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Railway applications - Wheelsets and bogies - Method of specifying the structural requirements of bogie frames

Applications ferroviaires - Essieux montés et bogies -
Méthode pour spécifier les exigences en matière de
résistance des structures de châssis de bogie

Bahnanwendungen - Radsätze und Drehgestelle -
Festlegungsverfahren für Festigkeitsanforderungen an
Drehgestellrahmen

This European Standard was approved by CEN on 15 February 2021 and includes Amendment approved by CEN on 10 October 2023.

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European foreword

This document (EN 13749:2021+A1:2023) has been prepared by Technical Committee 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of an identical text or by endorsement, at the latest by May 2024, and conflicting national standards shall be withdrawn at the latest by May 2024.

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 includes Amendment 1, approved by CEN on 10 October 2023.

This document supersedes A1 EN 13749:2021 A1.

The start and finish of text introduced or altered by amendment is indicated in the text by tags A1 A1.

The general scope and requirements of EN 13749 are unaltered by this revision. Changes were necessary to mainly correct errors in some formulae and textural corrections in line with the CEN rules.

Informative annexes in this standard give additional information that is not mandatory but intended to assist the understanding or use of the document.

NOTE Informative annexes sometimes contain optional requirements. For instance, a test method that is optional, or expressed as an example, contains requirements but there is no need to comply with these requirements to claim compliance with the document.

This document has been prepared under a standardization request addressed to CEN by the European Commission. The Standing Committee of the EFTA States subsequently approves these requests for its Member States.

For the relationship with EU Legislation, see informative Annex ZA, which is an integral part of this document.

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 organizations 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.

EN 13749:2021+A1:2023 (E)**1 Scope**

This document specifies the method to be followed to achieve a satisfactory design of bogie frames and includes design procedures, assessment methods, verification and manufacturing quality requirements. It is limited to the structural requirements of bogie frames including bolsters and axlebox housings. For the purpose of this document, these terms are taken to include all functional attachments, e.g. damper brackets.

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.

EN 15085-1:2007+A1:2013, *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 15085-3:2007, *Railway applications - Welding of railway vehicles and components - Part 3: Design requirements*

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 15663:2017+A1:2018, *Railway applications - Vehicle reference masses*

EN 15827:2011, *Railway applications - Requirements for bogies and running gears*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 15827:2011 and the following apply.

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

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp/>

NOTE Annex A identifies the symbols, units, coordinate system and bogie categories used in the informative annexes to this European Standard.

3.1**axlebox**

assembly comprising the box housing, rolling bearings, sealing and grease

3.2**bogie frame**

load-bearing structure generally located between primary and secondary suspension

3.3

bolster

transverse load-bearing structure between vehicle body and bogie frame

3.4

static force

force which is constant with time

Note 1 to entry: Force due to gravity is an example of static force.

3.5

quasi-static force

force, which changes with time at a rate which does not cause dynamic excitation

Note 1 to entry: Quasi-static force might remain constant for limited periods.

3.6

dynamic force

transient, impulsive or continuous force, uniform or random, that changes with time at a rate that causes dynamic excitation

3.7

load case

set of loads or combinations of loads that represents a loading condition to which the structure or component is subjected

3.8

exceptional load case

extreme load case representing the maximum load at which full serviceability is to be maintained and used for assessment against static material properties

3.9

fatigue load case

repetitive load case used for assessment against fatigue strength

3.10

safety factor

factor applied during the strength assessment which makes an allowance for a combination of the uncertainties and the safety criticality

3.11

sideframe

longitudinal structural member of the bogie frame

3.12

primary suspension

suspension system consisting of the resilient elements (and associated connecting and locating parts) generally located between the axlebox and bogie frame

3.13

secondary suspension

suspension system consisting of the resilient elements (and associated connecting and locating parts) generally located between the bogie frame and vehicle body or bolster

EN 13749:2021+A1:2023 (E)**3.14****track testing**

performing of tests under expected service conditions, on railway infrastructure that represents the actual operating environment, and monitoring and recording the responses

3.15**validation**

process of demonstrating by analysis and/or test that the system under consideration meets in all respects the technical specification, including requirements due to regulations, for that system

3.16**verification**

process of demonstrating by comparison or testing that an analytical result or estimated value is of an acceptable level of accuracy

4 Technical specification**4.1 Scope**

The technical specification shall consist of all the information describing the functional requirements of the bogie frame and the interfaces with associated components and assemblies. It shall also comprise, as a minimum, the general requirements of use, the conditions associated with the vehicle equipped with the bogies, the operating characteristics, the conditions associated with maintenance and any other particular requirements.

The technical specification shall also identify all appropriate mandatory regulations and define the parts of the validation and acceptance procedure (Clause 6) and the quality requirements (Clause 7), which are specifically required, and the way in which evidence to show that the requirements have been met is to be provided.

NOTE If the customer is unable to define the technical specification completely the supplier usually proposes a technical specification and submits it to the customer (and the approval authority where relevant) for agreement.

4.2 General requirements

The technical specification shall indicate the type of bogie required in terms of its use. It shall also indicate the intended life of the bogie, its average annual distance run and its total distance run and all the information that is applicable to a bogie frame associated with the Essential Requirements of a TSI as indicated in EN 15827:2011. Information that is particularly relevant to bogie frame design is indicated in the following clauses.

4.3 Design load cases

The technical specification for the bogie frame shall consist primarily of the load cases required for the design of the bogie as specified in EN 15827:2011, plus any additional load cases required by that standard or arising from the application. The load cases shall be based on the vehicle mass states given in EN 15663:2017+A1:2018. However, for some applications and fatigue assessment methods it will be necessary to use additional vehicle loading conditions (expressed as functions of the cases in EN 15663:2017+A1:2018) to obtain an accurate description of the vehicle payload spectrum for design purposes.

The development of the design load cases is discussed in Annex B and examples of design load cases associated with bogie running and due to the attachment of equipment are given in Annexes C and D respectively.

NOTE If the endurance limit approach to fatigue strength assessment is to be used, the data on the number of events is not required and only the extreme repetitive load conditions need to be specified.

4.4 Vehicle conditions and interfaces

The technical specification shall also include the following information from the requirements of EN 15827:2011 interpreted for applicability to the bogie frame:

- vehicle body interfaces and clearances;
- gauge reference profile and bogie movement envelope;
- suspension geometry and attachments;
- interfaces to traction and braking systems and all other attached equipment;
- electrical and pneumatic system connections;
- environmental requirements;
- maintenance requirements.

4.5 Particular requirements

The technical specification shall indicate any particular requirements related to the bogie frame that are not covered by the above clauses, for example, operating conditions, materials, types of construction and methods of assembly (e.g. treatment of welds, shot peening).

5 Verification of the design data

All necessary means (e.g. analysis, drawings, tests) shall be used to carry out the design.

The information supporting the design of the bogie frame shall be verified by the documents specified in the technical specification and those required by applicable standards and regulations which permit:

- the bogie frames to be designed and manufactured in accordance with the requirements of the technical specification, EN 15827:2011 and this document;

— all the checks considered necessary for the validation and acceptance to be carried out.

6 Validation and acceptance of the design

6.1 General

The aim of the validation plan is to prove that the design of the bogie frame fulfils the conditions specified in the technical specification. In addition, it shall show that the behaviour of the bogie frame, constructed according to the design, will give satisfactory service without the occurrence of defects such as catastrophic rupture, permanent deformation and fatigue cracks. It shall further demonstrate that there is no adverse influence on the associated bogie components or sub-assemblies.

The validation plan shall be compatible with that for the bogie as a whole as specified in EN 15827:2011 and in particular the requirements of the following clauses of this European Standard.

Acceptance of the product will normally be dependent on a satisfactory completion of the validation plan but may contain other conditions outside the scope of this European Standard.

The technical specification shall include guidance on how the bogie design is to be validated (including conformance with any applicable regulations) and shall state all the parameters that are necessary for the application of the different parts of the procedure. These parameters shall be specified in three stages:

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- the validation plan (e.g. combination of load cases for analysis and static tests, programmes for fatigue tests, routes for track tests);
- the values of the different load cases;
- the acceptance criteria (treatment of measured or calculated values, limiting stresses, criteria for completion of fatigue tests, etc.).

Clause 6.2 specifies which parts of the validation plan should be included in any particular case.

NOTE In order that the acceptance procedure is completely specified, the supplier identifies the methods of demonstrating conformance to the requirements if they are not incorporated into the technical specification.

6.2 The validation plan**6.2.1 Content**

The validation plan shall comprise a list of the validation steps planned to demonstrate compliance to the requirements specified in the technical specification.

The procedure for the validation of the mechanical strength of a bogie frame against the acceptance criteria shall be established on the basis of:

- analysis;
- laboratory static tests;
- laboratory fatigue tests;
- track tests.

The procedure for the validation of the mechanical strength of an axlebox housing may be validated by FEA simulation and laboratory fatigue testing or on-track-testing only.

NOTE 1 Annex D identifies the design requirements for attached equipment and validation testing is defined from a risk assessment for the particular equipment.

NOTE 2 For bolster structures which are positioned immediately above the secondary suspension, the loads in EN 12663 can be used.

The content of the plan shall be related to the importance of the problem to be dealt with. In principle, the validation plan shall identify and address those design assumptions and solutions that need to be verified.

All structural components shall be analysed to demonstrate that they will carry the loads to which they are subject.

For a new design of bogie frame destined for a new type of application all four validation stages shall be used, though the fatigue tests can be replaced by other methods of demonstrating the required fatigue life. The plan shall establish a strategy which defines the steps to be taken and the degree of testing necessary to verify, and give confidence in, the analytical results.

NOTE 3 This will determine the scope and objectives for the laboratory and track tests.

The load cases for freight wagon bogies are often based on the experience of the railways over a long period of time and these loads are generally applicable to all similar freight bogie designs. It is common practice that a freight bogie which has passed an appropriate fatigue test will not be subject to structural assessment track tests (only to those validating the dynamic behaviour).

The general requirements of the individual validation records are:

- definition of the validation objective;
- documentation of the method applied (including its limitations);
- presentation of the results;
- definition of acceptance criteria;
- statement of compliance.

In principle the same acceptance criteria should be applied to both the design and testing phases. For example, if the endurance limit approach is used for the analytical verification of the design it shall also be applied for the testing phase. However, if during testing the design cannot be verified using the basis of the endurance limit approach then a life assessment using an appropriate cumulative damage approach can be undertaken.

Where the design is a development of an earlier product any previous data, or other evidence of satisfactory performance that is still applicable, can be offered as validation of the revised product.

In the case of an existing design of bogie frame intended for a new application, or a modification to an existing design, a reduced programme can be used, depending on the significance of the differences. If the differences are small, analysis, supported if necessary, by measurements made during a limited test programme, will be sufficient to validate the design.

Static tests and fatigue tests shall be carried out in accordance with the technical specification and applicable regulations and to a level that is considered necessary to validate the design satisfactorily.

For the validation to be acceptable the series production bogie frames and the test frames shall be manufactured according to an equivalent set of specifications, including drawings, procedures and quality plan. Any differences that could influence the outcome of the tests shall be shown to be acceptable.

The test rig equipment shall be capable of producing, as far as is reasonably practicable, the same stresses as those which would appear on the bogie frame when placed under its intended vehicle and supported on its suspension.

In the case of an order for a very small number of bogies it might be impractical to justify all stages of the normal validation procedure. In such cases, analysis shall always be carried out and this shall be supported by taking the alternative measures specified in EN 15827:2011.

Where the load cases for a freight wagon bogie are based on the experience of the railways over a long period of time and these loads are generally applicable to all similar freight bogie designs, it is acceptable that a freight bogie which has passed an appropriate fatigue test need not be subject to structural track testing.

6.2.2 Structural analysis

In addition to the general requirements of the validation records in 6.2.1 structural analysis reports shall include the following information:

- boundary conditions, including design load cases and combinations (as specified in EN 15827:2011 and discussed in Annex B);
- documentation of the simulation model used (including limitations and simplifications);
- locations and types of stresses being assessed (e.g. principal, von Mises);
- permissible design limits (e.g. allowable stresses) and their basis/origin;

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- any particular acceptance criteria (e.g. stiffness, deflections, such as the interface between the axlebox housing and bearing);
- documentation of utilization at critical details (see E 4.2).

Load case data specific to the application, and which takes account of the bogie suspension characteristics, vehicle body parameters, track and operating characteristics, should always be used where such data are available (e.g. established empirical data or data from simulations, tests or a previous similar application). Annexes C and D provide examples of design load case data which has been used for specific applications, but this data cannot be considered to apply universally. It should be noted that the load case data in Annexes C and D does not take account of differences in the bogie suspension or the vehicle body characteristics or of load changes resulting from active suspension (e.g. tilt) systems, etc.

The structural analysis shall be carried out using the validation process and acceptance criteria as required by EN 15827:2011.

Annex E gives further guidance on factors to be considered in defining an analysis programme and includes the structural acceptance criteria as specified in EN 15827:2011.

6.2.3 Static tests

In addition to the general requirements for validation records in 6.2.1, laboratory static test reports shall include the following:

- documentation of the test program performed including magnitudes and combinations, direction and position of the loads (nominal values and actual values that have been applied);
- documentation of the test setup including jigs and actuators and any inherent simplifications and limitations;
- documentation of the measuring equipment, including type and location of sensors (strain gauges, load cells, displacement transducers, etc.) and associated calibration certification;
- methods of evaluation and interpretation of measured strains/stresses and permissible values;
- utilization results for the individual measurement locations.

The loads applied in the tests shall be based on the design load cases.

Annex F indicates general considerations and gives examples of programmes for static tests. Again, this data cannot be considered to apply universally as the load cases do not consider differences in the bogie suspension or the vehicle body characteristics. Therefore, these examples shall be followed only when they can be shown to be applicable.

6.2.4 Fatigue tests

In addition to the general requirements for validation records in 6.2.1, laboratory fatigue test reports shall include the following:

- documentation of the test program performed including magnitudes and combinations, direction and position of the loads, number of load cycles (nominal values and actual values that have been applied);
- documentation of test setup including jigs and actuators and any inherent simplifications and limitations;
- documentation of the measuring equipment including type and location of sensors (strain gauges, load cells, etc.) and associated calibration certification;