance à la fatigue basée sur la méthode des dommages cumulés

Ta slovenski standard je istoveten z: EN 17149-3:2025

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ICS:

45.060.01	Železniška vozila na splošno	Railway rolling stock in general

SIST EN 17149-3:2025 **en,fr,de**

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EUROPEAN STANDARD

NORME EUROPÉENNE

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EN 17149-3

January 2025

ICS 45.060.01

English Version

Railway applications - Strength assessment of rail vehicle structures - Part 3: Fatigue strength assessment based on cumulative damage

Applications ferroviaires - Évaluation de la résistance des structures de véhicule ferroviaire - Partie 3 : Évaluation de la résistance à la fatigue basée sur la méthode des dommages cumulés

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This European Standard was approved by CEN on 27 October 2024.

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European foreword

This document (EN 17149-3:2025) 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of an identical text or by endorsement, at the latest by July 2025, and conflicting national standards shall be withdrawn at the latest by July 2025.

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

This document is part of the EN 17149 series, *Railway applications — Strength assessment of railway vehicle structures*, which consists of the following parts:

— *Part 1: General*;

— *Part 2: Static strength assessment*;

— *Part 3: Fatigue strength assessment based on cumulative damage*.

Any feedback and questions on this document should be directed to the users’ national standards body. A complete listing of these bodies can be found on the CEN website.

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

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Introduction

If a fatigue strength assessment is necessary for rail vehicle structures, this assessment may be made with an endurance limit approach or a cumulative damage approach.

An endurance limit approach is based on the assessment of the stress ranges (e.g. derived from the design load cases or from measurements) against an admissible endurance limit. Such an approach is applicable in combination with the loads given in the EN 12663 series or EN 13749.

A fatigue strength assessment based on cumulative damage takes into consideration stress spectra with variable amplitudes and numbers of cycles or stress time histories. This document provides the basic procedure and criteria for a pragmatic method to be applied for fatigue strength assessments based on the cumulative damage approach.

This document does not provide any procedures or criteria for an endurance limit approach. However, the fatigue strength data included in this document can also be applicable for an endurance limit approach.

The main body of the document is based on the nominal stress approach, but the consideration of variable amplitudes and number of cycles using methods described in this standard may equally be applied with the structural stress and the notch stress approach (additional information for these assessment methods is included as informative annexes).

Within this document, the term fatigue strength assessment is always related to the cumulative damage approach unless otherwise noted.

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1 Scope

This document describes a procedure for fatigue strength assessment based on cumulative damage of rail vehicle structures that are manufactured, operated and maintained in accordance with standards valid for rail system applications.

This document is applicable for variable amplitude load data with total number of cycles higher than 10 000 cycles.

An endurance limit approach is outside the scope of this document.

The assessment procedure is restricted to ferrous materials and aluminium.

This document does not define design load cases.

This document is not applicable for corrosive conditions or elevated temperature operation in the creep range.

This document is applicable to all kinds of rail vehicles; however, it does not define in which cases a fatigue strength assessment using cumulative damage is to be applied.

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.

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EN 15085-3:2022+A1:2023, *Railway applications — Welding of railway vehicles and components — Part 3: Design requirements*

EN 17149-1:2024, *Railway applications — Strength assessment of rail vehicle structures — Part 1: General*

ISO/TR 25901-1:2016, *Welding and allied processes — Vocabulary — Part 1: General terms*

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3 Terms and definitions

For the purposes of this document, the terms, definitions, symbols and abbreviations given in ISO/TR 25901-1:2016 and EN 17149-1:2024 apply.

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

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

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

4 Stress determination

4.1 General

Fatigue loads acting on a component cause fatigue stresses that can be expressed as a stress spectrum. The stress spectrum used to perform the fatigue strength assessment based on cumulative damage approach shall be expressed in terms of stress ranges, mean stresses and number of cycles to represent the design life.

The design stress spectrum shall incorporate any necessary allowance to account for uncertainties in their values (see 6.2).

NOTE The EN 12663 series, EN 15827 and EN 13749 contain information on how to determine design loads for cumulative damage assessment of rail vehicles.

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The combination of the individual stress components direct stress and shear stress is considered in 7.5.

4.2 Parent material

The stresses for the parent material shall be determined as described in EN 17149-1:2024, 5.1 and 5.2.

4.3 Welded joints

4.3.1 Modified nominal stresses

The modified nominal stresses for welded joints shall be determined in accordance with EN 17149-1:2024, 5.1 and 5.3.

4.3.2 Structural stresses and notch stresses

For the fatigue strength assessment of welded joints, the structural stress approach and the notch stress approach may be applied. For the application of these approaches, the requirements for the calculation of the relevant stresses and fatigue strength are described in the following informative annexes:

— Annex G for the structural stress approach and

— Annex H for the notch stress approach.

5 Fatigue strength

5.1 Parent material

5.1.1 General

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This clause describes the method to derive the fatigue strength of parent material under the following conditions:

— materials used such as construction steel, weldable cast steel, cast iron (GJS and ADI), steel (rolled or forged), cast aluminium, and wrought aluminium;

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— application temperature up to 100 °C for aluminium and up to 200 °C for steel;

— plane stress tensor on the components surface (no significant stress component perpendicular to the surface as would occur e.g. with a press fit connection).

The restrictions specified above are met with most applications of parent material for rail vehicles, in which case a simplified assessment method is appropriate. If the scope of the application is exceeded, an assessment method shall be chosen which accounts for the specific application (e.g. high temperatures or 3-dimensional stress states).

Annex C gives an overview of the applicable material factors.

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5.1.2 Component fatigue strength $\Delta\sigma_R$ and $\Delta\tau_R$

The fatigue strength is specified by S-N curves, which specify the values of the component fatigue strength expressed as stress range $\Delta\sigma_R$ and $\Delta\tau_R$ (in N/mm², unless stated otherwise) related to:

— $N_C = 10^6$,

— stress ratio $R_\sigma = R_\tau = -1$,

— survival probability of $P_s = 97{,}5\ \%$,

— membrane stresses.

The values of the component fatigue strength are determined with Formula (1) and Formula (2):

$$\Delta\sigma_R \left(N_C = 10^6,\ R_\sigma = -1\right) = R_m \cdot f_{R,\sigma} \cdot f_{SR,\sigma} \cdot f_{R,C} \qquad (1)$$

$$\Delta\tau_R \left(N_C = 10^6,\ R_\tau = -1\right) = R_m \cdot f_{R,\tau} \cdot f_{R,\sigma} \cdot f_{SR,\tau} \cdot f_{R,C} \qquad (2)$$

5.1.3 Material properties

5.1.3.1 Tensile strength in accordance with material standards $R_{m,N}$

$R_{m,N}$ is the nominal tensile strength in accordance with the material standards considering the actual sheet thickness. For machined components, the thickness of the semi-finished product before machining shall be considered.

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For rolled sheets and extrusions an anisotropy factor f_A shall be considered in the direction transverse to the main direction of rolling in accordance with Table 1, unless this is already considered or explicitly excluded in the material standard or component specification. For other material applications $f_A = 1{,}0$.

$$R_m = f_A \cdot R_{m,N} \qquad (3)$$

Table 1 — Anisotropy factor f_A for steel and aluminium

Material	$R_{m,N}$ [N/mm²]	f_A
Rolled Steel	≤ 600	0,9
	> 600 ≤ 900	0,86
Rolled sheets and extrusions of aluminium	≤ 200	1,0
	> 200 ≤ 400	0,95
	> 400 ≤ 600	0,9
All other material applications	Any value	1,0
Heat-affected zone	Any value	1,0

For heat-affected zones in the vicinity of welded joints the nominal tensile strength for the heat-affected zone $R_{m,HAZ}$ shall be used instead of R_m. The value for $R_{m,HAZ}$ shall be derived from technical literature.

NOTE Examples for such technical literature are [2], [5], [57], [58].

5.1.3.2 Tensile strength specified by drawing or specification $R_{m,S}$

As an alternative to a material standard, the mechanical properties may be specified by the drawing or specification.

$R_{m,S}$ is the tensile strength in accordance with a drawing or component specification. If higher values than those specified in the material standards are specified for $R_{m,S}$ and the values are checked only by random testing, then the specified values are not sufficiently reliable and therefore would be non-conservative to use for the purposes of a fatigue strength assessment. To perform a fatigue strength assessment with a survival probability of P_S = 97,5 % the tensile strength $R_{m,S}$ specified by the drawing or component specification shall be reduced in accordance with Formula (4):

$$R_m = f_{Rm,S} \cdot R_{m,S} \tag{4}$$

If the strength value is checked by three random tests (e.g. hardness test or tensile test) a value of $f_{Rm,S}$ = 0,94 is applicable. For other numbers of tests, this value shall be adjusted in accordance with technical literature (e.g. [2]).

If a validated P_S = 97,5 % value within the component is available, $f_{Rm,S}$ may be set to 1,0.

NOTE Strength values verified with 3.1 certificate in accordance with EN 10204 are examples for such validated values.

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The $R_{m,N}$ values specified in material standards for a given wall thickness may be used for the purposes of fatigue strength assessment with a survival probability of P_S = 97,5 %.

5.1.3.3 Influence of technological size

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The assessment method described in this standard does not make any adjustment for the wall thickness of the component. The strength properties used shall consider the appropriate wall thickness.

For components made from semi-finished products the strength properties shall consider the wall thickness of the semi-finished product before machining.

5.1.3.4 Influence of application temperature

If the component operating temperature remains within the scope of applicability specified by this standard, no further adjustment to account for the application temperature is required for the fatigue strength assessment.

5.1.4 Design Parameters

5.1.4.1 Surface roughness factor f_{SR}

The surface roughness factor f_{SR} depends on the material, the nominal tensile strength R_m, the surface roughness R_Z and the manufacturing process and is specified by Formula (5) and Formula (6).

$$f_{SR,\sigma} = f_{SR,edge} \cdot \left(1 - a_{R,\sigma} \cdot \log \frac{R_Z}{[\mu m]} \cdot \log \frac{2\,R_m}{b_R}\right) \tag{5}$$

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$$f_{SR,\tau} = f_{SR,edge} \cdot \left(1 - f_{R,\tau} \cdot a_{R,\sigma} \cdot \log \frac{R_Z}{[\mu m]} \cdot \log \frac{2 R_m}{b_R}\right) \quad (6)$$

$a_{R,\sigma}$ and b_R are given in Table 2, $f_{SR,\ edge}$ and R_Z are given in Table 3 and $f_{R,\tau}$ is given in Table 4.

Table 2 — Factors $a_{R\sigma}$ and b_R for steel and aluminium

Material	$a_{R,\sigma}$	b_R [N/mm^2]
Steel (rolled or forged)	0,22	400
Steel castings	0,20	400
Spheroidal graphite cast iron (GJS)	0,16	400
Ausferritic spheroidal graphite cast iron (ADI)	0,16	400
Wrought aluminium	0,22	133
Cast aluminium	0,20	133

Typical values of the surface roughness R_Z correlating to the average surface roughness R_a are given in Table 3. The factor $f_{SR,edge}$ accounts for the effect of thermal cut edges of steel.

Table 3 — Typical values for R_Z, R_a and $f_{SR,edge}$

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R_Z [µm]	R_a [µm]	$f_{SR,edge}$	Example
[a]	[a]	1,0	Plate surface or machined edge of steel
80 [b]	25 [b]	1,0	Shot blasted rolled sheet surface; Rolled sheet and extrusions of aluminium
200 [b]	50 [b]	1,0	Rolled sheet surface of steel, not shot blasted; Forged steel; Cast surface
50 [b]	12,5 [b]	0,81	Thermal flame cutting of steel, shot blasted
200 [b]	50 [b]	0,81	Thermal flame cutting of steel, not shot blasted
25 [b]	6,3 [b]	0,94	Plasma or laser cut plate edges of steel, shot blasted
200 [b]	50 [b]	0,94	Plasma or laser cut plate edges of steel, not shot blasted
200	50	1,0	Plasma or laser cut plate edges of aluminium, not shot blasted. (An improvement in the surface roughness factor is only applicable if the affected material (typically 2 mm) is completely removed by machining after cutting.)

[a] The values in accordance with the drawing or component specification shall be used. When applied to castings the benefit of machined surfaces is only applicable if the machined surface is free from surface breaking defects.

[b] If explicit values for surface roughness are specified in the drawing or component specification those values shall be used for the fatigue strength assessment. When applied to castings the benefit of machined surfaces is only applicable if the machined surface is free from surface breaking defects.

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