SLOVENSKI STANDARD

SIST EN 13749:2011

01-oktober-2011

Nadomešča:

SIST EN 13749:2005

Železniške naprave - Kolesne dvojice in podstavni vozički - Metoda za specificiranje konstrukcijskih zahtev okvirjev podstavnih vozičkov

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

Bahnanwendungen - Radsätze und Drehgestellte - Spezifikationsverfahren für Festigkeitsanforderungen an Drehgestellrahmen

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

Ta slovenski standard je istoveten z: **EN 13749:2011**

ICS:

45.040	Materiali in deli za železniško tehniko	Materials and components for railway engineering

SIST EN 13749:2011 **en,fr,de**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 13749

March 2011

ICS 45.040

Supersedes EN 13749:2005

English Version

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

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Foreword

This document (EN 13749:2011) 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of an identical text or by endorsement, at the latest by September 2011, and conflicting national standards shall be withdrawn at the latest by September 2011.

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.

This document will supersede EN 13749:2005.

The general scope and requirements of EN 13749 are unaltered by this revision. Changes were necessary to make the standard compatible with more recent Euronorms. Certain areas of the normative text had to be revised to make correct reference to the structural analysis and validation processes now specified in the new bogie and running gear standard EN 15827. Other new normative references are to EN 15085 and EN 15663.

The other main changes that have been made concern the informative annexes and are summarized as follows:

a) to comply with CEN rules, the symbols and units have been removed from the normative text and added as informative Annex A, as they apply only to the other informative annexes;

b) the old informative Annex C has been removed and reference made to EN 15663, which now covers vehicle mass data;

c) the informative Annex E has been re-written to present the structural analysis and acceptance process as specified in EN 15827;

d) a number of errors in the example load case equations in informative Annex C have been corrected;

e) the guidance on component loads in informative Annex D has been revised to better reflect present practice;

f) the limitations of the example load case data in informative Annexes C, D, F and G have been given greater emphasis and it has been stressed that the loads should be used as presented only when it can be shown that they are applicable to the specific design.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association to support Essential Requirements of EU Directive 2008/57/EC.

For relationship with EU Directive 2008/57/EC, see informative Annex ZA, which is an integral part this document.

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, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

1 Scope

This European Standard 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 European Standard, these terms are taken to include all functional attachments, e.g. damper brackets.

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

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

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

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

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

EN 15663, *Railway applications — Definition of vehicle reference masses*

EN 15827:2011, *Railway applications — Requirements for bogies and running gear*

3 Terms and definitions

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

NOTE Annex A identifies the symbols, units, co-ordinate 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 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 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

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 may propose a technical specification and submit 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. 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, 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. 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) 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 it is proposed to use the endurance limit approach to fatigue strength assessment the data on the number of events is not required and only the extreme repetitive load conditions need to be defined.

4.4 Vehicle conditions and interfaces

The technical specification shall also include the following information from the requirements of EN 15827 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 defined 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 and this European Standard;

— 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 defined 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 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 defined in three stages:

— 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.).

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

NOTE In order that the acceptance procedure is completely defined, the supplier should identify 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 defined 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 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 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 validations 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.

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 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;

— any particular acceptance criteria (e.g. stiffness, deflections, such as the interface between the axlebox housing and bearing);

— documentation of utilisation at critical details (see 4.2 of Annex E).

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 is 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.

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.

6.2.3 Static tests

The purpose of static tests is described in F.1.

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;

— utilisation 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 take into account 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

The purpose of fatigue tests is described in G.1.

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;

— acceptance criteria (including schedules and methods of the non-destructive testing);

— test records of non-destructive tests;

— interpretation of results against the acceptance criteria.

The fatigue test plan shall be determined for the specific application.

Annex G indicates general considerations and gives examples of programmes for fatigue tests but, as for the static tests, these programmes do not take into account differences in the bogie suspension or the vehicle body characteristics and shall be adopted only if they can be shown to be appropriate to the application.

6.2.5 Track tests

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

— documentation of the test vehicle including the loading conditions;

— documentation of the test program including test routes, length, type of track, operating conditions;

— documentation of the measuring equipment used, including types and locations of sensors (strain gauges, load cells, displacement transducers, accelerometers, etc.) and associated calibration certification;

— methods of evaluation and interpretation of measured strains/stresses and permissible values;

— interpretation of results for the individual measurement locations.

To produce valid results the track tests shall be carried out with the test vehicle, payloads, track quality and speed profile all representative of the intended operating conditions. If the environment can affect the test results the tests shall be carried out under suitable conditions.

NOTE 1 The validation objectives that can be obtained by track tests are:

— verification of design assumptions concerning operating conditions and the operating envelope (without the limitations and simplifications that are inherent in simulations);

— verification/determination of real strain time histories (spectra/collectives) at the measurement locations under real operating conditions (without the limitations and simplifications of structural simulation models and load assumptions);

— design life estimation on the basis of real measured strain time histories (spectra/collectives) and a theoretical fatigue hypothesis.

NOTE 2 The limitations of track tests are:

— the test program can only represent a small part of the total operating design life of the bogie;

— simplification is unavoidable in the extrapolation of the test results to the total design life of bogie and the assessment of the results has to take into account the degree to which the test program was able to represent the total real life conditions;

— the design life prediction is based on a theoretical fatigue hypothesis and therefore has a level of confidence limited by the hypothesis itself (including any uncertainties in the classification of the assessed detail).

7 Quality requirements

For the validation to be applicable, all manufactured bogie frames shall be of a quality consistent with the requirements of the technical specification and the assumptions and data used as the basis of the design.

The bogie frame design and manufacture shall be covered by a quality plan as required by EN 15827.

Welded fabrication shall be carried out in accordance with the requirements of EN 15085-1 to EN 15085-5 or to a process that gives an equivalent level of control.

Annex A
(informative)

Symbols and units used in the informative annexes

NOTE Certain symbols used in this European Standard may have a different meaning to those adopted in related standards (e.g. EN 13103, EN 13104 and EN 13979-1).

A.1 Forces

Table A.1 — Forces

Force (N)	Position	Symbol		
		Static	Quasi-Static	Dynamic
Vertical	Load applied to bogie	F_z		
	Force on sideframe 1 or sidebearer 1	F_{z1}	F_{z1qs}	F_{z1d}
	Force on sideframe 2 or sidebearer 2	F_{z2}	F_{z2qs}	F_{z2d}
	Force on centre pivot	F_{zp}	F_{zpqs}	F_{zpd}
	Force at (vehicle body) c of g	F_{zc}		
Transverse	Load applied to bogie	F_y		
	Force on axle 1	F_{y1}	F_{y1qs}	F_{y1d}
	Force on axle 2	F_{y2}	F_{y2qs}	F_{y2d}
	Force at (vehicle body) c of g	F_{yc}		
	Force due to wind	F_{w1}		
Longitudinal	Force at each wheel	F_{x1}		
	Force at (vehicle body) c of g	F_{xc}		
	Force at (vehicle bogie) c of g	F_x		

A.2 Accelerations

Table A.2 — Accelerations

Acceleration (m/s^2)	Symbol	
	Vehicle body	Bogie (primary spring)
Vertical	a_{zc}	a_{zb}
Transverse (dynamic)	a_{yc}	a_{yb}
Centrifugal (quasi-static)	a_{ycc}	a_{ycb}
Longitudinal	a_{xc}	a_{xb}