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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	

June 2025

ICS

Will supersede EN 14363:2016+A2:2022

English Version

**Railway applications - Testing and simulation for the
acceptance of running characteristics of railway vehicles -
Part 5: Calculations/Simulations**

Applications ferroviaires ; Essais en vue de l'évaluation
du comportement dynamique des véhicules
ferroviaires circulant sur un réseau du système
ferroviaire lourd ; Partie 5 : Calculs/Simulations

Bahnanwendungen - Versuche und Simulationen für
die Bewertung der fahrtechnischen Eigenschaften von
Schienenfahrzeugen, die auf dem Vollbahnnetz
betrieben werden - Teil 5:
Berechnungen/Simulationen

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 256.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

This draft European Standard was established by CEN in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Contents	Page
European foreword	4
Introduction	5
1 Scope.....	6
2 Normative references.....	6
3 Terms and definitions	6
4 Calculations and simulations for safety against derailment on twisted track	7
4.1 Test method 1 and test method 2.....	7
4.2 Test method 3.....	7
5 Calculations and simulations for displacement characteristics.....	8
6 Simulations of loading of the diverging branch of a switch.....	8
7 Simulations of running safety in curved crossings for vehicles with small wheels.....	8
8 Simulations of on-track tests.....	8
8.1 Introduction.....	8
8.2 Fields of application.....	9
8.2.1 General.....	9
8.2.2 Extension of the range of test conditions	9
8.2.3 Assessment of vehicles following modification	9
8.2.4 Assessment of new vehicles by comparison with an already approved reference vehicle	10
8.2.5 Investigation of dynamic behaviour in case of fault modes	11
8.3 Validation	11
8.3.1 General principles	11
8.3.2 Vehicle model	11
8.3.3 Validation of the vehicle model	12
8.4 Input	26
8.4.1 Introduction.....	26
8.4.2 Vehicle model.....	26
8.4.3 Vehicle configuration	27
8.4.4 Track data.....	27
8.4.5 Track model parameters.....	28
8.4.6 Wheel/rail contact geometry	28
8.4.7 Rail surface condition	28
8.4.8 Direction of travel.....	29
8.4.9 Speed	29
8.4.10 Position of the vehicle in the trainset.....	29
8.4.11 Frequency content of simulations	30
8.5 Output	30
8.5.1 Methods to determine the estimated value from the simulation.....	30
8.6 Documentation	31
Annex A (informative) Computer simulations designed to examine whether the vehicle has an acceptable resistance to flange climbing derailment at low speed	32

A.1	General requirement.....	32
A.2	Computer output.....	32
A.3	Track input.....	32
A.4	Body-bogie yaw torque.....	33
A.5	Performance requirement	34
Annex B (informative)	Examples for model validation according to method 1.....	35
Annex ZA (informative)	Relationship between this European Standard and the Essential Requirements of EU Directive (EU) 2016/797 aimed to be covered	42
Bibliography		44

European foreword

This document (prEN 14363-5:2025) has been prepared by Technical Committee CEN/TC 256 “Railway Applications”, the secretariat of which is held by DIN.

This document is currently submitted to the CEN Enquiry.

This document together with prEN 14363-1:2025, prEN 14363-2:2025, prEN 14363-3:2025, and prEN 14363-4:2025 will supersede EN 14363:2016+A2:2022.

EN 14363:2025 includes the following significant technical changes with respect to EN 14363:2016+A2:2022.

This document is one of the series EN 14363 *Railway applications — Testing and Simulation for the assessment of running characteristics of railway vehicles* as listed below:

- Part 1: *General*;
- Part 2: *Safety against derailment on twisted track*;
- Part 3: *Stationary tests that are not obligatory on European level*;
- Part 4: *On-track testing*;
- Part 5: *Simulations and calculations*;
- Part 6: *Background information to the EN 14363 series of standards*.

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.

It is not necessary to require further assessment of vehicles which have been already assessed under the conditions of previous standards in this field. Test results achieved under the conditions of the previous standards remain valid and can be used for the extension of field of application of a vehicle or vehicle design according to this series of standards.

Introduction

General information for the application of this document is given in prEN 14363-1:2025.

1 Scope

This document applies to all railway vehicles including OTM's and Road-rail machines, which are operated on the heavy rail network with standard track gauge 1 435°mm and nominal static vertical wheelset forces up to 350 kN.

This document may also be applicable (partly or in full) to:

- rail systems with different track layout, e.g. urban rail systems and/or;
- rail systems with other than 1 435 mm nominal track gauge and/or;
- non-public rail networks and vehicles, e.g. mine rail systems.

NOTE For rail systems other than 1 435 mm track gauge or urban rail systems, the related post analysis, limit values and test conditions could be different. They are specified nationally taking into account track design and operating conditions.

This document contains methods to replace tests by simulations and/or calculations specified in prEN 14363-2:2025, prEN 14363-3:2025 and prEN 14363-4:2025, completely or partly or to support the assessment of railway vehicles according to this document.

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.

prEN 14363-1:2025,¹ *Railway applications — Testing and Simulation for the assessment of running characteristics of rail vehicles operated on the heavy rail network — Part 1: General*

EN 13848-1:2019, *Railway applications - Track - Track geometry quality - Part 1: Characterization of track geometry*

EN 13848-2:2020, *Railway applications - Track - Track geometry quality - Part 2: Measuring systems - Track recording vehicles*

EN 17343:2023, *Railway applications - General terms and definitions*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in prEN 14363-1:2025 and EN 17343:2023 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/>

¹ At draft stage.

4 Calculations and simulations for safety against derailment on twisted track

4.1 Test method 1 and test method 2

A replacement of physical testing of safety against derailment on twisted track according to test method 1 or test method 2 by calculations or simulations requires that a comparison of test results and calculation or simulation results shows credible results achieved for a tested reference vehicle (see prEN 14363-1:2025, 3.17) related to:

- vertical wheel forces and guiding forces for test method 1 testing or test method 2 testing of the reference vehicle; or
- vertical wheel forces and yaw moment for test method 3 testing of the reference vehicle.

The calculations performed to demonstrate safety against derailment on twisted track shall be performed either by using the process specified for test method 2 testing or by simulating running through a twisted curve with a radius of 150 m. The friction coefficient on the inner rail running surface shall be 90 % of μ_{dry} specified in prEN 14363-2:2025, 4.3, where an angle of attack of 20 mrad shall be used.

If running through a twisted curve with a radius of 150 m is chosen, the track shall have the vehicle test twist specified for test method 1. The bogie test twist shall be applied either by shimming of the bogie model (as when testing) or by introducing a dip in the most critical position of the track as described in Annex A. As assessment criterion, the quotient Y/Q shall be used with the limit value specified for test method 2. If a coefficient of friction of 0,36 is used on the outer wheel flange, then Y/Q or the wheel lift can be used as an acceptance criterion.

NOTE 1 The assessment criterion of method 1 testing “wheel lift” is very sensitive to the friction conditions.

NOTE 2 The possible manipulation of the track when simulating test method 1, means that the simulation is done only approximately per test method 1.

The calculated result $(Y/Q)_a$ for the assessed vehicle shall remain 10 % below the limit value specified for test method 2. In a deflated suspension condition the 10 % margin does not apply.

In case a simulation is performed with a model that is validated according to the validation method 1, described in 8.3.3.3, the confidence in the results is higher than in the process described above. Then, it is not necessary to apply the 10 %-margin to the normal vehicle status.

If during the tests of the reference vehicle a coefficient of $(Y/Q)_i$ higher than 100 % of μ_{dry} occurred, the calculation method can be further used to normalize measurement results, see prEN 14363-2:2025, 4.3.

4.2 Test method 3

Computer simulation according to informative Annex A may be used to assess the performance of safety against derailment in twisted track; this simulation is phase 2.

Phase 2 can only be used with a validated model. Typically, the results of phase 1 are used to validate the work carried out in phase 2, where phase 1 is the test method described in prEN 14363-2:2025, 4.5.3.1; test results of a reference vehicle (see prEN 14363-1:2025, 3.17) or test results according to test method 2 (see prEN 14363-2:2025, 4.5.2) may be used for the model validation.

5 Calculations and simulations for displacement characteristics

The determination of the displacement characteristics is carried out by simulation with a validated model fit for purpose either for method 1 (vehicle while standing) or method 2 (on-track tests), both of prEN 14363-3:2025, Clause 4. The validation method shall be validation method 1, see 8.3.3.3, however adapted to the required validation range for the selected method simulated (vehicle while standing or on-track testing).

6 Simulations of loading of the diverging branch of a switch

If a validated model per validation method 1 (see 8.3.3.3), fit for purpose exists, then it is allowed to execute simulation for assessment of loading of the diverging branch of a switch.

7 Simulations of running safety in curved crossings for vehicles with small wheels

The proof of running safety in a curved crossing may be performed by simulations in a full curve without crossing using a validated model (see 8.3.3.3, validated to ΣY or H , or see 8.3.3.4). Therefore H -forces (or ΣY -forces) and angles of attack shall be calculated for a 450 m curve without cant for a running clearance between wheel and rail within the range $10 \text{ mm} \leq (\text{TG} - \text{SR}) \leq 20 \text{ mm}$.

The friction coefficient shall be varied between 0,05 and 0,45 in steps of 0,1. The following speeds shall be investigated: 10 km/h, 25 km/h, 40 km/h and 60 km/h.

The assessment shall be made against the criteria given in prEN 14363-3:2025, 6.4.4.

8 Simulations of on-track tests

8.1 Introduction

The dynamic performance of the vehicle shall normally be verified by tests (static tests and on-track tests), but the use of simulation in place of on-track test is permitted under controlled conditions. The objective when using simulation is to achieve the same level of confidence in the results as would be achieved by on-track tests. The simulation process described in this annex sets out one means by which this can be achieved. Other simulation procedures that achieve the same level of confidence are also permitted.

The range of conditions of the validation determines the scope for which the model is then approved for simulations. Therefore it is recommended that the simulation validation covers the widest practical range of test conditions.

The limits and guidelines related to simulation and validation stated in this annex are based on the current state of the art. This implies that the given criteria, conditions, methods, etc, are to be seen as preliminary to gain experience and may most probably be reconsidered at the next update of the standard.

The validation processes described in this document relate only to the simulation of on-track tests described in prEN 14363-4:2025.

8.2 Fields of application

8.2.1 General

Four cases of application where numerical simulations can be used in place of testing are detailed in this annex. These are:

- extension of the range of test conditions where the full test programme has not been completed;
- approval of vehicles following modification;
- approval of new vehicles by comparison with an already approved reference vehicle;
- investigation of dynamic behaviour in case of fault modes.

The scope of these cases of application and the conditions for use of numerical simulation is described in the following subclauses. Other cases of application may exist.

A vehicle model shall be developed and validated by comparison with the available test results in accordance with 8.3.

8.2.2 Extension of the range of test conditions

Where on-track tests according to this document have been carried out, but the full range of test conditions has not been satisfied, then it is permissible to use numerical simulations to cover the deficiencies as part of the vehicle approval. This situation could arise where:

- sufficient track length is not available to meet the requirements for some test zones;
- the full range of speed and cant deficiency has not been tested;
- the full range of wheel/rail contact conditions has not been covered;
- measuring channels failed, or provided unreliable results.

It is permitted to use numerical simulations for a single or multiple test zones where the test results are not complete, if the variance of the errors of measured sections is similar to those of the simulated sections. A sufficient number of track sections from each of simulations and measurements is necessary to compare the statistics.

NOTE This method assumes that measurements and simulation belong to similar basic populations. Checking that the heterogeneity is not reduced or constant variance is not significantly altered can partly prove this.

8.2.3 Assessment of vehicles following modification

Vehicle modifications may be carried out for a number of different reasons, for example:

- change of the use of the vehicle;
- upgrade of the vehicle;
- modifications to improve the running behaviour:
 - during or following the approval test programme;
 - when some tests were done in a preliminary vehicle configuration and the final configuration is defined afterwards.

A model of the original vehicle is developed and validated against the test results for that vehicle in accordance with 8.3. The model of the vehicle is then modified to represent the physical changes to the vehicle as a result of the modification. Only the changes that influence the dynamic behaviour are required to be included in the modified model. The revised model is used to simulate the dynamic behaviour and the results are compared with the limit values for assessment.

Simulations for all test zones shall be carried out to demonstrate that the vehicle performance of the new vehicle is consistent when compared to the previously tested vehicle. The influence that the changed parameter(s) has (have) on the dynamic performance shall be examined for all zones. The results of this examination shall be reported and the influence on the performance indicated.

If a vehicle has been tested according to prEN 14363-2:2025, prEN 14363-3:2025 or prEN 14363-4:2025 and found to exceed some of the limit values, then it is permitted to use numerical simulations to demonstrate that modifications to the vehicle will improve the behaviour sufficiently to meet the limits. The values that previously exceeded the limits shall be under the limit values for track loading and at least 10 % below the limits for running safety. At the same time all other values shall remain below the limit and not increase by more than 1/3 of the previous margin to the limit value. In this situation the vehicle can be regarded as acceptable for the previously deficient limit values.

In any of the above cases it shall be independently confirmed (see 8.3.3.6), that the modifications have been correctly and appropriately applied to the model so that the resulting vehicle response is credible in the context of the original model and achieves the required effect on vehicle behaviour. This shall be documented in the reviewer's report.

NOTE In some cases, it can be useful to check if the modifications are applied correctly by reference to limited test results.

The data from the simulation is to be used to assess the modified vehicle.

8.2.4 Assessment of new vehicles by comparison with an already approved reference vehicle

Where vehicles are being introduced with a range of different types within the fleet (e.g. multiple units, etc.) then one vehicle type is defined as the reference vehicle. Vehicles that are similar to the reference vehicle can then be approved using numerical simulations, rather than on-track tests, to demonstrate the behaviour of the new vehicles, subject to the conditions given below.

Model(s) of the new vehicle(s) that are to be assessed are to be developed from the reference vehicle.

The existing and changed parameters are to be included in the simulation to demonstrate the influence of the changes on the performance.

Simulations for all test zones are carried out to demonstrate that the vehicle performance of the new vehicle is consistent when compared to the reference vehicle. The influence that the changed parameter(s) has (have) on the dynamic performance is to be examined for all test zones. The results of this examination are to be reported and the influence on the performance indicated.

If the change to the dynamic performance results in:

- an increase in any assessment quantity compared to the reference vehicle;
- and/or a fundamental change in the frequency and/or amplitudes of the dynamic response;

then a full review shall be carried out.

This review shall include analysis that investigates the changes to the dynamic response(s) of the new vehicle compared to the reference vehicle and an associated explanation of the effects identified. This comparison shall be carried out for at least 3 sections of each test zone, if it demonstrates that:

- the assessment quantities for running safety (see prEN 14363-4:2025, 4.5.2) from simulations do not increase by more than 1/3 of the previous margin to the limit values;

- and at the same time the values for track loading (see prEN 14363-4:2025, 4.5.3) from simulations do not increase by more than 2/3 of the previous margin to the limit values;

then the simulation can be used for vehicle assessment.

NOTE 1 Changes to individual components such as springs or dampers are likely to be acceptable provided the characteristics of the changed components are known and the changes are not extreme. Limited changes to masses, inertias or centres of gravity are also likely to be acceptable. A change to the concept of the suspension or introduction of components which were not present in the validated model for the tested vehicle is less likely to be acceptable.

Confirmation that the modifications have been correctly and appropriately applied to the model so that the resulting vehicle response is credible in the context of the original model shall be independently reviewed and documented in the reviewer's report (8.3.3.6).

NOTE 2 In some cases it could be useful to check if the modifications are applied correctly by reference to limited test results.

8.2.5 Investigation of dynamic behaviour in case of fault modes

The use of simulation to investigate fault modes in support of the requirements of prEN 14363-1:2025, 5.2.2 is permitted. In such cases the validity of the simulation of fault modes shall be independently reviewed and confirmed as being appropriate and the outcome of the review shall be documented in the reviewer's report. The process of selecting and assessing fault modes is independent from the assessment method (test method or simulations).

The model shall only be used within its range of validity.

8.3 Validation

8.3.1 General principles

Models used in numerical simulations are required to be validated by comparison with test results from the vehicle that is being modelled.

Information that is required to carry out the validation should include:

- design data for the modelled vehicle that is sufficiently detailed to enable the features that influence the vehicle dynamics to be incorporated into the model;
- test results for the modelled vehicle in a form that can be used for model validation including time history data in a digital form. It is necessary that these tests and data include a representative range of track conditions, curves, cant deficiency, speed and wheel/rail contact conditions;
- track data from the original test route to enable validation to be undertaken.

In case not all the information required in this annex can be used (e.g. because it is not available and cannot be obtained) in the validation of the model, the impact of the missing data on the model accuracy shall be assessed. As a consequence of this assessment, limitations on the application range of the model may need to be defined. This will need to be independently reviewed.

8.3.2 Vehicle model

The model shall include the main components such as wheelsets, bogies/running gear, vehicle body and all of the relevant connections between them (e.g. geometry, linear/nonlinear stiffness, damping, clearances, etc.). Data describing the vehicle body shall be included to the level of detail required to represent dynamic effects that are prominent in the dynamic performance (e.g. masses, inertias, position of centre of gravity, significant eigenmodes/flexible bodies).

The precision and level of detail that is appropriate in a model will depend on the particular assessment quantities that are to be evaluated.

Sufficient detail and precision is required to give confidence in the predicted vehicle performance under consideration.

8.3.3 Validation of the vehicle model

8.3.3.1 Introduction

In order to generate valid results, it is necessary that numerical simulations are carried out with care to ensure that:

- the vehicle model is a good representation of the actual vehicle;
- the software used is appropriate for the application;
- the correct conditions have been covered;
- the engineers undertaking the simulations are competent;
- and therefore, the simulation results will be valid.

If numerical simulations are to be used for a vehicle in different conditions (for example tare, laden, inflated, deflated, etc.), separate models will need to be validated for each condition.

Two validation methods are described here; these are detailed in 8.3.3.3 and 8.3.3.4. Both are regarded as equally valid and when validation is carried out only one of the methods is required to be used. The technique that is given for each method only applies to that method.

8.3.3.2 Validation process, general

The validation process is based on comparisons between physical test results of the vehicle and numerical simulations of the same tests. The primary purpose of validating a numerical vehicle model is to use that model to simulate the vehicle behaviour in-lieu of actual on-track tests. Vehicle approval requires the assessment of the vehicle's static, quasi-static and dynamic behaviour. Therefore, it is helpful if the model includes validation against the static, quasi-static and the dynamic tests.

The range of conditions, see e.g. 8.3.3.3.1, of the dynamic validation then determines what the model is approved to be used for. Therefore, it is recommended that the validation tests and simulation comparisons cover the widest practical range of conditions.

The validation process should also be made across the appropriate dynamic frequency range. All comparisons between simulation and actual on-track test results shall be made using the same vehicle model and software. A model that has been validated shall not be changed for subsequent simulations, except for the conditions given in 8.2.3 and 8.2.4.

It is required that the results of all appropriate work carried out to validate the vehicle model are presented in a validation report.

The following clauses describe the process to be used to ensure that the model is a good representation of the actual vehicle and it is suitable to be used for vehicle approval.

The data that can be required in order to undertake validation of the numerical simulations are given in Table 1.

The processes of model validation according to validation method 1 and validation method 2 are illustrated in the following flowchart (Table 1). Details about the two methods are given in 8.3.3.3 and 8.3.3.4.