



BSI Standards Publication

Railway applications — Testing and Simulation for the acceptance of running characteristics of railway vehicles — Running Behaviour and stationary tests

National foreword

This British Standard is the UK implementation of EN 14363:2016+A2:2022. It supersedes BS EN 14363:2016+A1:2018, which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to CEN text carry the number of the CEN amendment. For example, text altered by CEN amendment A1 is indicated by A1 A1.

The UK participation in its preparation was entrusted to Technical Committee RAE/1/-/8, Railway Applications - Vehicle/Track Interaction.

A list of organizations represented on this committee can be obtained on request to its committee manager.

The UK committee draws users' attention to the distinction between normative and informative elements, as defined in Clause 3 of the CEN/CENELEC Internal Regulations, Part 3.

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Informative: Information intended to assist the understanding or use of the document. Informative annexes do not contain requirements, except as optional requirements, and are not mandatory. For example, a test method may contain requirements, but there is no need to comply with these requirements to claim compliance with the standard.

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INS, RST and ENE speed conversions	
km/h	mph
5	3
10	5
20	10
30	20
80	50
160	100
190	120

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© The British Standards Institution 2023
Published by BSI Standards Limited 2023

ISBN 978 0 539 18944 5

ICS 45.060.01

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 April 2016.

Amendments/corrigenda issued since publication

Date	Text affected
31 January 2019	Implementation of CEN amendment A1:2018
31 March 2023	Implementation of CEN amendment A2:2022

English Version

**Railway applications - Testing and Simulation for the
acceptance of running characteristics of railway vehicles -
Running Behaviour and stationary tests**

Applications ferroviaires - Essais et simulations en vue
de l'homologation des caractéristiques dynamiques des
véhicules ferroviaires - Comportement dynamique et
essais stationnaires

Bahnanwendungen - Versuche und Simulationen für
die Zulassung der fahrtechnischen Eigenschaften von
Eisenbahnfahrzeugen - Fahrverhalten und stationäre
Versuche

This European Standard was approved by CEN on 15 July 2018 and includes Amendment 2 approved by CEN on 18 July 2022.

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Contents

Page

European foreword.....	8
Introduction	10
1 Scope	12
2 Normative references	14
3 Terms and definitions	15
4 Deviations from requirements.....	17
5 Test requirements	18
5.1 Measuring uncertainty.....	18
5.2 Test extent	18
5.2.1 General.....	18
5.2.2 Fault modes	18
5.3 Test vehicle.....	19
5.3.1 Selection and status of the vehicle	19
5.3.2 Loading conditions	19
5.3.3 Distribution of static wheel forces.....	20
5.4 Assessment of test result.....	20
5.5 Documentation of test	21
6 First stages assessment.....	22
6.1 Safety against derailment on twisted track.....	22
6.1.1 General.....	22
6.1.2 Signal processing.....	23
6.1.3 Rail test conditions.....	23
6.1.4 Vehicle test conditions	24
6.1.5 Test methods	26
6.2 Safety against derailment under longitudinal compressive forces in S-shaped curves.....	41
6.3 Evaluation of the torsional coefficient of a vehicle body	41
6.4 Determination of displacement characteristics	41
6.5 Loading of the diverging branch of a switch.....	41
6.6 Running safety in curved crossings for vehicles with small wheels.....	42
7 Second stage – dynamic performance assessment	42
7.1 General.....	42
7.2 Choice of measuring method.....	43
7.2.1 General.....	43
7.2.2 Base conditions for the use of the simplified measuring method and measurement of axle box forces.....	45
7.2.3 Simplifications for separate stability testing.....	45
7.3 Performing on-track tests	46
7.3.1 General.....	46
7.3.2 Test zones and track sections	52
7.3.3 Extent of tests	53
7.3.4 Test operation	54
7.4 Measured quantities and measuring points.....	54
7.5 Assessment quantities and limit values.....	56
7.5.1 General.....	56
7.5.2 Running safety.....	62

7.5.3	Track loading	63
7.5.4	Ride characteristics	63
7.6	Test evaluation	63
7.6.1	Overview	63
7.6.2	Recording the measuring signals.....	64
7.6.3	Statistical evaluation in test zones	65
7.6.4	Evaluation of test results in transition curves	73
7.6.5	Verification of stability	73
7.7	Documentation	73
7.7.1	General	73
7.7.2	Description of the vehicle design and status of the tested vehicle	73
7.7.3	Additional information for future extension of acceptance.....	74
7.7.4	Description of the test routes.....	74
7.7.5	Description of data capture	74
7.7.6	Description of evaluation	74
7.7.7	Test results (including additional information for model validation)	74
7.7.8	Deficiencies in reaching the target test conditions	76
7.7.9	Infrastructure conditions more severe than the target test conditions.....	76
	Annex A (informative) Information on safety against derailment	77
A.1	Factors influencing the safety against derailment of vehicles running on twisted track.....	77
A.1.1	General	77
A.1.2	Wheel unloading influences	77
A.1.3	Guiding force influences.....	77
A.2	Evaluation and limit value for safety against derailment.....	78
A.3	Friction conditions during testing on special track	79
A.4	Special conditions for vehicles with air springs.....	81
A.4.1	General	81
A.4.2	4-point levelling systems	82
A.4.3	3-point levelling system with longitudinal connection	82
A.4.4	2-point levelling systems	82
A.5	Test twist conditions for articulated vehicles.....	83
A.6	Test twist conditions for vehicles with more than two suspension levels.....	90
A.7	Calculation of the shim sizes (test method 1).....	91
A.8	Performing and evaluating a twist test for a two-axle vehicle (test method 2)	92
A.8.1	General	92
A.8.2	Required test rig	92
A.8.3	Performing the twist test	93
A.8.4	Evaluation of twist diagrams	93
A.9	Performing and evaluation of a twist test for a vehicle with two bogies with two axles (test method 2)	95
A.9.1	General	95

A.9.2	Required test rig.....	95
A.9.3	Performing and evaluating a combined body and bogie twist test (test method 2.1)	95
A.9.4	Performing separate twist tests on bogie centre distance and bogie wheel base (test method 2.2)	99
Annex B (informative)	Computer simulations designed to examine whether the vehicle has an acceptable resistance to flange climbing derailment at low speed	104
B.1	General requirement	104
B.2	Computer output	104
B.3	Track input	104
B.4	Body-bogie yaw torque	105
B.5	Performance requirement.....	105
Annex C (informative)	Tests for determination of the torsional coefficient of a vehicle body...	107
C.1	Force-deflection measurement directly at the vehicle body.....	107
Figure C.1	— Nomenclature of the supporting points.....	107
C.2	Force-deflection measurement at the contact points between wheel and rail after blocking of the suspension(s) between wheelset (bogie frame) and vehicle body	108
Annex D (informative)	Determination of displacement characteristics for application with EN 15273	109
D.1	Introduction	109
D.2	Determination of displacement characteristics	109
D.2.1	General.....	109
D.2.2	Assessment Requirements.....	109
D.2.3	Test conditions.....	109
D.2.4	Method 1: Stationary test	110
D.2.5	Method 2 – On-track test.....	113
Annex E (informative)	Assessment of the behaviour of vehicles with small wheels in curved crossings.....	115
E.1	Purpose.....	115
E.2	Area of application.....	115
E.3	Description of the crossing geometry.....	115
E.4	Test conditions.....	118
E.4.1	General.....	118
E.4.2	Method 1: Lateral forces and angle of attack	119
E.4.3	Method 2: Examination of the impact on the crossing nose	119
E.4.4	Limit values.....	119
E.4.5	Assessment.....	120
E.4.6	Dispensation	120
E.4.7	Simulation.....	120

Annex F (informative) Test specification for assessment of vehicle behaviour in switches and crossings.....	121
F.1 Introduction.....	121
F.2 Definitions.....	121
F.3 Test conditions	121
F.4 Assessment of the test results.....	122
F.5 Documentation	122
Annex G (normative) Coordinate system for measured quantities.....	126
Annex H (informative) Operational parameters.....	127
Annex I (informative) Position of the different wheelsets during test.....	129
Annex J (informative) Additional track loading assessment quantities.....	130
J.1 General	130
J.2 Maximum lateral force.....	130
J.3 Combination of lateral and vertical forces	130
Annex K (informative) Evaluation and background of the rail surface damage quantity.....	132
Annex L (informative) Typical maximum estimated values of ride characteristics	134
Annex M (normative) Track geometric quality – Selection of test tracks	135
M.1 Basis of evaluation	135
M.2 Assessment quantities for track geometric quality	135
M.3 Different measuring systems	136
M.4 Target test conditions.....	137
M.5 Reporting.....	139
Annex N (informative) Background of track quality description.....	140
Annex O (normative) Rail profile measurement.....	141
O.1 General	141
O.2 Manual measurements	141
O.2.1 Measurements for equivalent conicity	141
O.2.2 Measurements for radial steering index.....	141
O.3 Automatic measurements	141
Annex P (normative) Requirements for evaluation of equivalent conicity.....	142
Annex Q (informative) Radial steering index.....	143
Q.1 Introduction.....	143
Q.2 Calculation of radial steering index.....	144
Annex R (normative) Statistical evaluation	147
R.1 Objectives and principles of statistical analysis.....	147
R.1.1 General	147
R.1.2 One-dimensional method	147

R.1.3	Two-dimensional method or simple regression.....	147
R.1.4	Multiple regression	147
R.2	Determination of the percentiles for each track section.....	148
R.3	Preparation of the random samples.....	149
R.4	One-dimensional analysis for estimated maximum values.....	149
R.5	Two-dimensional analysis for estimated values	149
R.6	Multiple regression analysis for estimated values	150
R.7	Statistical evaluation for the overturning criterion	152
R.8	Regression assumptions.....	153
R.8.1	Regression assumptions and associated problems.....	153
R.8.2	Identification and correction techniques.....	154
Annex S (informative) Running behaviour of special vehicles.....		156
S.1	General.....	156
S.2	Vehicle design and classification.....	156
S.3	Use of the simplified measuring method.....	157
S.4	Test conditions.....	157
S.5	Specific limit value.....	157
Annex T (informative) Simulation of on-track tests.....		158
T.1	Introduction	158
T.2	Fields of application.....	158
T.2.1	General.....	158
T.2.2	Extension of the range of test conditions	158
T.2.3	Assessment of vehicles following modification	159
T.2.4	Assessment of new vehicles by comparison with an already approved reference vehicle	159
T.2.5	Investigation of dynamic behaviour in case of fault modes.....	160
T.3	Validation.....	160
T.3.1	General principles.....	160
T.3.2	Vehicle model	161
T.3.3	Validation of the vehicle model.....	161
T.4	Input.....	175
T.4.1	Introduction	175
T.4.2	Vehicle model	175
T.4.3	Vehicle configuration.....	175
T.4.4	Track data	176
T.4.5	Track model parameters.....	177
T.4.6	Wheel/rail contact geometry.....	177

T.4.7	Rail surface condition	177
T.4.8	Direction of travel	178
T.4.9	Speed	178
T.4.10	Position of the vehicle in the trainset.....	178
T.4.11	Frequency content of simulations	178
T.5	Output.....	179
T.6	Documentation	179
T.7	Examples for model validation according to Method 1	180
Annex U (informative)	Extension of acceptance.....	187
U.1	General	187
U.2	Determination of the safety factor	195
U.3	Dispensation.....	195
U.3.1	General	195
U.3.2	Special cases	195
U.4	Use of the simplified method 	196
U.5	Requirements depending on the initial approval.....	196
Annex V (normative)	Symbols.....	198
Annex W (informative)	List with the main technical changes compared to EN 14363:2005, EN 15686:2010 and EN 15687:2010.....	202
Annex ZA (informative)	Relationship between this European Standard and the Essential Requirements of EU Directive (EU) 2016/797 aimed to be covered	205
Bibliography		207

European foreword

This document (EN 14363:2016+A1:2018+A2:2022) 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 February 2023, and conflicting national standards shall be withdrawn at the latest by February 2023.

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 2018-07-15.

This document includes Amendment 2 approved by CEN on 2022-07-18.

A2 This document supersedes EN 14363:2016+A1:2018.

In comparison with the previous edition, the following technical modifications have been made:

- Introducing ERA/OPI/2018-3, clauses 4.1.5, 4.1.6 and 4.1.7 in 7.3.1, Table 2;
- Deleting informative Annex X;
- Update of informative Annex ZA **A2**

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

The start and finish of text introduced or altered by amendment is indicated in the text by tags **A2** **A2**.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), 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 acceptance of a vehicle or vehicle design according to this standard.

Prior to the first issue of this standard, national procedures were applied for vehicle acceptance, for example in Germany or UK. The underlying principles that were applied in these earlier standards are also incorporated in this standard. The fundamentals have not been changed but the formulation of the requirements has been made consistent. Therefore it is considered that also vehicles that were previously approved utilizing these earlier requirements have an equal status compared to vehicles that are approved according to this standard. This applies to the infrastructure and operating conditions that were considered in the earlier approval. This includes also a use as reference vehicle for extension of acceptance.

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, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

Acceptable running characteristics of a railway vehicle (hereafter called vehicle) are essential for a safe and economic operation of a railway system. They are related to:

- the vehicle,
- the operating conditions,
- the characteristics of the infrastructure (track layout design and track quality) and
- the contact conditions of the wheel/rail interface.

The objective is to quantify the vehicle's performance under known representative conditions of operation and infrastructure.

This standard describes methods to assess the vehicle performance in the following areas:

- safety against derailment on twisted track (see 6.1);
- running safety under longitudinal compressive forces in s-shaped curves (see 6.2);
- evaluation of the torsional coefficient (see 6.3);
- determination of displacement characteristics (see 6.4);
- loading of the diverging branch of a switch (see 6.5);
- running safety in curved crossings (see 6.6);
- running safety, track loading and ride characteristics (see Clause 7).

The vehicle performance is assessed in two stages. Usually in the first stage the basic characteristics and low speed behaviour are investigated before first runs on the line under controlled operating conditions. In the second stage the running behaviour is assessed. The assessment of a vehicle according to the elements listed above can be performed either by physical testing, numerical simulation, calculation or comparison with a known solution (dispensation). Details about the requirements relating to the choice of the appropriate assessment method are given in this document.

The operational envelope (speed and cant deficiency) that the vehicle has been assessed for needs to be documented.

The establishment of this document was based on existing rules, practices and procedures. The following principles were applied:

- the railway system requires comprehensive technical rules in order to ensure an acceptable interaction of vehicle and track;
- the performance of new railway vehicles has to be evaluated and assessed before putting them into service;
- it is of particular importance that the existing level of safety and reliability is not compromised even when changes in design or operating conditions are demanded, e.g. by the introduction of higher speeds, higher vertical wheel forces, modification of the suspension, etc.
- it is possible to demonstrate compliance with the requirements of this standard by comparison of relevant parameters or by simulation if changes are made to the design or to the operating conditions;
- as the combination of all the target test conditions described is not always achievable, the compliance against the missing target test conditions can be demonstrated by other means.

Requirements on running safety under longitudinal compressive forces in S-shaped curves of certain vehicles are given in EN 15839, while EN 16235 specifies a method to get dispensation from on-track testing for A_1 vehicles equipped with established or standardised running gear A_1 , if certain conditions are fulfilled.

The informative Annexes A, B, C, D, E, F; Q, S, T and U contain requirements that have to be fulfilled when the annex is applied.

1 Scope

This European Standard defines the process for assessment of the running characteristics of railway vehicles for the European network of standard gauge tracks (nominally 1 435 mm).

In addition to the assessment of the running characteristics of vehicles for acceptance processes, this standard also defines quantities and dependencies that are not directly used for acceptance purposes. This information is for example intended for the validation of simulation models. It can also be used to define operating conditions outside the reference conditions to be used for the approval.

The assessment of running characteristics applies to vehicles which:

- are newly developed;
- have had relevant design modifications; or
- have changes in their operating conditions.

The assessment process is based on specified target test conditions (see 3.1) given in this document.

Experience over many years has demonstrated that vehicles complying with this standard can be operated safely on infrastructure with conditions more severe than the target test conditions, if the current general operating rules are applied. As an example it is generally current practice to restrict cant deficiency in curves below a certain radius. It may be necessary to adapt these operating rules, if a deterioration of the infrastructure conditions is observed. These operating rules are defined on a national basis. The procedure to evaluate these operating rules is out of the scope of this standard.

NOTE 1 There are margins included in the specified limit values and the statistical evaluation. They cannot be quantified, but they explain why vehicles can also be operated at full speed and cant deficiency in many cases outside of the target test conditions.

This standard also enables the demonstration of compliance against the target test conditions for the case that their combination is not achievable during tests. It is also possible to carry out the assessment of a vehicle for limited test conditions such as test zones 1 and 2 or reduced speed or reduced cant deficiency. In this case the approval of the vehicle shall be restricted accordingly.

NOTE 2 National regulations sometimes allow the increase or decrease of the values for speed, curve radius and cant deficiency for local operation based on safety considerations taking into account the local characteristics of the infrastructure (track layout, track structure, track geometrical quality and contact conditions). These local characteristics can be different from those included in the assessment for the vehicle acceptance.

NOTE 3 The methods of this standard can also be applied to gather information about the compatibility between the vehicle and infrastructure with conditions more severe than the target test conditions. The results of such investigations can be used to determine safe operating rules for such infrastructure conditions.

Where testing the vehicle demonstrates that the performance of a vehicle complies with the requirements of this standard when operating at maximum speed and maximum cant deficiency under infrastructure conditions that are more severe than the target test conditions, the obtained results are accepted and there is no need to carry out additional tests to fulfil the requirements defined in this standard.

This standard addresses four aspects:

1) Vehicles

The assessment of the running characteristics applies principally to all railway vehicles. The document contains acceptance criteria for all types of vehicles with nominal static vertical wheelset forces up to 225 kN (of the highest loaded wheelset of the vehicle in the assessed load configuration specified in 5.3.2). In addition for freight vehicles with nominal static vertical wheelset forces up to 250 kN the acceptance criteria are defined. The acceptance criteria given in this document apply to vehicles designed to operate on standard gauge tracks.

2) Infrastructure

In the acceptance process the range of curve radii is defined, for which the vehicle is assessed. A vehicle accepted according to the requirements of this standard is able to be operated on all standard gauge tracks complying with EN 13803-1 and EN 13803-2.

EN 14363 also gives guidance about the handling of geometric track quality associated with the assessment.

3) Conditions of the wheel rail interface

This standard contains requirements relating to the necessary range of equivalent conicity to be included in the assessment as target test conditions.

In some national systems, either parts or all, equivalent conicities are significantly higher than the target test conditions of this standard. These cases are outside the scope of this standard. Nevertheless the methodology defined in this standard for the proof of running stability can also be used for higher equivalent conicities.

NOTE 4 In these cases running safety is demonstrated by application of existing national requirements for high equivalent conicities during stability testing. Experience shows, that it is not necessary to include the maximum occurring values of equivalent conicity in such national requirements.

4) Operating conditions

The document requires the specification of the combination of admissible speed and admissible cant deficiency as well as the loading conditions for each type of vehicle.

NOTE 5 Recommended values of cant deficiencies for broad international approval are given in informative Annex H.

This standard is not directly applicable to:

- railways with different track layout, e.g. tramways, metros and underground railways;
- railways with non-standard gauge tracks;

but assessment can be conducted by analogy with this document, e.g. the test procedures described in this standard can be applied also to vehicles operated in networks with other track gauges (e.g. 1 524 mm and 1 668 mm). The related limit values and test conditions could be different. They are specified nationally taking into account track design and operating conditions.

The strength of the vehicle and mounted parts, passengers and train crew vibration exposure, comfort, load security and effects of cross wind are out of the scope of this standard.

This document includes the assessment of track loading quantities, the quantification of track deterioration or track fatigue is out of the scope of this standard.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 13803-1, *Railway applications — Track — Track alignment design parameters — Track gauges 1435 mm and wider — Part 1: Plain line*

EN 13803-2, *Railway applications — Track alignment design parameters — Track gauges 1 435 mm and wider — Part 2: Switches and crossings and comparable alignment design situations with abrupt changes of curvature*

EN 13848-1, *Railway applications — Track — Track geometry quality — Part 1: Characterisation of track geometry*

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

EN 13848-5:2008+A1:2010, *Railway applications — Track — Track geometry quality — Part 5: Geometric quality levels — Plain line*

EN 14033-1, *Railway applications — Track — Railbound construction and maintenance machines — Part 1: Technical requirements for running*

EN 15273-1, *Railway applications — Gauges — Part 1: General — Common rules for infrastructure and rolling stock*

EN 15273-2, *Railway applications — Gauges — Part 2: Rolling stock gauge*

EN 15302:2008+A1:2010, *Railway applications — Method for determining the equivalent conicity*

EN 15663:2009, *Railway applications — Definition of vehicle reference masses*

EN 15746-1, *Railway applications — Track — Road-rail machines and associated equipment — Part 1: Technical requirements for running and working*

EN 15839, *Railway applications — Testing for the acceptance of running characteristics of railway vehicles — Freight wagons — Testing of running safety under longitudinal compressive forces*

EN 15954-1, *Railway applications — Track — Trailers and associated equipment — Part 1: Technical requirements for running and working*

EN 15955-1, *Railway applications — Track — Demountable machines and associated equipment — Part 1: Technical requirements for running and working*

EN 16235, *Railway application — Testing for the acceptance of running characteristics of railway vehicles — Freight wagons — Conditions for dispensation of freight wagons with defined characteristics from on-track tests according to EN 14363*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1

target test conditions

conditions specified in this standard for the performance of on-track tests

3.2

bogie yaw resistance

torque around the vertical axis between bogie and vehicle body required to rotate a bogie while supporting a vehicle body

3.3

unsprung mass

mass of a wheelset including all components that are attached to it and which are not suspended by the primary suspension or the wheelset guidance, e.g. brake discs, gear wheels, bearings, axle boxes plus half of the primary suspension mass, half the mass of suspension links and if applicable the unsuspended part of the traction equipment

Note 1 to entry: Sometimes it will be necessary to regard different wheelsets of a running gear separately.

Note 2 to entry: Sometimes it will be necessary to include or exclude parts which are separately suspended with regard to the problem in question, e.g. magnetic brakes.

3.4

primary suspended mass

mass between primary and secondary suspension of a running gear with two vertical suspension stages, i. e. the bogie frame together with all components attached to it, e.g. braking equipment, antennas, pipes and cables plus half of the primary and secondary suspension mass, half the mass of suspension links and traction rods and if applicable the primary suspended part of the traction equipment

Note 1 to entry: Sometimes it will be necessary to include or exclude parts which are separately suspended with regard to the problem in question, e.g. magnetic brakes.

3.5

secondary suspended mass

mass supported by the secondary suspension of a running gear, i. e. the mass of the relevant part of a vehicle body with all components attached to it, e.g. upper bolster or adapter beam plus half of the secondary suspension mass, half the mass of suspension links and traction rods and if applicable the secondary suspended part of the traction equipment

3.6

bogie mass

mass of the bogie which rotates against the vehicle body around the vertical axis during the entrance into curves

Note 1 to entry: In most cases this mass is similar to the sum of the unsprung masses and the primary suspended mass of a running gear with two or more wheelsets.

3.7

yaw moment of inertia of whole running gear

moment of inertia of the mass of the running gear which rotates against the vehicle body around the vertical axis during the entrance into curves

3.8

displacement characteristics

combination of lateral and roll displacements of a vehicle when subjected to cant excess or deficiency

3.9

running behaviour

behaviour of a vehicle or running gear with regard to the interaction between vehicle and track covering the specific terms running safety, track loading and ride characteristics

3.10

running characteristics

characteristics of a vehicle or running gear with regard to running behaviour, safety against derailment in twisted track and under longitudinal compressive forces in S-shaped curves, torsional coefficient of a vehicle body, displacement characteristics, loading of the diverging branch of a switch and running safety in curved crossings

3.11

equivalent conicity

$\tan \gamma_e$

$\overline{A_1}$ tangent of the cone angle of a wheelset with coned wheels whose lateral movement has the same kinematic wavelength as the given wheelset $\overline{A_1}$

Note 1 to entry: See also EN 15302.

3.12

radial steering index

q_E

$\overline{A_1}$ ratio between curve radius R_E negotiable without longitudinal creepage and the actual curve radius R of the track section and it describes the radial steering capability of a free wheelset in a track section $\overline{A_1}$

3.13

operation envelope

$\overline{A_1}$ the combinations of speed and cant deficiency for which the vehicle is intended to be operated $\overline{A_1}$

Note 1 to entry: See informative Annex H.

3.14

conventional technology vehicle

vehicles which are operated under normal operating conditions and correspond completely or in those construction parts which are relevant to the running behaviour to the proven state of the art

3.15**special vehicle**

vehicle which is designed for maintenance, inspection or renewal of infrastructure elements or for special transport purposes which fleets are operated with a low global mileage (for the whole fleet) compared to normal railway vehicles including, but not necessarily restricted to the following list:

- maintenance vehicles:
 - on-track machines (see EN 14033);
 - cranes and matching wagons;
 - road rail machines (see EN 15746-1);
 - demountable machines (see EN 15955-1);
 - trailers (see EN 15954-1);
- monitoring and inspection vehicles, including:
 - track inspection vehicles;
 - catenary inspection vehicles;
- special transport vehicles, including:
 - transformer transporter;
 - crucible transporters.

Note 1 to entry: Trolleys as described in EN 13977 have no requirements in EN 14363 according to their hand-operation. Additional information is given in 7.1 and in informative Annex S.

3.16**reference vehicle**

vehicle that has the same fundamental design concept as the vehicle to be assessed and that has been tested and approved according to this standard or to an equivalent standard

3.17**engineering change**

change to the design of the vehicle that potentially varies the performance of the vehicle, when evaluated according to this standard

4 Deviations from requirements

If deviating from some points of the requirements of this standard for a particular assessment, these deviations shall be reported and explained. Then the influence on the assessment of the vehicle in terms of the acceptance criteria shall be evaluated and recorded. The outcome of this study shall be considered as an integral part of the requirements of this standard when applied to the assessment process of the vehicle, as long as evidence can be furnished that safety is at least the equivalent to that ensured by complying with these rules.

5 Test requirements

5.1 Measuring uncertainty

The different methods applied today for assessment of measuring uncertainty, are at least as strict as the requirements used when the limit values for the vehicle assessment were established. The limit values already include a margin for measuring uncertainty and no additional adjustment of the result or the limit value shall be made.

NOTE The measuring methods (equipment and processing) used today generally have the capability of achieving a measuring uncertainty at least as good as those in use, when the limit values for the vehicle assessment were established.

The appropriate equilibrium conditions of measured wheel/rail forces (quasi-static sum of Y and sum of Q forces) and inertia forces (uncompensated acceleration multiplied with mass) shall be checked. Maximum deviations from regression against cant deficiency and speed shall be reported. Sections with large deviations from the expected results shall be excluded from the evaluation if they cannot be explained by physical effects.

5.2 Test extent

5.2.1 General

For a vehicle designed to be operated under conditions assumed by the track layout given in EN 13803-1 and EN 13803-2 the test extent is given in the Clause 6 and Clause 7 of this standard and if necessary complemented by 5.2.2.

5.2.2 Fault modes

For the purposes of this standard, it is assumed, that potentially catastrophic failures of conventional mechanical parts are managed by the design and maintenance regime of the vehicle.

If an analysis of the requirements from the maintenance regime and operation condition show that the vehicle needs to be operated in a failure condition, assessment of running safety shall be performed according to this standard.

Running safety shall be demonstrated by tests, simulation or a combination of both. The extent of the test procedure and/or the simulation cases shall be defined by reference to the analysis. The aim of this testing is to assess the behaviour when operating in the investigated failure condition and testing can be restricted to the relevant test zones.

NOTE 1 Possible fault modes to be considered include but are not limited to failures of active suspension systems, tilt systems, air suspension, yaw dampers.

It is assumed that a failure will be repaired before a second one occurs and it is therefore not necessary to look at combinations so that, unless the analysis indicates a need for it (e.g. physical coupling), no superposition of different fault modes needs to be considered.

For the fault modes it is sufficient to assess only the criteria of running safety and only up to maximum speed (V_{adm}) and maximum cant deficiency (I_{adm}). The test speed range and test cant deficiency range as in Table 2 shall be adapted to appropriate ranges.

If running safety cannot be demonstrated for a relevant fault mode, limiting criteria for a safe operation shall be determined and possible measures for supervision and/or mitigation shall be defined to reduce the criticality of the fault mode.

NOTE 2 Safety requirements for supervision systems and compensating measures and requirements for reliability and availability of such systems are not handled in this document.

5.3 Test vehicle

5.3.1 Selection and status of the vehicle

The test vehicle shall be selected from a design type:

- according to the principle of random selection from identical stock; or
- by taking account of specific vehicle or running gear characteristics.

It shall be representative of the series production of a vehicle type. The results of testing of running behaviour refer to the actual status of the test vehicle during the test. The status of the test vehicle shall be determined and shall correspond to the desired status of the design series to be tested with respect to:

- the vehicle parameters relevant to running characteristics (Table U.1 gives guidance to select relevant characteristics); as well as
- the construction and maintenance status.

A1 In this context, evidence (for example technical specifications, letter declaring conformity and/or test reports) shall be provided to show whether the values of the most important vehicle parameters for running behaviour are within the construction and maintenance tolerances. **A1**

Vehicles are generally tested in their new condition according to this standard. The specified tests and the associated limit values include a margin for the normal variation of vehicle parameters. It is not required to test all conceivable conditions.

5.3.2 Loading conditions

For testing the vehicle in empty and/or loaded condition the following definitions apply:

- empty: Between dead mass and operational mass in working order as defined in EN 15663 except that it is not necessary to test with worn parts subject to wear (e.g. discs, brake pads, wheels, etc.);
- loaded: design mass under normal payload as defined in EN 15663.

Apart from this rule the loaded condition of passenger vehicles of long distance and high speed trains to be operated without obligatory seat reservation shall include 160 kg/m² (2 persons/m²) in standing areas instead of 0 kg/m².

A1 NOTE 1 If necessary, for vehicles of long distance and high speed trains the loading conditions with and / or without seat reservation are considered in certain test conditions. **A1**

NOTE 2 For some vehicles it might be sufficient to test in a single appropriate intermediate load case and follow for the evaluation the method of extension of approval according to informative Annex U, e.g. for a special vehicle a variation from -15 % to +10 % (according to informative Annex S) of the tested nominal static vertical wheelset force is allowed.

It is acceptable that during the tests consumables are reduced (e.g. due to fuel consumption) in a range that is normal for the operation of the vehicle. For locomotives, only test results with a load above the operational mass in working order according to EN 15663 are acceptable.

For some vehicles, collection, transport and distribution of various items (ballast, track components, weed killer liquid...) may result in a large variable mass. For such vehicles the following rules shall be applied:

- fuel used for a vehicle's own propulsion and other items quoted in Table 2 of EN 15663:2009 shall be taken into account as "consumables"; for Clause 4 of EN 15663:2009, the vehicle is not considered as a freight vehicle, meaning that the design mass of consumables is considered greater than the operational mass of consumables;

- all items used in the working process, which can be collected and/or distributed or spread along the railway track, shall be considered as “payloads”.
- if a certain $\langle A_1 \rangle$ loading condition $\langle A_1 \rangle$ is only applicable in working mode or travelling mode as described in EN 14033-2 (max. speed ≤ 60 km/h), then this $\langle A_1 \rangle$ loading condition $\langle A_1 \rangle$ does not need to be considered for on-track testing according to this standard.

5.3.3 Distribution of static wheel forces

The distribution of the (vertical) wheel and wheelset forces is a fundamental parameter to describe the vehicle status during the test programme. To determine the wheel forces in the load cases used for testing as described in 5.3.2, they shall be measured directly in at least one load case. Other load cases may be calculated taking into account the masses of consumables and payload.

It is recommended to measure the vertical wheel forces of the test vehicle in all load cases used for testing.

The vehicle mass and the wheelset forces shall be reported together with the determined vertical wheel forces and ratios of vertical force difference according to the following formulae:

Vehicle mass:

$$m_{\text{veh}} = \frac{\sum_{j=1}^n (Q_{j1} + Q_{j2})}{g}$$

Vertical wheelset force:

$$P_{F0,j} = Q_{j1} + Q_{j2}$$

Maximum vertical wheelset force of the vehicle:

$$P_{F0,\max} = \max(Q_{j1} + Q_{j2}) \text{ for } j = 1, n$$

where

n is the number of wheelsets in the vehicle.

Ratio of vertical wheel force difference per wheelset related to the vertical wheelset force of the wheelset:

$$\Delta q_j = \frac{|Q_{j1} - Q_{j2}|}{P_{F0,j}}$$

NOTE It is intended to specify the measuring procedure for static vertical wheel and wheelset forces in the new standard prEN 15654-2 (Railway applications — Measurement of vertical forces on wheels and wheelsets — Part 2: Test in workshop for new, modified and maintained vehicles), that will be published later than this standard.

5.4 Assessment of test result

For vehicle assessment the target test conditions should be achieved. If not all of the target test conditions are achieved, the test results shall be interpreted or adjusted using one or more methods described in this standard (e.g. multiple regression in normative Annex R or simulation in informative Annex T). All deviations from the target test conditions shall be documented.

NOTE If an attempt is made to close gaps (between the target and the achieved test conditions) that are too big, this may lead to unreliable results and make it difficult to maintain the required confidence in the vehicle being able to respect the limit values.

5.5 Documentation of test

The test shall be documented with sufficient detail that the execution of the test is comprehensible and that special occurrences can be identified. This includes all necessary information to assess the test results, as a minimum:

- name of the test organization and test leader;
- date and time of the test;
-  description of weather conditions during test runs ;
- description of the vehicle design with its relevant parameters;
- status of the tested vehicle;
- description of the test facilities or test routes;
- description of measuring equipment;
- description of evaluation method;
- results from plausibility checks from instrumented wheelsets;
- special circumstances associated with the performance of the test;
- test results.

6 First stages assessment

6.1 Safety against derailment on twisted track

6.1.1 General

The assessment methods described in this clause are intended to ensure that vehicles can run safely on twisted tracks. The existence of twist in railway tracks is fundamental. This is a result of transition layout between levelled track and canted track as well as cross level deviations (maintenance limits). When running through twisted tracks there is an increased risk of derailment because of the risk of initiating flange climbing as a result of reduced vertical wheel force and high lateral forces. The vertical wheel forces are influenced by the following effects:

- twist on bogie wheel base;
- twist on bogie centre distance or axle distance for non-bogie vehicles;
- torsional hysteresis;
- eccentricity of centre of gravity;
- twist of the bogie and vehicle body as a result of tolerances or vehicle design;
- eccentricity of the centre of gravity due to cant excess – this influence is eliminated in the test;
- roll torque of the lateral axle box forces.

NOTE 1 It is assumed that the reduction in the guiding forces in larger curve radii has a stronger influence on the safety against derailment than the higher unloading of the guiding wheel due to the higher allowed cant excess in these radii.

The assessment methods for proving safety against derailment create an artificial and extreme situation for the vehicles.

This sub clause specifies three testing methods to investigate the derailment performance of vehicles while negotiating twisted track. All three methods are derived from work by ORE (later ERRI) and subsequently reported in documents prepared by the B55 groups of ORE. The objective of the test methods is common but the methods that are described below are independent and shall not be directly compared. In addition the values and conditions referred to in each method shall only apply to that method; it is not possible to directly compare test conditions and numerical results between the test methods.

The test conditions specified in the three methods detailed below for the assessment of safety against derailment on twisted track do not represent the worst conditions which could occur. Nevertheless, experience over many years has demonstrated that vehicles that comply with the assessment criteria specified in this sub clause operate safely on European Railways. This assessment shall be carried out for initial acceptance of all vehicles using one of the methods described below.

Method 1 represents a vehicle negotiating track with a 150 m radius curve with defined twist in the track. The assessment criterion is the wheel lift Δz .

Method 2 determines the guiding forces between wheel and rail as a vehicle negotiates a 150 m radius curve without twist. It measures separately the change in vertical wheel force when the vehicle is subjected to twisted track. The assessment criterion is the ratio of guiding force and vertical wheel force on the outer wheel $(Y/Q)_a$. This method includes the possibility of approval by calculation based on previous test results of a reference vehicle.

NOTE 2 ORE B55, Rp.8 [6] gives a lot of models and parameters for freight- and special vehicles that can be used to describe a reference vehicle.

Method 3 determines the bogie yaw resistance (X -factor) when negotiating the minimum radius curve specified for the vehicle. ^[A1] It measures separately the relative wheel unloading $\Delta Q/Q$ when the vehicle is subjected to twisted track. The assessment criterion is the X -factor together with the relative wheel unloading $\Delta Q/Q$ ^[A1]. Where it is not possible to demonstrate the simultaneous acceptable performance of both criteria using Method 3 (phase 1), validated computer simulations according to informative Annex B may be used.

The three test methods result in safe operation of the vehicles when the track twist including design twist and cross level is maintained in accordance with the rules given in EN 13848-5:2008+A1:2010, 8.6.

NOTE 3 The requirements for assessment of safety against derailment on twisted track of special vehicles operated in degraded working track are given in EN 14033-2.

For the extension of acceptance the assessment by calculation or testing is only necessary if the modification of the parameters might increase the risk of derailment.

NOTE 4 The most important factors influencing the safety against derailment are given in A.1.

A dispensation from tests and calculations of the safety against derailment is allowed for freight wagons, if the parameters and running gear types match with those that have shown results compliant with the limit value in published tests or calculations and the nominal wheel flange angle is 70° .

NOTE 5 Parameters and running gear types that meet the required criteria are included in the tabulated results given in Appendix A, Appendix B and Appendix C of UIC 530-2:2008 [12] available on the UIC-website. ^[A1] *deleted text* ^[A1]

6.1.2 Signal processing

The assessed signal for wheel lift Δz shall be low-pass filtered with a cut-off frequency between 5 Hz and 1 Hz depending on the speed in order to eliminate the detection of very short duration of wheel climbing occurrences.

If the Y and Q -forces are measured continuously with instrumented wheelsets, the signals shall be filtered as described in Table 5 for on-track testing.

6.1.3 Rail test conditions

Tests according to Methods 1 and 2 shall be done under nominally dry conditions in order to consider high friction forces between wheel and rail.

Information used in the determination of the rail conditions shall be gathered by measuring:

- Y_i and Q_i on the inner leading wheel;
- angle of attack α ; and
- average vertical wheel force ^[A1] Q_{F0} ^[A1] of the leading wheelset;

and evaluated as described below.

During tests, the coefficient τ shall be at least 80 % of the value expected for dry rails. Therefore, the condition:

$$(Y/Q)_i \geq 0,8 \cdot \tau_{\text{dry}} + \gamma$$

as a function of the angle of attack shall be respected. In the above formula the contact angle of the tread γ at the contact point on the inner rail shall be inserted.

The coefficient τ_{dry} represents the ratio of the lateral friction force and the vertical force. For pure lateral creepage the coefficient τ_{dry} for dry rail conditions is defined as follows (see A.3):

$$\left(\frac{1}{\tau_{\text{dry}}}\right)^n = \left(\frac{1}{a}\right)^n + \left(\frac{1}{b \cdot \alpha}\right)^n$$

where

$\langle A_1 \rangle$

$$a = \frac{Q_{F0}^2 - 242,5 Q_{F0} + 57\,150}{100\,000}$$

$$b = \frac{Q_{F0}^2 - 242,5 Q_{F0} + 21\,950}{100}$$

$$n = 0,005 Q_{F0} + 2,2$$

$\langle A_1 \rangle$

angle of attack α in rad and static vertical wheel force $\langle A_1 \rangle Q_{F0} \langle A_1 \rangle$ in kN.

If the actual mean vertical wheel force on the inner rail during the test differs from $\langle A_1 \rangle Q_{F0} \langle A_1 \rangle$ it is permitted to use this value in the above formulae.

The maximum values of τ_{dry} are obtained for the maximum values of α .

NOTE These formulae were determined with a wheel diameter of 1 m and static vertical wheel forces between 40 kN and 112,5 kN. For the application in this standard, they are deemed to be valid also outside these conditions.

If the angle of attack is replaced with the total creepage (lateral and longitudinal creepage), this formula describes the friction /creepage diagram for dry track.

If during the tests a coefficient higher than 100 % of τ_{dry} occurred, the tests may be repeated.

To determine friction during tests, the measurement of the angle of attack is necessary.

The method is not appropriate if the angle of attack is very small (e.g. below 0,0015 rad). In the case of bogies with a low angle of attack determination of the friction conditions is to be done by measuring on a leading wheelset of a vehicle which generates a higher angle of attack.

6.1.4 Vehicle test conditions

6.1.4.1 General

For methods 1 and 2 the effects of the running direction and the direction of curvature shall be analysed taking the vehicle design and the distribution of vertical wheelset forces in the vehicle into consideration. The test conditions and the wheelsets to be tested shall be determined for the worst case as a result of this analysis.

EXAMPLE For single vehicles with two wheelsets or bogies, the two outer wheelsets should be analysed in the leading position, unless the vehicle is symmetrical; then testing of one wheelset could be sufficient.

For all methods all the relevant connections between body and bogie of the vehicle which influence the assessment quantities shall be correctly attached. If it is necessary to remove dampers for a correct shimming in method 1, the effect on the vertical wheel forces shall be studied taking into account the low test speed. The result of this study shall be respected in the final assessment of the test results.

Single vehicles which are a part of a trainset may be tested separately. It shall be demonstrated that the test condition represents the forces and moments that exist when the vehicle is installed in the train set.

As long as the coupling forces and moments are lower or equal to the forces and moments between vehicles equipped with standard buffers and draw gear at their ends, vehicles may be tested separately.

6.1.4.2 Loading conditions

Vehicles shall be tested in the empty condition (see 5.3.2).

If the suspension is nonlinear, safety against derailment shall be tested in the worst combination of load and stiffness (e.g. this will occur for a two-rate spring at the smallest loading point above the application point of the second stiffness where, at full vehicle test twist, the relieved second stiffness just remains in contact/operation).

6.1.4.3 Conditions for vehicles with air springs

Safety against derailment shall be tested with inflated and deflated air springs.

For deflated cases, the most critical situation shall be tested (usually all bogies deflated).

With inflated air spring the vertical wheel force distribution may be changed by the response time of the levelling system. The type of the levelling system has an important influence (e.g. 4-point levelling, 3-point levelling and 2-point levelling), informative Annex A gives some additional information.

The effect of the levelling system's response time shall be investigated. During the test the effects of the levelling system shall be measured by including breaks in the test procedure to enable the system to stabilize.

6.1.4.4 Conditions for bogie vehicles with more than two axles per bogie

For methods 1 and 2 vehicle test twist for a bogie is related to the outer wheel base of the bogie. Twist displacements of intermediate wheelsets shall be interpolated.

6.1.4.5 Conditions for articulated vehicles

In the case of articulated vehicles where adjacent vehicle-bodies are suspended on a common running gear or articulation, the influence of inter-vehicle constraints shall be analysed in order to determine their significance. The test conditions and the wheelsets to be tested shall be determined as a result of this analysis. Intermediate running gear or bogies shall also be tested. It could be necessary to test more than one vehicle body at the same time.

A.5 gives some additional information and examples.

6.1.4.6 Conditions for vehicles with more than two suspension levels

The word suspension is used to indicate freedom between adjacent bodies which may or may not include springs or dampers. A.6 shows an example of such an arrangement, many other different types exist.

The relevant vehicle test twists for the individual suspension levels shall be defined by analogy to the rules given for bogie vehicles for each test method. A.6 gives an example for the vehicle illustrated.

6.1.4.7 Conditions for vehicles with steered wheelsets

For vehicles including mechanisms which steer the wheelsets, the track conditions (e.g. S-curves) may lead to angles of attack which are larger than those obtained on the test track. This shall be considered in the tests for methods 1 and 2. The worst conditions occurring in operation with regard to the angle of attack shall be determined. Normally, in full curves the angles of attack and therefore the guiding forces are low. However, in transitions or reverse curves the steering mechanism may generate adverse angles of attack.

In order to get the highest guiding forces during the test, these additional angles of attack shall be simulated by suitable methods (e.g. by removing the steering mechanism and fixing the wheelsets to this angle of attack).

For vehicles with self-steering wheelsets or other running gear which show a major influence of wheel/rail contact geometry on the steering effect and the resulting angle of attack, appropriate investigations (e.g. forced angle of attack, variation of wheel/rail geometry) shall be carried out.

6.1.5 Test methods

6.1.5.1 Method 1: Test on twisted test track

6.1.5.1.1 General

The safety against derailment shall be determined by measuring the wheel lift of the outer wheel of the leading wheelset when running through a curved twisted test track. The $(Y/Q)_a$ values shall be measured, $(Y/Q)_{a,max}$ be calculated and the results shall be reported but $(Y/Q)_{a,max}$ is not an assessment quantity.

6.1.5.1.2 Test conditions

The vehicle test twist values shall be applied as follows:

— for bogie test twist:

$$g_{lim}^+ = 7 \quad \text{if } 2a^+ \leq 4 \text{ m and}$$

$$g_{lim}^+ = \frac{20}{2a^+} + 2,0 \quad \text{if } 2a^+ > 4 \text{ m}$$

with $2a^+$ as the bogie wheel base in m and g_{lim}^+ in ‰.

— for vehicle body test twist:

$$g_{lim}^* = 7 \quad \text{if } 2a \leq 4 \text{ m and}$$

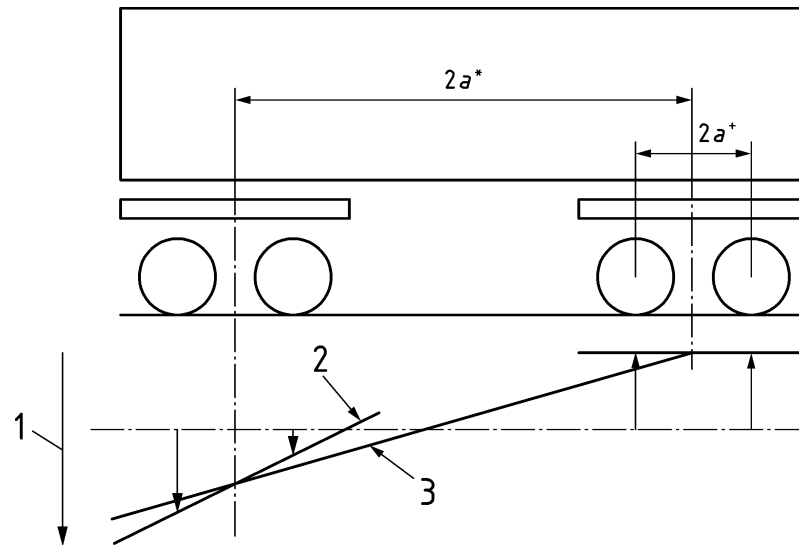
$$g_{lim}^* = \frac{20}{2a} + 2,0 \quad \text{if } 4 \text{ m} < 2a \leq 20 \text{ m}$$

$$g_{lim}^* = 3 \quad \text{if } 20 \text{ m} < 2a \leq 30 \text{ m}$$

$$g_{lim}^* = \frac{90}{2a} \quad \text{if } 2a > 30 \text{ m}$$

with $2a$ as the longitudinal dimension of twist in m (for single vehicles the longitudinal dimension of twist equals $2a^*$, the distance between centre pivots for vehicles with bogies or the distance of the wheelsets for non-bogie vehicles) and g_{lim}^* in ‰.

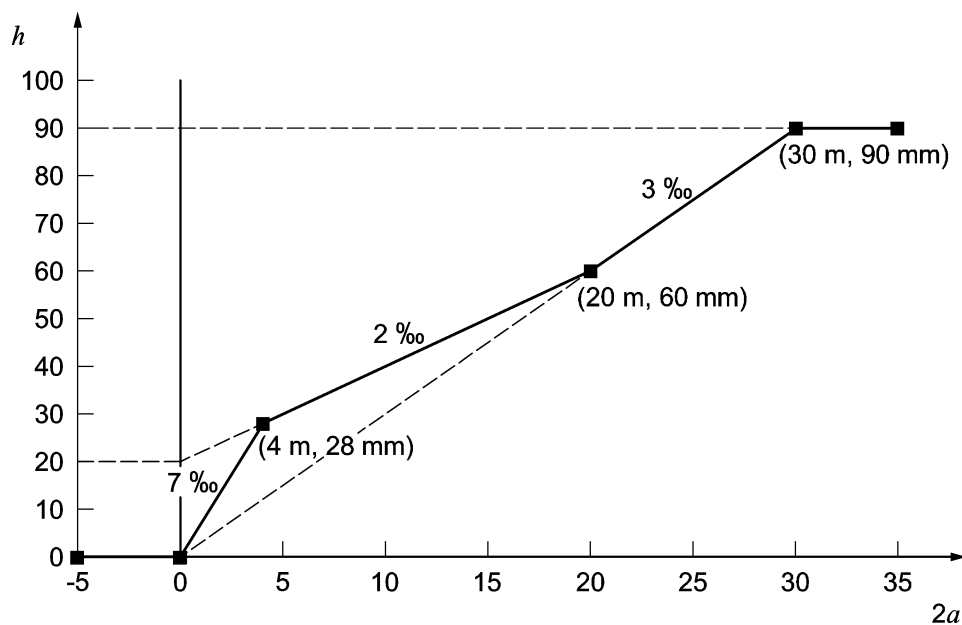
For bogie vehicles the twist due to the bogie wheel base $2a^+$ and the twist due to the bogie centre distance $2a^*$ shall be combined as shown in Figure 1.

**Key**

- 1 vertical displacement
- 2 bogie test twist
- 3 vehicle body test twist

Figure 1 — Combination of bogie and vehicle body test twist

Figure 2 shows the test twist values depending on length dimensions $2a^+$ and $2a^*$. The maximum vertical height difference from twist shall be 90 mm which corresponds to a twist value of 3 ‰ at 30 m. For lengths greater than 30 m the vertical height difference from twist shall be 90 mm.

**Key**

- h twist height
- $2a$ twist length

Figure 2 — Test twist values and twist heights

For articulated vehicles the influence of bodies and bogies that are not being tested shall also be considered and actions shall be taken to identify these influences. Where appropriate, these influences shall be removed by physical means (for example by shims) or the influence mitigated by other means (for example by calculation to demonstrate the consequence on the performance) or minimized to a justifiable level.

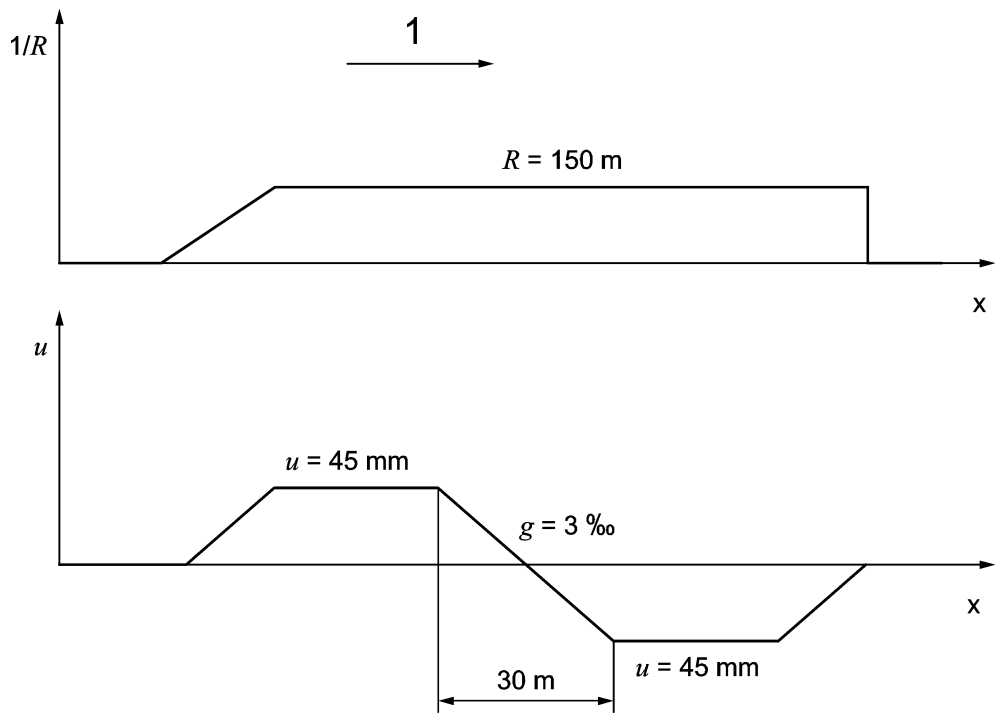
The objective is to apply the correct test twist to the vehicle. The condition of the test track shall be determined; using the measured track condition (twist, length of twist, cant, length of constant cant) any necessary adjustments to the vehicle (for example by the use of shims) to achieve the required test twist conditions shall be determined and reported. The achieved test twists (g^+, g^*) in the most critical position shall not deviate by more than 10 % from the intended values (g^{+lim}, g^{*lim}).

The influence of longitudinal forces in the train set shall be minimized. The vehicle shall not be braked. The speed shall be constant and not exceed 10 km/h.

Tests shall be carried out successfully a minimum of 3 times.

6.1.5.1.3 Track features

Figure 3 contains an example for installing a test track with characteristics described below.



- Key
- 1/R curvature
 - u cant
 - 1 running direction
 - x track coordinate

Figure 3 — Example for general layout of test track

Tests shall be done on a test track with the following characteristics:

- nominal curve radius $R = 150\text{ m}$;

- nominal gauge in the range between 1 440 mm and 1 465 mm along the test track, variations of ± 5 mm around the nominal value are accepted.
- test track shall not exceed a tolerance for mean to peak alignment of 10 mm; section of twisted track with constant curvature and a nominal twist of 3 ‰;
- the twist is realized by varying the height of the outer rail from a positive to a negative cant. It is also permitted to use a horizontal track centre line by lowering and lifting both rails; the actual cant shall be measured at each rail fastening position and documented;
- sudden changes of contact geometry, gauge and curvature within the tolerances shall be avoided inside the measuring area. If sudden changes of contact geometry, gauge or curvature are included together with friction values at the upper end of the acceptable range, the test can be too severe and the test may be repeated.

Test conditions as described in 6.1.3 (dry rail conditions) shall be fulfilled for the inner rail. For the outer rail the test shall be carried out with wheel flange and rail in a dry condition and no residual lubrication shall be present. This shall be documented.

6.1.5.1.4 Vehicle condition

The test shall be planned to ensure that the direction of running and track curvature are in such a way that the wheel with the lowest vertical wheel force of a tested wheelset is tested in the leading position running on the outer rail of the curve. This may include additional shims in the suspensions. The aim is to make sure that the lower vertical wheel force is located at the most unfavourable position. The achieved vertical wheel force distribution shall be verified.

It is not necessary to test at the maximum permitted vertical wheel force difference.

For vehicles with air suspension the vertical wheel force distribution in the inflated and the deflated condition is different. This may lead to different requirements for shimming. If it can be demonstrated by the measured Y and Q forces, that one suspension condition is less critical with a sufficient margin (10 % difference between the two results of $(Y/Q)_a$), then the shimming for the more critical condition with respect to wheel climbing is acceptable for both conditions.

A1 If the installed twist of the test track is smaller than the test twist specified in 6.1.5.1.2, the missing twist shall be included within the vehicle, for example by including shims in the springs (and anti-roll bar seats) in an appropriate way. Justification of the used method of shimming shall be documented. This shall demonstrate that the effect of the shimming achieves the same effect as the application of the required twist at track level. A.7 contains suggestions for calculating the thickness of the shims depending on their location. **A1**

The nominal flange angle of the design wheel profile of the vehicle used for the test shall be $\leq 70^\circ$. If the vehicle is normally equipped with a profile with a nominal flange angle $> 70^\circ$, a special profile with a flange angle of 70° shall be used for testing.

NOTE On new wheelsets or after machining the actual values of flange angles that are achieved may vary by the extent allowed by the tolerances defined in the specification for the wheel profile.

If the vehicle to be investigated was not only transferred to the test site but was already operated for a certain distance, it is required that the flange angle of the wheel profile or the contact angle during a theoretical wheel climbing is $\leq 71^\circ$. If the wheel flange angle is above this value, the test may be regarded as valid in the conditions stated in 6.1.5.1.6. The wheel profiles used for the test shall be measured at the beginning of these tests and documented.

It is not required to reprofile wheels during the test. Measurement of flange angle before starting the test is sufficient.

6.1.5.1.5 Measurement

The following values shall be measured:

- lateral forces on the inner and outer wheel of the tested wheelset Y_i, Y_a ;
- vertical wheel forces on the inner and outer wheel of the tested wheelset Q_i, Q_a ;
- angle of attack of a leading wheelset α (see 6.1.3);
- wheel lift $\Delta z = (z - z_0)$ of the guiding wheel of the tested wheelset.

The reference value z_0 is obtained with the wheelset on a straight track ~~A1~~ *deleted text* ~~A1~~. Forces shall be measured either by:

- appropriate devices on the rail; or
- appropriate devices on the vehicle.

In the case of rail measurements the measuring positions have to fulfil the following conditions as shown in Figure 4:

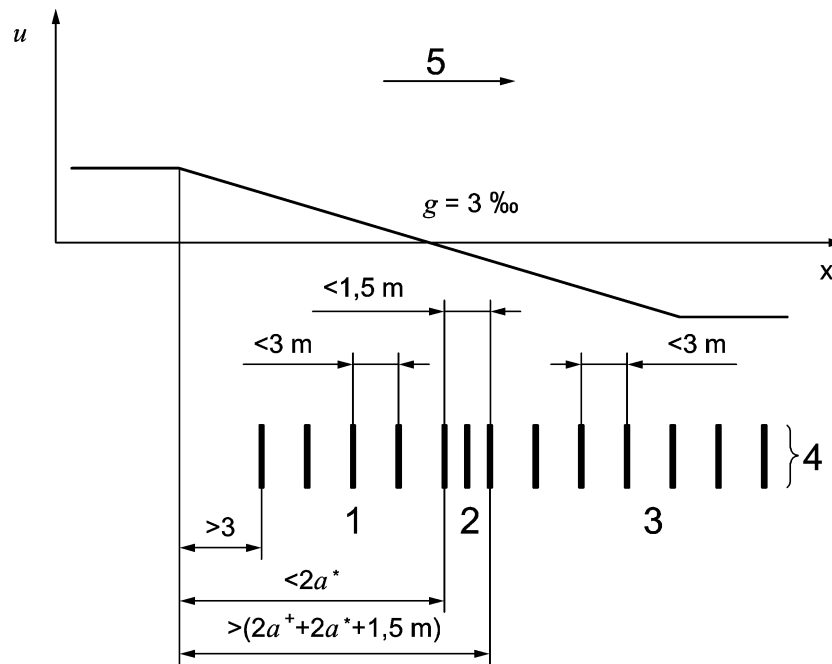
- measuring positions shall be within the twisted part of the track;
- in zone 2 where the track twist first influences the whole vehicle the distance between two measuring sections shall not be greater than 1,5 m;
- in the other areas of the twisted track the distance between two measuring sections shall not be greater than 3 m.

NOTE For testing articulated trains, it is useful to extend zone 2 towards the end of the twisted section in order to cover also the area where the maximum wheel unloading occurs.

For each measuring section the value of $(Y/Q)_a$ of the leading wheelset shall be recorded. Wheel lift of the outer wheel of the leading wheelset Δz shall be recorded continuously.

To determine the friction conditions $(Y/Q)_i$ and α have to be evaluated as mean values of all measuring sections or of a continuous recorded signal.

If vehicle based measurement is used, the processing of measuring signals shall be done by analogy to the above conditions.

**Key**

1	zone 1	3	zone 3	5	running direction	x	track coordinate
2	zone 2	4	measuring points	u	cant		

Figure 4 — Track based measuring positions to be used in method 1 in the twisted curve

6.1.5.1.6 Assessment

Assessment is made for the maximum value $\Delta z_{\max}$ of wheel lift of the outer wheel of the tested wheelset. The limit value is $\Delta z_{\max} \leq \Delta z_{\lim} = 5 \text{ mm}$, this shall be achieved on the three separate tests.

This limit value is defined for typical combinations of wheel and rail profiles such as S1002 according to EN 13715 and 49E1, 54E1 or 50E6 according to EN 13674-1. For other profiles, this limit can be adapted, if the contact point reaches the part of the flange with the angle of 70° at wheel lifts only above 5 mm.

The three successful tests are not necessarily consecutive test runs. However, if two consecutive tests fail, despite valid test conditions, the vehicle shall be rejected.

When the flange angle is above the value specified in 6.1.5.1.4, the test run shall be considered as successful if both following conditions are achieved:

- $\Delta z_{\max} \leq \Delta z_{\lim} = 5 \text{ mm}$;
- $(Y/Q)_{a,\max} \leq (Y/Q)_{a,\lim} = 1,2$.

If wheel lift is higher than the limit, additionally $(Y/Q)_a$ on the outer rail shall be checked. If $(Y/Q)_a$ is below the value 1,12 (value corresponding a friction value of 0,4 and flange angle of 70°) the test shall be repeated.

NOTE If a wheel lift occurs at low values of $(Y/Q)_a$, this is an indication of excessive friction on the outer rail.

6.1.5.1.7 Reporting

Additionally to the general reporting according to 5.5 for each test condition that was part of the test programme the following details shall be included:

- the actual detail of the track features of the test site at the time of the test, including reference to the point identified in 6.1.5.1.3;

- shims applied as specified in 6.1.5.1.2 and 6.1.5.1.4;
- speed of passage through the test site;
- Y/Q for inner and outer rails at all measuring positions;
- maximum value of Δz .

6.1.5.1.8 Dispensation

Based on the test results of a reference vehicle (see 3.16) dispensation from testing is possible, either if:

- the influence of the changes to the vehicle compared to the reference vehicle is demonstrated and this shows that the acceptance criteria will not be exceeded;

or if:

- a calculation of guiding forces and vertical wheel forces of the reference vehicle under method 1 test conditions demonstrates credible results when compared with measurement results; and
- calculations for the reference vehicle and the assessed vehicle are made under method 2 test conditions to quantify the influence of the parameter change; and
- the calculated result of $(Y/Q)_a$ for the assessed vehicle under the conditions of method 2 testing (see 6.1.5.2) remains 10 % below the limit value (in a deflated suspension condition the 10 % margin does not apply); and
- the calculated result of the assessed vehicle under the conditions of method 2 testing does not increase by more than 1/3 of the margin between the calculated result of the reference vehicle and the limit value.

6.1.5.2 Method 2: Test on twist test rig and flat test track

6.1.5.2.1 General

In method 2 the risk of flange climbing is assessed by the ratio of the horizontal guiding force Y and vertical wheel force Q . The assessment is carried out in two stages:

- 1) The measurement of the reduction of the vertical wheel force Q_a on a test rig which simulates twisted track
- 2) The measurement of the guiding force Y_a on an appropriate test track.

The calculation of the ratio $(Y/Q)_a$ is based on the test results.

6.1.5.2.2 Measurement of the reduction of the vertical wheel force

6.1.5.2.2.1 General

An appropriate test rig shall be used on which at least the supports of the wheelsets of one running gear may be lifted and/or lowered. With this the twist of the track on running gear wheel base as well as on running gear centre distance can be simulated.

6.1.5.2.2.2 Test conditions

The following values shall be used on the twist test rig:

- for bogie test twist:

$$g_{\text{lim}}^+ = 7 - \frac{5}{2a^+} \quad \text{if } 2a^+ < 4 \text{ m}$$

$$g_{\text{lim}}^+ = \frac{15}{2a^+} + 2,0 \quad \text{if } 2a^+ \geq 4 \text{ m}$$

with $2a^+$ as the bogie wheel base in m and g_{lim}^+ in ‰.

— for vehicle body test twist:

$$g_{\text{lim}}^* = 7 - \frac{5}{2a} \quad \text{if } 2a < 4 \text{ m and}$$

$$g_{\text{lim}}^* = \frac{15}{2a} + 2,0 \quad \text{if } 4 \text{ m} \leq 2a \leq 20 \text{ m}$$

$$g_{\text{lim}}^* = 3 - \frac{5}{2a} \quad \text{if } 20 \text{ m} < 2a \leq 30 \text{ m}$$

$$g_{\text{lim}}^* = \frac{85}{2a} \quad \text{if } 2a > 30 \text{ m}$$

with $2a$ as the longitudinal dimension of the vehicle (distance between centre pivots for single bogie vehicles or wheelsets for non-bogie vehicles) in m and g_{lim}^* in ‰.

For bogie vehicles the twist on the bogie wheel base $2a^+$ and the twist on the bogie centre distance $2a$ shall be combined as shown in Figure 1. This combination can be performed during the test as described in A.9.3 or by calculation using separate test results as described in A.9.4.

6.1.5.2.2.3 Measurements

The displacements of the wheels shall be measured continuously during the twist test. Additionally the vertical wheel forces Q_{jk} of all wheels shall be measured by suitable devices.

By testing the vehicle on the test rig the following vehicle parameters are evaluated:

- $\overline{Q_{F0,j}}$ average vertical wheel force for each wheelset on level track (twist $g = 0$);
- ΔQ_{jk} deviation of vertical wheel force from $\overline{Q_{F0,j}}$ due to the combined bogie and body twist and eccentricity of centre of gravity including friction and tolerances;
- $Q_{jk,\text{min}}$ minimum vertical wheel force due to the combined bogie and body twist and eccentricity of centre of gravity including friction and tolerances (see A.9.4.4).

A.8 and A.9 contain guidelines for testing and evaluation.

6.1.5.2.3 Measurement of the guiding force

6.1.5.2.3.1 General

The guiding forces of the outer wheels are determined in a flat, curved track.

6.1.5.2.3.2 Test conditions

Tests shall be done on a test track with the following characteristics:

- flat curve (without twist and cant);
- nominal curve radius $R = 150 \text{ m}$;
- no transition between straight and curved track;
- nominal gauge in the range between 1 440 mm and 1 465 mm; along the test track, variations of $\pm 5 \text{ mm}$ around the nominal value are accepted.

- test track shall not exceed the following tolerances for mean to peak longitudinal level: 10 mm and mean to peak alignment: 10 mm;
- sudden changes of contact geometry, gauge and curvature within the tolerances shall be avoided inside the measuring area. If sudden changes of contact geometry, gauge or curvature are included together with friction values at the upper end of the acceptable range, the test can be too severe and the test may be repeated

Direction of running and direction of curvature shall be in such a way that the wheel with the lowest vertical wheel force of the extreme wheelset is in the leading position running on the outer rail of the curve. This may include additional shims in the suspension.

Test conditions concerning the state of the rail as described in 6.1.3 (dry rail conditions) shall be fulfilled.

The influence of longitudinal forces in the train set shall be minimized. The vehicle shall not be braked. The speed shall be constant and not exceed 10 km/h.

Tests shall be done a minimum of 3 times.

6.1.5.2.3.3 Measurements

Forces may be measured by:

- appropriate devices on the rails; or
- appropriate devices on the vehicles.

The following values shall be measured:

- lateral forces on the inner and outer wheels of the tested wheelset Y_i , Y_a ;
- vertical wheel force on the inner wheel of the tested wheelset Q_i ;
- angle of attack of a leading wheelset α (see 6.1.3);
- if the results are used for comparison between calculation and measurement, the vertical wheel force on the outer wheel Q_a shall be measured in addition.

In the case of rail measurements the measuring positions shall fulfil the following conditions:

- at least 3 measuring positions shall be in zone 1 - at the beginning of the curve area between 3 m and up to $2a^*$ from the start of the curve. This ensures that the yaw between body and bogie is still taking place;
- at least 3 measuring positions shall be within zone 2 in a curve area where the angle around the vertical axis between bogie and body remains constant.

NOTE For the investigation of intermediate bogies of articulated trains it might be necessary to take into account also the guiding forces at the curve exit. In that case either the curve can be instrumented at the exit in the same manner as in zone 1 or the vehicle can be run also in the reverse direction.

Figure 5 shows an example of the measuring position in a 150 m radius curve.

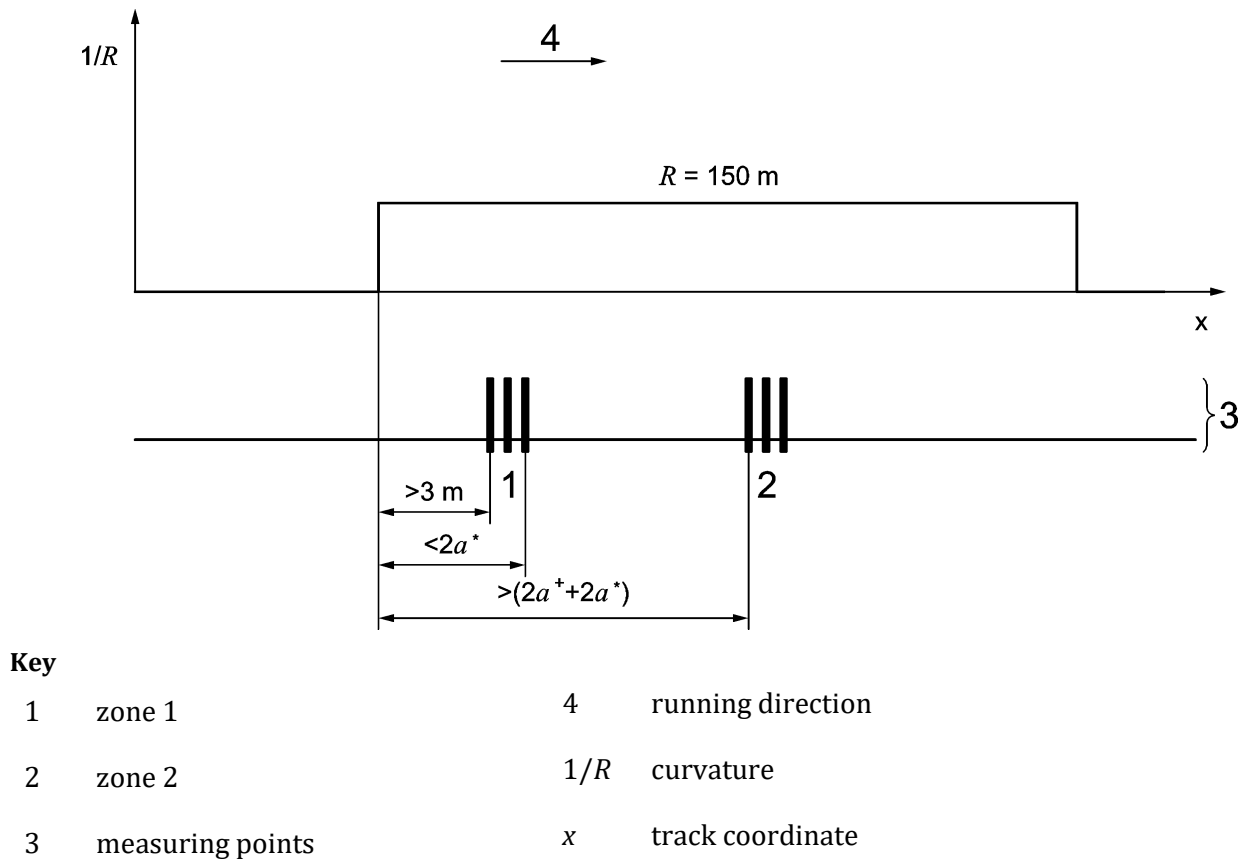


Figure 5 — Track based measuring positions for determination of Y and Q in the flat curve

For each measuring position the values of Y_{ja} and Y_{ji} of the tested wheelset j shall be recorded. The mean values $Y_{ja,mean}$ and $Y_{ji,mean}$ of the measuring positions shall be evaluated separately for zone 1 and zone 2. The assessment is done with the higher of these two mean values.

For the evaluation of Y_i the direction of forces shall be noted (in most cases opposite to Y_a).

To determine the friction conditions $(Y/Q)_i$ and α shall be evaluated as mean values of all measuring positions or of a continuous recorded signal.

If vehicle based measurement is used the results shall be analysed in an equivalent way to the above conditions.

6.1.5.2.4 Assessment

Safety against derailment shall be analysed for the tested wheelsets of the vehicle. The following formula shall be evaluated for each tested wheelset:

$$\left(\frac{Y}{Q}\right)_{j,a} = \frac{Y_{j,a,mean}}{Q_{jk,min} + \Delta Q_{j,H}}$$

where

- $Y_{j,a,\text{mean}}$ is the higher of the mean values of the lateral guiding force evaluated for zone 1 and zone 2 by the tests described in 6.1.5.2.3.3.
- $Q_{jk,\text{min}}$ is the smallest vertical wheel force evaluated by twist test described in 6.1.5.2.2.3 (see also A.9.4.4)
- $\Delta Q_{j,H}$ is the change of the vertical wheel force due to the moment of the sum of lateral wheel forces: $\Delta Q_{j,H} = (Y_{j,a} + Y_{j,i}) \frac{h}{2b_A}$

where

- h is the effective height above rail of the primary lateral suspension
- $2b_A$ is the lateral distance of wheel/rail contact points (normally 1 500 mm)

A vehicle is considered to be safe against derailment if the condition:

$$(Y/Q)_{j,a} \leq 1,2$$

is fulfilled for a flange angle of 70° (this corresponds to $\mu = 0,36$ from A.2).

For lower flange angles β the limit value is calculated by:

$$\left(\frac{Y}{Q} \right)_{a,\text{lim}} = \frac{\tan \beta - 0,36}{1 + 0,36 \cdot \tan \beta}$$

A.2 shows some background information for the evaluation parameter $(Y/Q)_a$ and the limit value.

NOTE The limit value $(Y/Q)_{\text{lim}} = 1,2$ for a flange angle of 70° is based on statistical investigations described in ORE B55 [6]. It is identical with the Nadal's criterion for a flange angle of 70° and a wheel/rail friction coefficient of 0,36. In spite of the fact that this limit value has not been derived from the Nadal's formulae, and the friction coefficient between wheel and rail during the test should according to 6.1.3 be higher than 0,36, the Nadal's formula is accepted as a physical relationship between the flange angle, wheel/rail friction coefficient and the limit value of the safety against derailment due to wheel climbing. Hence, the Nadal's formula is used here for a recalculation of the limit value for flange angles lower than 70° . The value of wheel/rail friction coefficient of 0,36 used for this limit value recalculation, however, does not represent the real friction coefficient present during the test. Consequently, the formula above is not the limit value according to Nadal as often used in measurements and computations, but only a conversion formula to adjust the limit value identified in ORE B55 for flange angles lower than 70° .

6.1.5.2.5 Reporting

Additionally to the general reporting according to 5.5, for both test stages and each test condition that was part of the test programme the following details shall be documented:

- for each test condition performed according to 6.1.5.2.2.2 details about the applied twist;
- for each test condition performed according to 6.1.5.2.3.2 details about the curve;
- shims, if applied;
- speed of passage through the test curve;
- Y/Q for inner and if available also for outer rails in the test curve;
- for each test condition performed, the results of the measurements according to 6.1.5.2.2.3 (vertical wheel force and twist on test rig);

- for each test condition performed, the results of the measurements according to 6.1.5.2.3.3 (forces in flat curve).

6.1.5.2.6 Dispensation

Based on the test results of a reference vehicle (see 3.16) dispensation from testing is possible, either if:

- the influence of the changes to the vehicle compared to the reference vehicle is demonstrated and this shows that the acceptance criteria will not be exceeded;

or

- calculation of safety against derailment for the reference vehicle when compared with the tested values demonstrates credible results; and
- using the same calculation method, the calculated result $(Y/Q)_a$ for the assessed vehicle remains 10 % below the limit value (in a deflated suspension condition the 10 % margin does not apply); and
- the calculated result $(Y/Q)_a$ does not increase by more than 1/3 of the margin between the test result and the limit value.

6.1.5.3 Method 3: Test on twist test rig and yaw test rig

6.1.5.3.1 General

The risk of flange climbing is assessed in one or two phases.

In phase 1 two tests are carried out:

- 1) The measurement of the reduction of the vertical wheel force Q_a on a test rig which simulates twisted track.
- 2) The measurement of bogie yaw resistance generated as a vehicle negotiates the smallest radius of curvature that the vehicle is designed to go through.

Where it is not possible to demonstrate an acceptable performance using phase 1, validated computer simulations according to informative Annex B may be used. This is the second phase. Phase 2 cannot be used unless the tests of phase 1 have been done. The results of phase 1 are used to validate the work carried out in phase 2. If phase 2 also fails, either method 1 or method 2 shall be used.

Method 3 shall only be used under the following conditions:

- conventional technology vehicle as defined in 3.14 and
- vehicles with two two-axle bogies per vehicle body or articulated train with two-axle bogies, where the test location can accommodate and test a sufficient number of vehicle bodies to produce reliable results and
- flange angles of wheels between 68° and 70°.

6.1.5.3.2 Measurement of the reduction of the vertical wheel force

6.1.5.3.2.1 General

An appropriate test rig shall be used on which at least the supports of the two wheelsets of one bogie may be lifted and/or lowered. With this the twist of the track on bogie wheel base as well as on bogie centre distance can be simulated.

6.1.5.3.2.2 Test conditions

The following values shall be used on the twist test rig:

— for bogie test twist:

$$g_{\text{lim}}^+ = 6,67 \quad \text{if } 2a^+ < 5,45 \text{ m and}$$

$$g_{\text{lim}}^+ = \frac{20}{2a^+} + 3,0 \quad \text{if } 2a^+ \geq 5,45 \text{ m}$$

with $2a^+$ as the bogie wheel base in m and g_{lim}^+ in ‰.

— for vehicle body test twist:

$$g_{\text{lim}}^* = \frac{20}{2a^*} + 3,0$$

with $2a^*$ as the longitudinal dimension of the vehicle (distance between centre pivots) in m and g_{lim}^* in ‰.

Tests shall be done as a combined body and bogie twist test as shown in Figure 1 and as described in A.9.3.

NOTE This type of test is identical with the test used in method 2 but with different twist conditions.

It is permissible to undertake the test by just lifting wheels, rather than also lowering wheels, provided that the defined twists are imposed over the bogie and body.

6.1.5.3.2.3 Measurements

The displacements of the wheels shall be measured continuously during the twist test. Additionally the vertical wheel forces Q_{jk} of the wheels experiencing the greatest percentage of unloading shall be measured by suitable devices.

6.1.5.3.3 Measurement of bogie yaw resistance

6.1.5.3.3.1 General

The test described in this clause is intended to evaluate body-to-bogie yaw torque which is generated by the passage of the vehicle through curves.

6.1.5.3.3.2 Test conditions

The tests shall be carried out on a test rig that shall be capable of determining the torque required to rotate the bogie up to at least the maximum body-bogie yaw angle. The characteristics of the test rig including its friction behaviour should be considered.

Tests shall be carried out in both directions of yaw rotation up to at least a body/bogie yaw angle of:

$$\Delta\psi_{\text{test}}^* = \frac{2a^*}{2 \cdot R_{\text{min}}} + \frac{0,020}{2a^+}$$

NOTE 1 The formula includes a difference of the lateral displacements of the wheelsets of 20 mm due to the wheelset-track clearance in addition to the yaw angle determined by the minimum curve radius R_{min} specified for the vehicle.

The test shall be continued beyond the zero yaw angle to enable the hysteresis loop to be closed.

A mean yaw velocity of 1°/s shall be achieved over at least ± 75 % of the yaw angle amplitude.

NOTE 2 It is possible to achieve higher yaw velocities than this value. This will occur at smaller yaw angles. A combination of the maximum yaw angle and velocity is considered as unrealistic.

For vehicles with air springs tests shall be done in the inflated and deflated condition.

6.1.5.3.3 Measurements

Body-bogie yaw angle $\Delta\psi^*$ and yaw-moment M_z required to rotate the bogie shall be measured continuously and recorded in a diagram $M_z = f(\Delta\psi^*)$. Figure 6 shows an example of a bogie-rotation diagram.

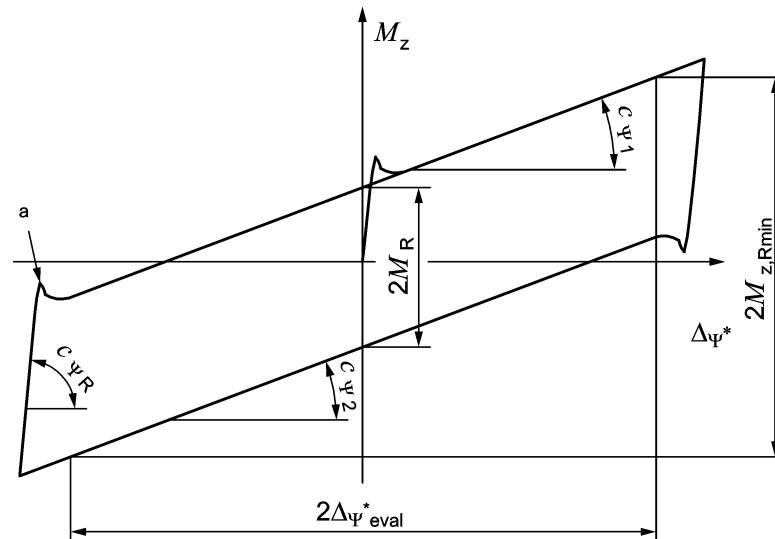


Figure 6 — Bogie-rotation diagram

M_R is the yaw hysteresis magnitude and results from friction and damping in the system.

The mean slope

$$c_\psi = \frac{c_{\psi 1} + c_{\psi 2}}{2}$$

is the yaw stiffness of the secondary suspension. If rotation is achieved by sliding of friction faces between body and bogie then c_ψ becomes zero.

The series stiffness $c_{\psi R}$ of the friction or damping element may be essential for the understanding of the dynamic behaviour of a vehicle.

The feature “a” in Figure 6 may be caused by characteristics of the test rig including inertia of turntable and bogie and is to be neglected.

6.1.5.3.4 Assessment

The results for phase 1 shall be determined. For acceptance both criteria shall be respected simultaneously.

The analysis of the suspension performance when negotiating twisted track (see 6.1.5.3.2) shall be done for the end wheelsets of the vehicle for each wheel using the wheel unloading factor $\Delta Q/Q_0$

where

$\langle A_1 \rangle Q_{F0} \langle A_1 \rangle$ is the average vertical wheel force for the tested wheelset on level track (twist $g^0 = 0$)

ΔQ is the deviation from $\langle A_1 \rangle Q_{F0} \langle A_1 \rangle$ at maximum twist condition

The following criterion shall be respected:

$\langle A_1 \rangle$

$$\frac{\Delta Q}{Q_{F0}} \leq 0,6 \sqrt{A_1}$$

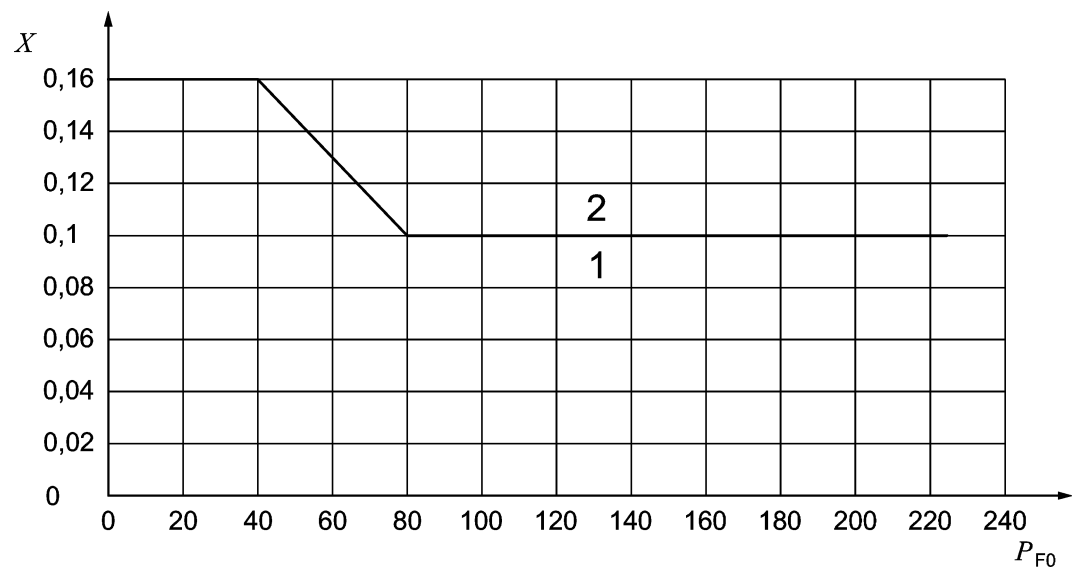
Based on the results of the measurement of bogie yaw resistance in small radius curves (see 6.1.5.3.3), the bogie X-factor shall be computed from the formula

$$X = \frac{M_{z,Rmin}}{2a^+ P_{F0}}$$

where

$M_{z,Rmin}$ is the yaw moment required to rotate the bogie relative to the body (excluding gauge clearance) evaluated for

$$\Delta \psi_{eval}^* = a^* / R_{min}$$



Key

- 1 permissible
- 2 not permissible
- X 'X' Factor
- P_{F0} nominal static vertical wheelset force in kN

Figure 7 — Maximum permissible factor X for freight vehicles

The following criterion shall be respected:

$X \leq 0,1$ for passenger vehicles and locomotives, for freight vehicles it shall be below the limits shown in Figure 7.

6.1.5.3.5 Reporting

Additionally to the general reporting according to 5.5 when the vehicle has successfully passed phase 1, for both tests, the following shall be reported:

- for each test condition, that was part of the test programme, details including reference to the points identified in 6.1.5.3.2 (twist test) and 6.1.5.3.3 (bogie rotation test);

- for each test condition, that was part of the test programme, results of the measurements made as detailed in 6.1.5.3.2.3 (twist test) and 6.1.5.3.3.3 (bogie rotation test).

In the event that phase 1 is not successfully passed then phase 2 is available to be used. Additionally, in this case the following shall be reported:

- the requirements detailed in B.1;
- the simulated track conditions according to B.3;
- the conditions of B.4;
- the output requirements of B.5.

6.2 Safety against derailment under longitudinal compressive forces in S-shaped curves

It is recognized that longitudinal forces within trains have the potential to increase the risk of derailment when negotiating S-shaped curves. This risk is regarded as low for conventional trains but for certain freight wagons and train operation methods the risk can be higher. In the case of at-risk freight wagons within the scope of EN 15839 the procedure defined in EN 15839 shall be used. In the case of special vehicles EN 14033-1 specifies conditions for dispensation from EN 15839. However, this risk should be considered when non-conventional configurations are developed.

6.3 Evaluation of the torsional coefficient of a vehicle body

The torsional coefficient of the vehicle body is only to be determined if it is needed for the assessment according to 6.1 or 6.2 or for purposes of model validation.

The torsional coefficient c_t^* is a basic parameter of a vehicle related to the safety against derailment under longitudinal compressive forces and influences also the safety against derailment in twisted tracks together with the suspension system. It is defined by the following formula:

$$c_t^* = M_t / \left(\frac{\vartheta}{l} \right) = (M_t / \vartheta) \cdot l \quad (1)$$

where

M_t is the torsional moment

ϑ is the angle of torsion

l is the longitudinal distance between supports

To determine the torsional coefficient value of a vehicle body, different methods of testing can be used. Methods are given in the informative Annex C.

NOTE The torsional coefficient of a bogie frame c_t^* is defined in the same way.

6.4 Determination of displacement characteristics

The determination of displacement characteristics are related to the requirements of EN 15273 and are included as informative Annex D.

6.5 Loading of the diverging branch of a switch

This standard does not specify any requirements for the assessment of vehicle behaviour in switches and crossings. Where there is a national requirement for evaluation of the vehicle behaviour in switches and crossings, informative Annex F presents a methodology and associated background to provide a consistent approach.

6.6 Running safety in curved crossings for vehicles with small wheels

This standard does not specify any requirements for the assessment of vehicle behaviour in curved crossings. Where there is a national requirement for evaluation of the behaviour of a vehicle with small wheels in curved crossings, informative Annex E presents a methodology and associated background to provide a consistent approach.

7 Second stage – dynamic performance assessment

7.1 General

All new or modified vehicles shall be checked with regard to their dynamic characteristics to evaluate the running safety, the track loading and the ride characteristics of the vehicle. An assessment may be carried out for the initial acceptance of the vehicle type or it may be for an extension of acceptance. The assessment is based on the evaluation of the performance of the vehicle while running on the track on a sample of track sections (curves with different radii and straight tracks) with defined assessment conditions. Then a statistical analysis of the assessed parameters is performed and the results are compared with limit values. If the conditions described in this sub clause are fulfilled, this gives the foundation for the type approval for the lifetime of the vehicle or the whole fleet of vehicles.

[A1] The initial assessment of the dynamic performance of a vehicle type shall generally be performed based on on-track tests. **[A1]** The conditions for carrying out this process are given in this sub clause. In certain circumstances the tests may be supplemented by simulation (see informative Annex T) or other means, e.g. when the combination of the target test conditions cannot be achieved during the test.

An extension of acceptance for vehicles that are of the same basic design, or that have gained acceptance and subsequently undergone engineering change, is possible. This assessment shall be carried out either by means of a partial on-track test or by simulation of an on-track test or a combination of both. The procedure (test extent and measuring method) to be applied for the partial on-track test (including dispensation from test) is defined in informative Annex U. The possible application of simulation is described in informative Annex T.

For multiple units, the individual vehicles may have different parameters (e.g. forces, stiffness). In this case, selected vehicles may be used as reference vehicles. All other vehicles are regarded as vehicles with extension of acceptance due to changes of vehicle parameters. Therefore, the allowable differences in vehicle parameters, as given in U.3.2, determine the extent of measurements and tests.

For freight wagons equipped with established or standardized running gear as described in EN 16235, a dispensation from Clause 7 requirements (on-track testing) is granted if the requirements described in EN 16235 are fulfilled.

When planning on-track tests, the admissible speed V_{adm} and the admissible cant deficiency I_{adm} for the vehicle have to be selected. The chosen values determine the future use of the vehicle.

It may be necessary to test a vehicle for more than one combination of V_{adm} and I_{adm} as shown in informative Annex H.

For convenience standardized values for I_{adm} should be used for acceptance as given in informative Annex H.

NOTE 1 Using values equal to or higher than the maximum limiting values stated in EN 13803-1 will give the least restrictions for future operation. For national operation, other values of operational parameters may be a better choice. In many European countries operation within the standard timetables requires a minimum performance of the vehicles (see informative Annex H).

It is not necessary for acceptance to distinguish between admissible cant deficiencies which differ by no more than 2 %. This is the difference e.g. resulting from inaccuracy converting cant deficiency to uncompensated lateral acceleration using $g = 10 \text{ m/s}^2$ instead of $g = 9,806 \text{ m/s}^2$.

In case of a deactivation of a tilting system, the cant deficiency is to be reduced, e.g. to the maximum allowed values for conventional vehicles. In consequence the vehicle shall also be tested under these operational conditions.

NOTE 2 It is recognized that locomotives or power heads, which are operated with cant deficiencies higher than used for conventional trains without a tilting system (e.g. SJ-X2000) exist.

NOTE 3 Reasons for limiting operating conditions could be restricted capabilities of vehicle design or restricted availability of suitable test tracks.

As the target test conditions of equivalent conicities for stability testing are depending on the speed, it may also be necessary to test vehicles with high admissible speeds for more than one combination of speed and equivalent conicity.

Test procedures are based on the classification of the test vehicle into:

- locomotives, multiple units (EMU, DMU) and passenger coaches;
- freight wagons;
- special vehicles.

In 3.15 special vehicles are defined as such according to their use. However, their testing requirements are based on their design characteristics. Informative Annex S describes basic principles to be applied to special vehicles, before considering general test requirements of the present Clause 7.

Vehicles with maximum admissible speed $V_{adm} \leq 60$ km/h are granted dispensation from dynamic performance assessment.

7.2 Choice of measuring method

7.2.1 General

On-track tests can use the two different measuring methods:

- normal measuring method;
- simplified measuring method.

Figure 8 gives an overview of the assessment quantities used in both measuring methods.

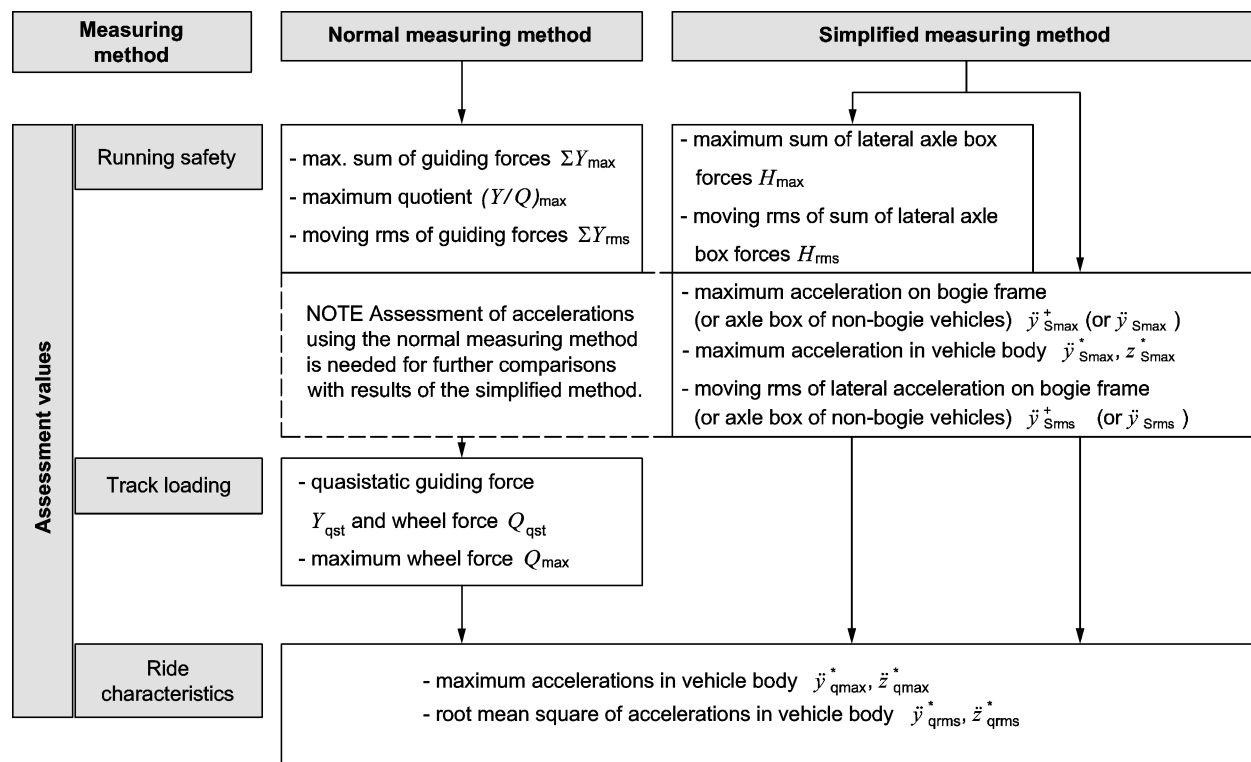


Figure 8 — Measuring methods and assessment quantities

On-track test with normal measuring method includes the assessment of:

- running safety;
- track loading;
- ride characteristics of the vehicle;

with direct measured forces between wheel and rail and accelerations in the running gear and in the vehicle body.

On-track test with simplified measuring method includes the assessment of:

- running safety;
- ride characteristics of the vehicle;

A1 with measured accelerations at the running gear and accelerations in the vehicle body **A1**. In some cases lateral forces between wheelset and axle box are also measured. If the simplified method is applicable, it is assumed that the vehicle will comply with track loading limit values, without needing a direct assessment of the associated quantities.

For initial acceptance the simplified measuring method is only applicable if the base conditions in 7.2.2 are fulfilled.

For an extension of an acceptance state additional conditions for the use of the simplified measuring method are given in informative Annex U including the indication of required axle box force measurement. They are dependent upon the test methods of the initial and the new acceptance as well as on the results achieved during the initial acceptance and the modifications of relevant parameters.

7.2.2 Base conditions for the use of the simplified measuring method and measurement of axle box forces

In general the simplified measuring method may be applied to conventional technology vehicles, if all of the conditions in Table 1 are fulfilled:

Table 1 — Base conditions for the use of a simplified measuring method

Running gear type one of the following:	
— single wheelsets; — bogie with two wheelsets $2a^+ \leq 3,3$ m; — bogie with three or more wheelsets with spacing between outer wheelsets $\leq 4,5$ m with additional measurement of lateral axle box forces H.	
Vehicle configuration one of the following:	
Single vehicles — with two single wheelsets; — with two bogies.	
Articulated vehicles consisting of two or more vehicle bodies, with the following possible arrangements of running gears per vehicle body — up to two single wheelsets; — up to two bogies.	
Nominal static vertical wheelset force P_{F0} (for all vehicles)	≤ 200 kN ^a
Maximum admissible speed of the vehicle V_{adm}	
vehicles with single wheelsets	≤ 100 km/h
freight wagons with bogies	≤ 120 km/h
other vehicles with bogie mass $m^+ > 10$ t	≤ 120 km/h
other vehicles with bogie mass $m^+ > 10$ t and additional measurement of lateral axle box forces H	≤ 160 km/h
other vehicles with Bogie Mass $m^+ \leq 10$ t and $(P_{F0} \cdot V_{adm}) \leq 34\,000$ [kN km/h] ^a	≤ 200 km/h
Admissible cant deficiency I_{adm}	
freight wagons	≤ 130 mm
multiple units with nominal static vertical wheelset forces $P_{F0} \leq 170$ kN ^a and $V_{adm} \leq 160$ km/h	≤ 165 mm
other vehicles	≤ 150 mm
^a P_{F0} is the nominal static vertical wheelset force of the highest loaded wheelset of the vehicle in the assessed load configuration (see 5.3.2).	

7.2.3 Simplifications for separate stability testing

If stability testing is performed separately, the application of the simplified measuring method is sufficient as the method is consistent with the normal measuring method.

NOTE This permits the required high conicity condition to be achieved also by modification of the wheel profile on a running gear without instrumented wheelsets and to keep normal profiles on the instrumented wheelsets. For testing stability the instrumentation of running gear (or in the case of a vehicle with single axle running gear, with instrumentation on the vehicle body) is sufficient.

If a vehicle is equipped with an instability monitoring system based on established standards, results collected by this system may be used to demonstrate running stability.

7.3 Performing on-track tests

7.3.1 General

The running conditions during tests (and also for numerical simulations) shall include defined combinations of:

- speed;
- cant deficiency;
- curve radius.

Therefore, the assessment is carried out on different test zones. In each test zone, the test conditions for track and operation differ with regard to the ranges of test parameters to be examined. To allow a statistical evaluation of test results, the test lines are divided into track sections. The measured results from the track sections in which the required test parameters were fulfilled are allocated to the corresponding test zone. If multiple regression is used (see normative Annex R) all track sections in curves form together the basis for the statistical evaluation calculated at different target values specified for the different test zones.

Table 2 defines the test zones and the associated ranges of values for track layout. In the first part it also gives the objective of the testing and anticipated vehicle dynamic behaviour. In a second section the target test conditions for track layout, track quality, wheel/rail contact and operation (speed and cant deficiency) are defined. These target test conditions shall be complied with as far as possible in on-track testing of running characteristics. A third section specifies the requirements for the track sections.

NOTE As it was found in the DYNOTRAIN project, that the nominal rail inclination has no influence on test results, testing on two networks is no longer necessary, if profiles representative for the service of the vehicle are used during testing. In that case the range of contact conditions varies sufficiently for the statistical evaluation due to variations of gauge and rail shape on test lines.

As the effects of aerodynamic forces are outside the scope of this document they shall not have a significant influence on the tests. This should be assumed unless there are reasonable grounds to believe otherwise.