

BS EN 15273-2:2013+A1:2016



BSI Standards Publication

Railway applications — Gauges

Part 2: Rolling stock gauge

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National foreword

This British Standard is the UK implementation of EN 15273-2:2013+A1:2016. It supersedes BS EN 15273-2:2013, which is withdrawn.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 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.

Normative: Requirements conveying criteria to be fulfilled if compliance with the document is to be claimed and from which no deviation is permitted.

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.

When rounded values require unit conversion for use in the UK, users are advised to use equivalent values rounded to the nearest whole number. The use of absolute values for converted units should be avoided in these cases. For the values used in this standard:

5 km/h has an equivalent value of 3 mile/h
8 km/h has an equivalent value of 5 mile/h
10 km/h has an equivalent value of 5 mile/h
30 km/h has an equivalent value of 20 mile/h
40 km/h has an equivalent value of 25 mile/h
64 km/h has an equivalent value of 40 mile/h
80 km/h has an equivalent value of 50 mile/h
120 km/h has an equivalent value of 75 mile/h
160 km/h has an equivalent value of 100 mile/h
200 km/h has an equivalent value of 125 mile/h
300 km/h has an equivalent value of 190 mile/h

Gauging practices used in Great Britain are documented in Railway Group Standards, published for the GB main line railway industry by Rail Safety and Standards Board Limited (RSSB), www.rssb.co.uk. Railway Group Standards are freely available from www.rgsonline.co.uk.

The gauging practices used in Great Britain diverge significantly from the International Union of Railways (UIC) gauging practices used in much of the rest of Europe. Although BS EN 15273 *Railway applications — Gauges* defines a number of different gauging methodologies and applications, the underlying philosophy is that of the UIC method of gauging, which depends on the use of reference profiles. It should be noted, therefore, that BS EN 15273 and Railway Group Standards sometimes use the same terms, but with different meanings. The terminology used in one cannot be used to interpret the requirements of the other.

Definitions of standard vehicle gauges specifically intended for use in Great Britain, with application rules for infrastructure and rolling stock, are set out in the relevant Railway Group Standard.

National Annex NA gives the definitions used in Great Britain for some of the key terms used in BS EN 15273.

Mandatory European requirements relating to rolling stock gauges are set out in the High Speed Rolling Stock Technical Specification for Interoperability (HS RST TSI), and the Conventional Rail Locomotive and Passenger Technical Specification for Interoperability (CR LOC+PAS TSI). Both TSIs contain GB specific cases relating to gauging requirements. These should be read in conjunction with BS EN 15273.

Except where a decision has been made to adopt standard European gauges, and to use the associated gauging techniques documented in BS EN 15273, the gauges and gauging practices used on the GB main line railway should continue to be those documented in Railway Group Standards.

BS EN 15273 should be used where a decision has been made to adopt standard European gauges, and to use the associated gauging techniques.

The UK participation in its preparation was entrusted by Technical Committee RAE/1, Railway Applications, to Panel RAE/1/-/12, Railway Applications — Gauging.

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

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Compliance with a British Standard cannot confer immunity from legal obligations.

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English Version

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Applications ferroviaires - Gabarits - Partie 2 : Gabarit
du matériel roulant

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Fahrzeugbegrenzungslinien

This European Standard was approved by CEN on 15 December 2012 and includes Amendment 1 approved by CEN on 25 July 2016.

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Contents

Page

European Foreword	10
Introduction	11
1 Scope	12
2 Normative references	12
3 Terms and definitions	12
4 Symbols	13
5 Common requirements	18
5.1 Static and kinematic gauges	18
5.1.1 Description of the calculation method	18
5.1.2 Vehicle classes	18
5.1.3 Applicability of static and kinematic gauges depending on running gear of the vehicle.....	19
5.1.4 Limitations for the use of static gauges.....	20
5.1.5 Requirements for use of kinematic gauges	20
5.1.6 Dimensional tolerances on vehicles.....	21
5.2 Dynamic methods	21
5.2.1 General principles.....	21
5.2.2 Dynamic method based on a reference profile.....	21
Annex A (normative) Gauge G1.....	23
A.1 General.....	23
A.1.1 Bogie classes	23
A.1.2 Rail-wheel adhesion coefficient	23
A.1.3 Minimum horizontal curve radius	23
A.2 Static gauge G1	24
A.2.1 Reference profiles for the lateral parts and upper parts	24
A.2.2 Reference profiles of the lower part of static gauge G1	25
A.2.3 Associated rules for static gauge G1	26
A.2.4 Reduction formulae	27
A.3 Kinematic gauge G1	28
A.3.1 General.....	28
A.3.2 Reference profiles of the upperparts of gauge G1	29
A.3.3 Reference profiles of the lower part of kinematic gauge G1	29
A.3.4 Determination of the vehicle heights	32
A.3.5 Contact ramps.....	45
A.3.6 Use of shunting devices on curved tracks	47

A.3.7	Conditions for embarkation onto ferries.....	48
A.3.8	Taking account of the transverse displacements of vehicles	49
A.3.9	Formulae.....	51
A.3.10	Reduction formulae applicable to wagons (dimensions in metres)	58
A.3.11	Formulae to be applied for bogies and associated parts.....	60
A.3.12	Verification of gauge of pantographs and non-insulated live parts on vehicle roof.....	61
A.3.13	Pantograph gauge verification for tilting body vehicles or running with $I_p > I_C$	65
A.3.14	Specific rules for doors in the open position and movable steps in the exit position	69
A.3.15	Position of steps.....	69
A.3.16	Tilting vehicles.....	70
A.4	Track operation position of the vehicles: angular displacement coefficient (A).....	79
Annex B (normative)	Gauges GA, GB, GC.....	84
B.1	Common elements with gauge G1.....	84
B.2	Static gauges GA, GB, and GC (loading gauges)	84
B.2.1	Upper part reference profiles	85
B.2.2	Reduction calculation formulae for static gauges GA and GB.....	85
B.2.3	Reduction calculation formulae for static gauges GC	86
B.3	Kinematic gauges GA, GB, and GC	86
B.3.1	Upper part reference profiles	87
B.3.2	Reference profiles for lower parts	87
B.3.3	Formulae for traction units (except motor coaches)	87
B.3.4	Formulae for motor coaches	90
B.3.5	Formulae for coaches and vans	92
B.3.6	Formulae for wagons	94
Annex C (normative)	Gauges GB1, GB2	98
C.1	Static gauges GB1 and GB2	98
C.1.1	Reference profile of static gauge GB1	98
C.1.2	Kinematic gauges GB1 and GB2	100
Annex D (normative)	Kinematic gauge GI3.....	102
D.1	Reference profile GI3	102
D.2	Associated rules for the kinematic reference profile to determine the maximum vehicle profile.....	103
D.2.1	Traction units (except motor coaches)	103
D.2.2	Motor coaches	105
D.2.3	Coaches and vans	106
D.2.4	Wagons.....	108
Annex E (normative)	Gauge G2	111
E.1	Static gauge G2	111
E.1.1	Reference profile for static gauge G2	111

E.1.2	Reference profile of kinematic gauge G2.....	112
Annex F (normative) Finnish gauge FIN1		113
F.1	General.....	113
F.2	Associated rules	113
F.2.1	Vertical position of the vehicle.....	113
F.2.2	Lower parts of the rolling stock	113
F.2.3	Rolling stock parts close to the wheel flanges.....	113
F.2.4	Rolling stock width.....	114
F.2.5	Movable steps and access doors opening outwards for coaches and motor coaches	114
F.2.6	Pantographs and non-insulated roof-mounted parts	114
F.2.7	Rules and instructions	114
F.3	Reduction formulae	114
F.3.1	General rules	114
F.3.2	Reduction formulae	115
F.4	Reference profiles of gauge FIN1.....	116
F.5	Increase in the minimum height of the lower part of the rolling stock able to pass over marshalling humps and rail brakes	117
F.6	Increase in the minimum height of the lower part of the rolling stock unable to pass over marshalling humps and rail brakes	117
F.7	Passage over transitions and humps.....	118
F.7.1	Position of rail brakes and other shunting devices	118
F.7.2	Running over marshalling hump passing track	119
F.8	Gauge of the vehicle lower step.....	119
F.8.1	General.....	119
F.8.2	Requirements for the distance between the step and the platform in the transverse plane....	120
F.8.3	Gauge check.....	120
F.9	Gauge of outwards opening doors and of folded down steps for coaches and motor coaches.....	120
F.9.1	General.....	120
F.9.2	Requirements for the distance between the door and the fixed equipment in the transverse plane	121
F.9.3	Gauge check.....	121
F.10	Pantographs and non-insulated parts	122
Annex G (normative) French gauge FR 3.3		123
G.1	General.....	123
G.2	Reference profile of kinematic gauge FR 3.3	124
G.3	Reference kinematic profiles for lower parts.....	124
G.4	Associated rules for kinematic gauge FR 3.3 for determining the kinematic gauge.....	124
G.4.1	Vertical reductions.....	124
G.4.2	Transversal reductions for heights $h > 3,250$ m	125
G.4.3	Verification of gauge of pantographs and non-insulated live parts on vehicle roof	130

Annex H (normative) Belgian gauges BE1, BE2 and BE3	131
H.1 General	131
H.2 Associated rules	131
H.2.1 Rules for the lower parts	131
H.2.2 Upwards vertical displacements	131
H.2.3 Side doors in the open position	132
H.2.4 Movable step rules	132
H.2.5 Pantograph rules	132
H.3 Kinematic reference profiles for the upper parts	133
H.4 Reduction formulae	135
H.4.1 Reduction formulae for traction units	135
H.4.2 Reduction formulae for hauled vehicles	138
H.5 Kinematic gauge of the 3 kV and 25 kV pantograph in the collection position on the Belgian network	141
H.5.1 General principles	141
H.5.2 Verification of pantographs located between the end wheelsets or between the bogie centres (verification of stationary vehicle on a canted track)	141
H.5.3 Verification of pantographs located beyond the end wheelsets or beyond the bogie centres (verification in operation on an insufficiently canted track)	142
H.5.4 Pantographs in the lowered position	142
H.5.5 Other non-insulated roof-mounted parts	142
Annex I (normative) Portuguese gauges PTb, PTb+, PTc	144
I.1 General	144
I.2 Kinematic reference profiles	145
I.3 Reference profiles for the lower part	147
I.4 Associated rules for PT gauges	148
I.4.1 Vertical displacements	148
I.4.2 Transverse displacements	148
I.4.3 Associated rules for the parts of height $h < 400$ mm above the running surface	148
I.4.4 Reduction formulae	149
I.5 Associated rules for pantographs and other roof-mounted parts	153
I.5.1 Reference profile for pantographs	153
I.5.2 Pantograph in collecting position	154
I.5.3 Pantograph in the lowered position and other roof-mounted parts	155
I.6 Associated rules for tilting body vehicles	155
I.6.1 Quasi-static displacements (z_p)	155
I.6.2 Calculation of the reductions	156
I.6.3 Requirement for adjusting the tilting system for vehicles fitted with active systems	157
I.6.4 Limits related to the speed of tilting body vehicles	158
Annex J (normative) Swedish gauges SEa and SEc	159

J.1	Swedish dynamic gauges SEa and SEc: General	159
J.2	Reference profiles.....	160
J.3	Reference profile of gauge SEa.....	160
J.4	Reference profile for lower part of gauges SEa and SEc	161
J.5	Pantograph reference profile for gauge SEa	161
J.6	Dynamic reference profile SEc.....	162
J.6.1	Reference profile for parts below 0,15 m of gauge SEc	162
J.6.2	Reference profile for pantograph for gauge SEc	163
J.7	Methodology for calculating movements by means of geometric formulae	163
J.7.1	Curves in the horizontal plane	164
J.7.2	Straight track.....	166
J.7.3	Vertical curves, calculation of upper parts	167
J.7.4	Calculation of the lower parts	168
J.7.5	Marshalling humps	169
J.7.6	Ferry ramps	169
J.7.7	Pantograph	170
J.7.8	Swept envelope.....	170
J.8	Methodology for calculating movements by simulation	171
J.8.1	Modelling and simulations.....	173
J.8.2	Parameters to be considered in the simulations.....	173
J.8.3	Cases of simulation	174
J.8.4	Horizontal curves.....	174
J.8.5	Straight track.....	174
J.8.6	Running over points.....	175
J.8.7	Track parameters	175
J.8.8	Calculation parameters	175
J.8.9	Statistical post-processing.....	176
J.8.10	Geometric overthrow in a horizontal curve	176
J.8.11	Vertical geometric movement towards the upper part of the profile	177
J.8.12	Vertical geometric movement towards the lower part of the profile	177
J.8.13	Marshalling humps	178
J.8.14	Ferry ramps	179
J.8.15	Pantographs	179
J.8.16	Swept envelope.....	180
J.9	Checking relative to the permitted reference profile	180
J.10	Dynamic gauging method: verification	180
J.10.1	Verification by simulation	181
J.10.2	Verification by static testing.....	181
J.10.3	Verification by on-line running tests	182

J.10.4	(Informative) Dynamic gauge: Irregularities	182
J.11	(Informative) Two-dimensional statistical post processing.....	183
J.12	(Informative) Input data catalogue.....	184
Annex K	(normative) Static gauges OSJD	186
K.1	Static reference profiles of the upper parts (for rolling stock)	186
K.2	Associated rules	188
K.2.1	Additional overthrows for $h \geq 3,220$ m	188
K.2.2	Reduction formulae	188
K.3	Determination of the allowable vertical dimensions	190
K.4	Static reference profiles for the lower parts	191
Annex L	(normative) German gauges DE1, DE2, DE3	193
L.1	Gauge DE1	193
L.1.1	Kinematic reference profile	193
L.1.2	Associated rules	194
L.2	Kinematic gauge DE2.....	195
L.2.1	Kinematic reference profile	195
L.2.2	Associated rules	196
L.3	Kinematic gauge DE3.....	197
L.3.1	Kinematic reference profile	197
L.3.2	Associated rules	197
L.4	Absolute gauging of pantographs.....	198
L.4.1	General	198
L.4.2	Associated rules	198
L.4.3	Contact wire	200
L.4.4	Responsibility for input data	200
Annex M	(normative) Netherlands gauges NL1 and NL2	203
M.1	Reference profiles of kinematic gauges NL1 and NL2	203
M.2	Associated rules	204
Annex N	(Informative) UK gauging methods.....	205
N.1	General	205
N.1.1	Gauge types	205
N.1.2	Maintenance	205
N.1.3	Tolerances	205
N.1.4	Multiple operation.....	205
N.1.5	Configuration	205
N.1.6	Reference axes	206
N.1.7	Vehicle data.....	206
N.2	Static gauging	206
N.2.1	Principles.....	206

N.2.2	Vehicle geometry	207
N.2.3	Suspension displacements	208
N.3	Dynamic gauging	209
N.3.1	Principles	209
N.3.2	Geometric gauging	209
N.3.3	Absolute gauging.....	211
N.3.4	Comparative gauging	213
N.3.5	Vehicle shape and size.....	216
N.3.6	Range of operating conditions.....	217
N.3.7	Suspension movements	219
N.3.8	Calculating swept envelopes.....	220
N.3.9	Dynamic reference profiles.....	228
N.3.10	Assessing the vehicle	230
N.4	UK geometric gauges.....	231
Annex O (Informative)	Recommended practice for dynamic gauging	232
O.1	Vehicle models.....	232
O.1.1	Principles.....	232
O.1.2	Vehicle conditions	232
O.1.3	Masses	232
O.1.4	Suspension modelling	233
O.1.5	Stiffness.....	233
O.1.6	Dampers.....	233
O.1.7	Air springs	233
O.1.8	Swing links	234
O.1.9	Friction.....	234
O.1.10	Active devices	234
O.1.11	Inter-vehicle connections	234
O.1.12	Suspension component tolerances	235
O.1.13	Suspension maintenance allowances	235
O.1.14	Suspension failure modes	235
O.1.15	Vehicle modelling accuracy.....	235
O.2	Validation of vehicle modelling	235
O.2.1	General notes on validation tests	235
O.2.2	Simulation model	237
O.2.3	Matching accuracy.....	238
O.2.4	Weighbridge test.....	238
O.2.5	Bogie rotation test	239
O.2.6	Sway test	239
O.2.7	Dynamic ride test.....	240

O.3	Simulation method	241
O.3.1	Principles.....	241
O.3.2	Dynamic analysis	241
O.3.3	Track data.....	242
O.3.4	Cant, speed and curve radius: general cases	242
O.3.5	Cant, speed and curve radius: specific cases.....	243
O.3.6	Application of cant and curve radius	243
O.3.7	Side wind loads	243
O.3.8	Transient outputs	244
O.3.9	Curving analysis.....	246
O.4	Example of a virtual route.....	247
O.5	Example of a drawing showing vehicle size and shape	250
O.6	Presentation of swept envelope data	251
O.6.1	Presentation of results.....	251
O.6.2	Heading format	251
O.6.3	Transient results matrix.....	252
O.6.4	Curving results matrix	253
Annex P (normative)	Spanish gauges GHE16, GEA16, GEB16, GEC16, GEC14, GEE10 and GED10 ..	254
P.1	General	254
P.2	Static gauges GHE16, GEA16, GEB16, GEC16, GEE10 and GED10.....	255
P.2.1	Reference profiles for static gauges	255
P.2.2	Associated rules.....	263
P.3	Kinematic gauges GHE16, GEA16, GEB16, GEC16, GEC14, GEE10 and GED10	266
P.3.1	Reference profiles for kinematic gauges.....	266
P.3.2	Associated rules.....	275
Annex Q (normative)	Vehicle widening depending on the available spaces of the infrastructure.....	293
Annex R (normative)	Static and kinematic gauges: list of documents for a vehicle gauge conformance certification.....	294
R.1	General	294
R.2	List of documents to be produced for design control.....	294
R.3	List of documents to be taken into account to verify conformity to the gauge.....	294
Annex S (informative)	A–deviations.....	296
Annex ZA (informative)	Relationship between this European Standard and the Essential Requirements of EU Directive 2008/57/EC 	298
Bibliography		303

European Foreword

This document (EN 15273-2:2013+A1:2016) 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 May 2017, and conflicting national standards shall be withdrawn at the latest by May 2017.

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

This document includes amendment 1 adopted by CEN on 25 July 2016.

This document replaces A1 EN 15273-2:2013 A1.

The beginning and end of added or modified text is indicated by the following references: A1 A1

A1 This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports the essential requirements of EU Directive 2008/57/EC. A1

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

A1 *deleted text* A1

Common rules for infrastructure and rolling stock according to EN 15273-1 are applicable.

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, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

EN 15273 comprises three parts, namely:

- EN 15273-1 that covers general definitions and the rules applicable to rolling stock and structure gauges;
- EN 15273-2 that gives the rules for calculating the rolling stock gauges and the associated rules for the various profiles;
- EN 15273-3 that gives the definition for the structure gauges. It explains the parameters concerned and gives a possible methodology for determining the structure gauges and the distances between centres of the tracks.

The gauges included in these standards have been developed as part of their application on European railways. Other networks such as regional, local, urban and suburban networks may apply the gauge regulations defined in this standard. They may be required to make use of specific methodologies, particularly where:

- specific rolling stock is used (for example: underground trains, trams, etc. operating on two rails);
- the range of curve radii is different;
- others, etc.

The catalogue included in this European Standard only includes a selection of gauges and is not exhaustive. Each network is free to define the gauges in accordance with their own needs.

1 Scope

This document is applicable to the authorities involved in all types of railway operation.

This European Standard is applicable to new vehicle designs, to modifications and to the checking of the gauge for vehicles already in use.

The application of the rules of this European Standard makes it possible to determine the maximum dimensions of vehicles related to the structures.

This European Standard contains:

- the associated rules for all the gauges for rolling stock;
- the requirements for composing the technical gauge report to submit to the Acceptance Authority in order to confirm vehicle conformity to this standard;
- the requirements for maintaining the vehicle characteristics influencing gauging throughout its operational life.

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 12299, *Railway applications — Ride comfort for passengers — Measurement and evaluation*

EN 14363:2005, *Railway applications — Testing for the acceptance of running characteristics of railway vehicles — Testing of running behaviour and stationary tests*

EN 15273-1:2013, *Railway applications — Gauges — Part 1: General — Common rules for infrastructure and rolling stock*

EN 15273-3:2013+A1:2016, *Railway applications — Gauges — Part 3: Structure gauges*

EN 15663 +A1:2016, *Railway applications — Definition of vehicle reference masses*

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3 Terms and definitions

For the purposes of this document, the following terms and definitions specific to part 2 apply.

3.1 empty vehicle

vehicle load state: definition according to EN 15663

3.2 [.....]₀

value to be considered only when it is positive; negative values are regarded as being equal to zero

3.3 |...|

mathematical absolute value

4 Symbols

For the purposes of this document, the symbols and abbreviations given in Table 1 are applicable.

Table 1 — Symbols and abbreviations (drawn from part 1)

Symbol	Designation	Unit
a	Distance between end wheelsets of vehicles not fitted with bogies or between bogie centres	m
A	Coefficient of displacement	
b	Semi-width or distance parallel to the running surface, relative to the track centreline or of the vehicle	m
b_1	Semi-width of the primary suspension springs	m
b_2	Semi-width of the secondary suspension springs	m
b_G	Semi-spacing of side bearers	m
b_{lac0}	Standard width of the gap between the platform and the step	m
b_{lac}	Horizontal gap between the platform and step	m
$b_{obstacle}$	Distance parallel to the running surface between the structure and the track centreline	m
b_q	Semi-width of the platform installation	m
b_{q0}	Semi-width of the standard platform installation	m
b_{q0a}	Semi-width of the standard platform installation on the outside of a curve	m
b_{q0i}	Semi-width of the standard platform installation on the inside of a curve	m
b_w	Semi-width of the pantograph head	m
C	Roll centre	
CR	Reference profile	
d	Dimension over wheel flanges	m
dg_a	Geometric overthrow of the vehicle on the outside of the curve	m
dg_{amax}	Maximum geometric overthrow allowed on the outside of the curve	m
dg_{av}	Vertical geometrical offset for parts of the vehicle positioned outboard of the wheelsets	m
dg_i	Geometric overthrow of the vehicle on the inside of the curve	m

Table 1 (continued)

Symbol	Designation	Unit
$dg_{\max}$	Maximum geometric overthrow allowed on the inside of the curve	m
dg_{iv}	Vertical geometrical offset for parts of the vehicle positioned between the wheelsets	m
D	Cant	m
D_{pl}	Transverse displacement	m
e_a	Vertical reduction on the outside of the curve	m
e_i	Vertical reduction on the inside of the curve	m
e_p	Offset of the pantograph due to the vehicle characteristics	m
e_{po}	Offset of the pantograph at the upper verification point	m
e_{pu}	Offset of the pantograph at the lower verification point	m
e_v	Lowering of track components	m
E	Transverse reduction relative to the reference profile	m
E_a	Transverse reduction relative to the reference profile for cross-sections beyond the outermost wheelsets or beyond the bogie centres	m
E_i	Transverse reduction relative to the reference profile for cross-sections between the outermost wheelsets or between the bogie centres	m
E_{fra}	Width to be cleared for the projection of collector shoes on the outside of a curve	m
E_{fri}	Width to be cleared for the projection of collector shoes on the inside of a curve	m
h	Height in relation to the running surface	m
h_c	Roll centre height	m
h_o	Height of the tilting body rotation centre	m
$h_{o\min}$	Minimum height specified for the vertical geometric displacements of the rolling stock below the reference profile according to the vertical curve of the track	m
h_p	Height of the tilting pantograph rotation centre	m
h_q	Height of the platforms	m
h_t	Installation height of the lower pantograph joint in relation to the running surface	m
$h_{u\min}$	Minimum height specified for the vertical geometric displacements of the rolling stock above the reference profile according to the vertical curve of the track	
I	Cant deficiency	m
I'_c	Intermediate cant deficiency value between 0 and I_c	m

Table 1 (continued)

Symbol	Designation	Unit
I'_p	Intermediate cant deficiency value taken into account for tilting body vehicles	m
I_c	Maximum cant deficiency value for non-tilting vehicles set by the infrastructure	m
I_{max}	Maximum cant deficiency	m
I_p	Cant deficiency of tilting body vehicles	m
j	Minimum vertical reference clearance at the level of the side bearers	m
j'_a	Additional transverse clearances, towards the outside of the curve, relative to those of the reference vehicle	m
j'_i	Additional transverse clearances, towards the inside of the curve, relative to those of the reference vehicle	m
J	Actual vertical clearance at the level of the side bearers	m
l	Track gauge, distance between the rail running edges	m
l_N	Nominal track gauge	m
l_{max}	Maximum track gauge	m
L	Standard distance between the centrelines of the rails of the same track	m
m_P	Transverse gauge engagement authorized for an open door	m
m_E	Transverse gauge engagement authorized for an extended step	m
n	Distance from the section under consideration to the adjacent end wheelset or to the closest centre	m
n_a	n for the sections outside the wheelsets or bogie centres	m
n_i	n for the sections between the wheelsets or bogie centres	m
n_μ	Distance from the section under consideration to the motor bogie centre of motor coaches	m
p	Bogie wheelbase	m
p'	Carrying bogie wheelbase of motor coaches	m
P_o	Reduction at the upper verification point of the pantographs	m
P_{oa}	Reduction at the upper verification point of the pantographs beyond the bogie centres	m
P_{oi}	Reduction at the upper verification point of the pantographs between the bogie centres	m
P_u	Reduction at the lower verification point of the pantographs	m

Table 1 (continued)

Symbol	Designation	Unit
P_{ua}	Reduction at the lower verification point of the pantographs beyond the bogie centres	m
P_{ui}	Reduction at the lower verification point of the pantographs between the bogie centres	m
q	Transverse clearance between wheelset and bogie frame, or wheelset and body for vehicles not fitted with bogies	m
q^s	Displacement due to the quasi-static roll taken into account by the infrastructure	m
R_{min}	Minimum curve radius	m
R_p	Radius corresponding to the maximum roll of a tilting body vehicle	m
R_v	Vertical curve radius of longitudinal profile	m
s	Flexibility coefficient	
s_0	Flexibility coefficient value taken into account in the agreement between the rolling stock and the infrastructure	
s_n	Flexibility coefficient of the pantograph carrying structure	
s'_0	Flexibility coefficient taken into account in the agreement between the rolling stock and the infrastructure for the pantograph gauge	
s_{lim}	Limit value of the flexibility coefficient	
S	Allowed additional overthrow	m
S_0	Standard value of additional overthrow linked to the reference profile	m
t	Transverse displacement caused by the flexibility of the pantograph raised to 6,50 m and under the influence of a transverse force of 300 N at the head level.	m
v	Vehicle speed	m/s
V	Vehicle speed	km/h
V'_c	Intermediate value of the standard train speed	km/h
V'_p	Intermediate value of the tilting train speed	km/h
w	Transverse clearance between bogie and body	m
w_∞	Transverse clearance between bogie and body on a straight track	
$w_{a(R)}$	Transverse clearance between bogie and body towards the outside of the curve varying according to the track curve radius	m
$w_{i(R)}$	Transverse clearance between bogie and body towards the inside of the curve varying according to the track curve radius	m
w'_∞	Transverse clearance between aligned bogie and body for bogies carrying motor elements	

Table 1 (continued)

Symbol	Designation	Unit
$w'_{a(R)}$	Transverse clearance between bogie and body towards the outside of the curve varying according to the track curve radius for bogies carrying motor elements	m
$w'_{i(R)}$	Transverse clearance between bogie and body towards the inside of the curve varying according to the track curve radius for bogies carrying motor elements	m
x	Distance taken into account from the point of origin O for the calculation of e_v	m
x_a	Additional reduction for long vehicles beyond the bogie centres	m
x_i	Additional reduction for long vehicles between the bogie centres	m
y	Distance between the theoretical centre and the geometric centre of the bogie – see below	m
z	Part of transverse displacement caused by the quasi-static roll taken into account by the rolling stock	m
z'	Difference between the transverse roll based on the calculation and the actual roll of the upper verification point of the pantograph	m
z''	Difference between the transverse roll based on the calculation and the actual roll of the lower verification point of the pantograph	m
z'_P	Difference between calculated transversal roll and actual roll at the upper verification point of the pantograph mounted on a vehicle with a tilting body or which is submitted to $I_P > I_C$	m
z''_P	Difference between calculated transversal roll and actual roll at the lower verification point of the pantograph mounted on a vehicle with a tilting body or which is submitted to $I_P > I_C$	m
z_{cin}	Part of transverse displacement caused by the quasi-static roll and taken into account by the rolling stock in the case of the kinematic gauge	m
α	Additional angle of roll of the body due to the clearance to the side bearers	degree
α''	Angle made by the gangway between the platform and the ferry	degree
γ	Centrifugal acceleration	m/s ²
Δ_a	Fixed term corresponding to: $n_a(a + n_a) - \frac{p^2}{4}$	m ²
Δ_i	Fixed term corresponding to: $n_i(a - n_i) + \frac{p^2}{4}$	m ²
δ	Angle of roll of the canted track	degree
λ	Angle made by the straight line joining the centre of gravity at the roll centre with the vertical	degree
μ	Rail-wheel adhesion coefficient	
η	Angle of roll of the vehicle relative to the running surface	degree

Table 1 (continued)

Symbol	Designation	Unit
η_0	Angle of dissymmetry of a vehicle due to construction tolerances, to suspension adjustment and to unequal load distributions	degree
η'_0	Angle of dissymmetry of a vehicle in which the clearance to the side bearers does not exceed j	degree
θ	Angle resulting from the suspension adjustment tolerances of the vehicle	Radian
τ	Pantograph construction and installation tolerance: deviation tolerated between the vehicle body centreline and the middle of the head raised to 6,5 m without any transverse force	m

5 Common requirements

- It is mandatory to respect the association specified in each gauge between its profile and its associated rules.
- Even though a vehicle does not or does not totally meet the requirements of this standard, it can be approved for operation with limitations. It is not then compatible with all the Infrastructures cleared for the same name gauge. Although the general framework is that of the TSI gauges, it is possible that the vehicle may not meet the interoperability requirements from the gauge point of view.
- Where the vehicle is intended to be operated separately or in multiples, it shall meet the requirements of this document both individually and when forming a part of a train. Where the vehicle may be coupled permanently, this unit shall also meet the requirements of this standard.
- The vehicle characteristics that influence the gauge shall be maintained throughout the operational life of the vehicle and shall be stated in the maintenance documentation, including the factors influencing displacements and their limiting or maximum values (e.g. limits of wear on suspension components).
- Wear limits and tolerances of all parts, equipment and systems influencing dynamic movements of the vehicle shall be included in the documents provided by the manufacturer for approving the use of the vehicle (see Annex R).

5.1 Static and kinematic gauges

5.1.1 Description of the calculation method

Taking into account the transverse displacements of vehicles (specified in the associated rules for each gauge), the half-widths of the vehicles considered shall not exceed the corresponding half-width of the reference profile of the gauge, reduced by the values E_i or E_a calculated by applying the formulae given in this European Standard.

Reductions E_i and E_a shall be taken at their positive values or 0, if negative.

5.1.2 Vehicle classes

In order to apply the correct formulae to each kind of vehicle, the vehicles have been classified as follows:

- locomotive: traction unit equipped with motor bogies. These are not intended to carry passengers or goods;

NOTE 1 From the gauge point of view, powered non-bogie locomotives are considered to be equivalent to non-bogie wagons.

- coach: trailer vehicle designed to carry passengers, equipped with carrying axles or bogies;

NOTE 2 From the gauge point of view, non-bogie coaches are considered to be equivalent to non-bogie wagons.

- van: trailer vehicle designed to carry goods, to be inserted in the composition of passenger trains;

NOTE 3 From the gauge point of view, non-bogie vans are considered to be equivalent to non-bogie wagons.

- wagon: trailer vehicle designed to carry freight. In this standard, formulae relating to wagons with bogies refer to a body-bogie link ensured by a centre bearing and side-bearers;

- special wagons: wagons whose loading surface height above the rail is reduced to allow maximum loading capacities in the vertical direction. This category includes what are sometimes called low floor wagons: pocket wagons, “rolling-road” wagons and similar wagons. Special wagons do not meet all requirements for wagons, so they are subjected to various restrictions related to the gauge, such as the prohibition of running on certain marshalling humps or ferry embarkation ramps.

- motor coach: traction unit carrying passengers or goods, with one or two motor bogies;

NOTE 4 From the gauge point of view, non-bogie motor coaches are considered to be equivalent to non-bogie wagons.

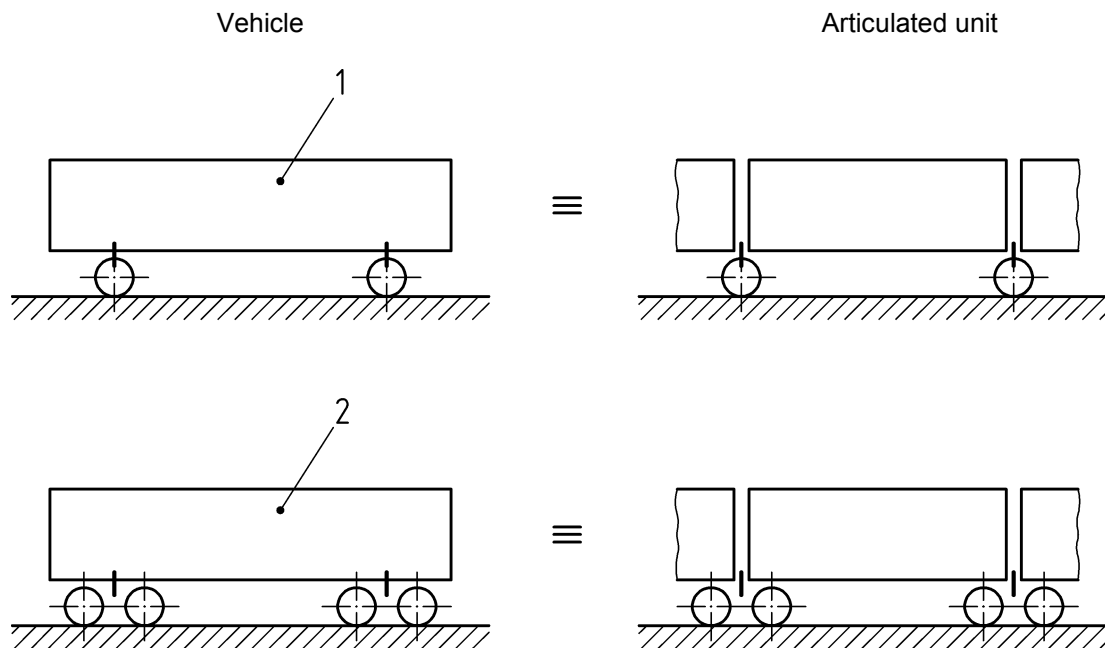
- vehicles with no fixed bogie centres.

In the case of vehicles without fixed bogie centres, in order to determine the a and n values, the intersection of the bogie longitudinal centreline with that of the vehicle body will be considered as a theoretical centre, determined graphically, when the vehicle is on a 150 m radius curve, the clearance effects being evenly distributed and the wheelsets centred on the track: if y is the distance from this theoretical centre to the geometrical centre of the bogie (at an equivalent distance from the two outermost wheelsets), p^2 shall be replaced by $(p^2 - y^2)$, and p'^2 by $(p'^2 - y^2)$ in the formulae.

5.1.3 Applicability of static and kinematic gauges depending on running gear of the vehicle

The static and kinematic gauges given in this European Standard are generally applicable to vehicles whose running gear is shown below (see Figure 1).

- vehicles not fitted with bogies with the body sprung on two wheelsets. In the case of vehicles with bodies sprung on a number of different axles, it will be necessary to adapt the formulae to the actual geometric conditions;
- bogie vehicles with the body sprung on two bogies with two wheelsets. In the case of vehicles with more than two bogies or fitted with bogies with more than two axles or fitted with one bogie and one axle, it will be necessary to adapt the formulae to the actual geometric conditions;
- articulated unit: Figure 1 illustrates the calculation equivalence between non-bogie and bogie vehicles with symmetrical articulated units.



Key

- 1 2-wheelsets
- 2 2-bogie

Figure 1 — Correspondence between separate vehicles and articulated units

Formulae given in this European Standard for static and kinematic gauges will not apply to other kinds of articulated units. The user will have to determine new formulae suitable for the actual geometric configurations.

5.1.4 Limitations for the use of static gauges

The use of static gauges is allowed only if the flexibility coefficient of the vehicle is less than the limit value as indicated in the associated rules for each static gauge (0,2 for G1, 0,3 for GA, GB, GB1, GB2 and GC etc.).

If the flexibility coefficient of the vehicle is greater than the limit value, it is mandatory to use other gauges, kinematic or dynamic, that take into account the extra inclination in respect to maximum values allowed for static gauges.

5.1.5 Requirements for use of kinematic gauges

- a) The formulae specified in each kinematic gauge shall be applied by introducing all the “worst case” parameters, i.e. with their maximum values (e.g. clearances, transverse and vertical displacements etc.) while taking realistic combinations of the parameters into account.
- b) If, as a departure from the above point, a vehicle is designed using one or several parameters with their optimized value (an optimized value, or one encountered during operation), the gauge documents file shall be submitted to the authority responsible for conformity assessment in the form of simulation analysis reports, test reports, risk analyses etc. In this case, the whole range of situations (e.g. maximum operating speed, maximum cant deficiency, dynamic displacements, load states etc.) shall be taken into account. It should be noted that this procedure could result in a vehicle being specified that would not be compatible with all infrastructures even if they fit the gauge of the same name.

If the vehicle examined does not completely meet the requirements of this European Standard, each case shall be documented to evaluate the effects and the gauge documents will have to be approved by the authority for gauging acceptance.

- c) Kinematic gauges apply also to open wagons plus load units. In this case, the flexibility coefficient of the load itself shall be taken into account, adding it to the flexibility of the suspension of the wagon itself.

In these conditions, the “load + wagon” unit can be regarded as a current type wagon.

- d) Wagons loaded with containers and swap bodies (transported on carrier wagons equipped with load fixing devices) and semi-trailers (transported on pocket wagons) are examples of the above application.

Measurement of the flexibility coefficient: EN 14363 explains the procedure for measuring the flexibility coefficient of a vehicle. This shall be adopted to meet the requirements of this European Standard.

5.1.6 Dimensional tolerances on vehicles

These tolerances are the differences between the nominal dimensional values and the values that construction technology actually allows to be attained.

The dimensions of finished vehicles shall remain within the maximum construction gauge of the vehicle.

For kinematic gauges covered by this European Standard, a part of vehicle tolerances can be ignored, up to:

- 0,01 m on the heights of upper and lower parts;
- 0,002 5 m for semi-widths *b*.

This allowance cannot be adopted to increase the nominal dimensions of the vehicles systematically.

The vehicle construction tolerances shall be specified in a dimensional specification (see Annex R).

5.2 Dynamic methods

5.2.1 General principles

Safe operation of rolling stock on a railway network calls for the maintenance of adequate clearances between the vehicles and the adjacent infrastructure and between vehicles on adjacent tracks.

These clearances are obtained by subtracting from the infrastructure and other structures situated along the tracks the dynamic gauge of the rolling stock and the distance between this and the structures.

This European Standard contains:

- a) a list of principle reference profiles for the dynamic method existing in Europe together with their associated rules to calculate the maximum dimensions of rolling stock;
- b) the associated rules for the absolute method to calculate maximum dimensions for rolling stock.

5.2.2 Dynamic method based on a reference profile

A dynamic reference profile is a given general cross-section that the vehicles shall not exceed under specified conditions.

A vehicle swept envelope shall be calculated by defining the maximum vehicle space to be occupied under normal service and fault conditions. This envelope shall remain within the dynamic reference profile on networks where the rolling stock is required to operate.

The gauging methodology according to this European Standard describes two different ways of calculating the movements of the rolling stock.

1) Movement calculation by geometric formulae:

Geometric formulae generate extreme movement data for selected cases and cross-sections in order to enable a preliminary vehicle sizing or a simplified gauging procedure.

2) Movement calculation by simulation:

Dynamic simulations generate a matrix of extreme vehicle movement data relative to the track centreline for combinations of curve radii and cant deficiency or excess. Movements are calculated for each vehicle of the train in each load/suspension condition by generating time-dependent data for significant points at selected cross-sections. The movements of these points shall be statistically assessed according to the method specific to each dynamic gauge.

Whatever calculation method is selected for the vehicle movements, it will be possible to include the effects mentioned below in the calculations or to add them to the calculated movements:

- nominal dimensions of the rolling stock;
- geometric overthrow on curves (in the horizontal plane or in the vertical plane);
- vehicle tolerances and maintenance limits;
- excessive dissymmetry of the vehicle inclination, ($\eta_0 > 1^\circ$);
- deflection under load;
- suspension displacement and wear;
- wheel radius differences between bogies or wheelsets;
- adjustment devices to compensate for varying wheel diameters as well as suspension displacement and wear;
- pantograph flexibility.

Finally, the vehicle swept envelope is checked against the corresponding dynamic reference profile.

Annex A (normative)

Gauge G1

A.1 General

A.1.1 Bogie classes

Bogies are classified as follows:

- motor bogie: bogie, the wheelsets of which are considered as powered (adhesion coefficient $\mu \geq 0,2$);
- carrying bogie: bogie, the wheelsets of which are not considered as powered (adhesion coefficient $\mu < 0,2$);
- mixed bogie: bogie with powered wheelset and carrying axle.

The definition of the adhesion coefficient is given in the following subclause.

A.1.2 Rail-wheel adhesion coefficient

Adhesion coefficient is:

$$\mu = \sqrt{\left(\frac{F_w}{g \cdot M_e}\right)^2 + 0,0045} \quad (\text{A.1})$$

Symbols:

g = acceleration due to gravity (9,81 m/s²);

F_w = the maximum traction force at the wheel rim, in N;

M_e = mass per wheelset, in kg;

If $\mu < 0,2$, the bogie is considered to be the carrying type;

If $\mu \geq 0,2$, the bogie is considered to be the motor type.

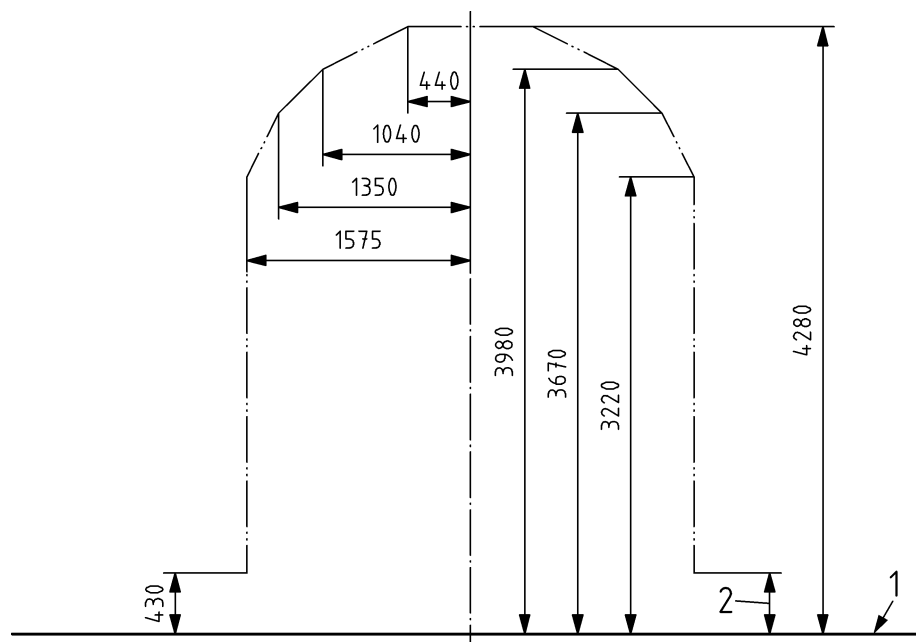
A.1.3 Minimum horizontal curve radius

Gauge G1 takes into account a minimum curve radius of 150 m even if the vehicle under study can move over even smaller curve radii.

A.2 Static gauge G1

A.2.1 Reference profiles for the lateral parts and upper parts

Dimensions in millimetres



Key

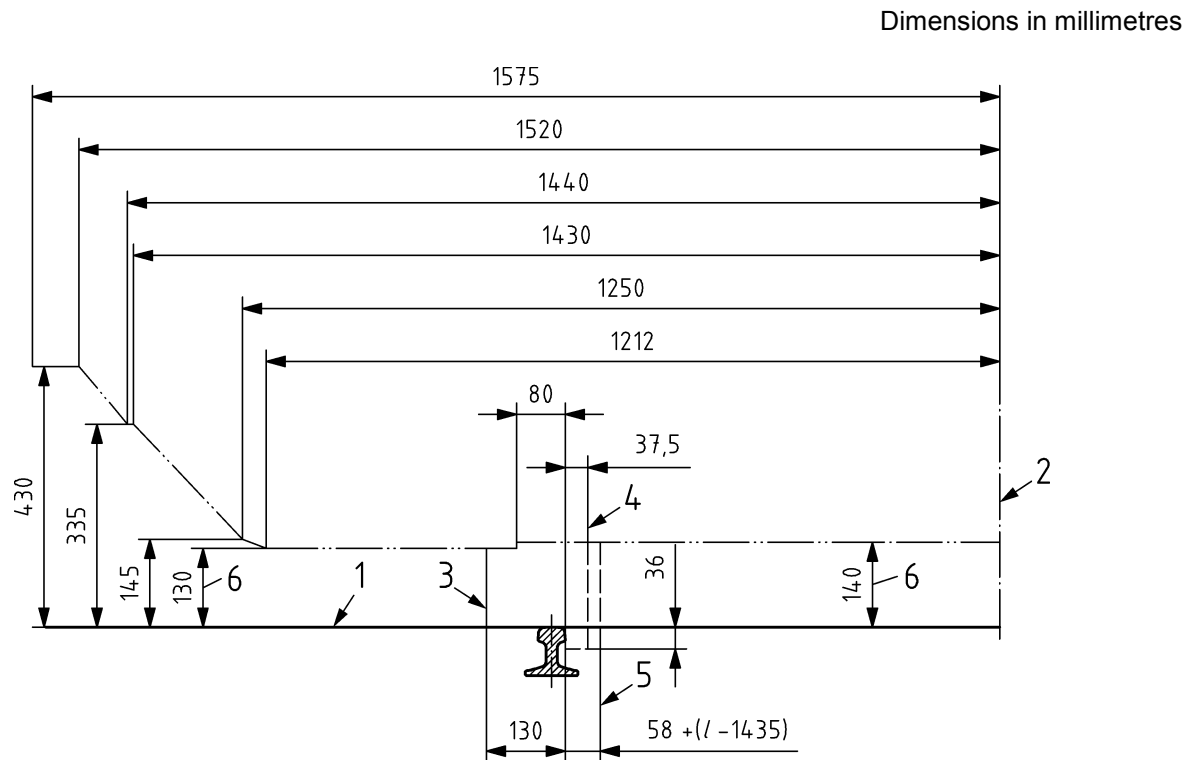
- 1 running surface
- 2 lower parts according to A.2.2

Figure A.1 — Reference profile for static gauge G1

A.2.2 Reference profiles of the lower part of static gauge G1

A.2.2.1 Static reference profile G11 of the lower parts

The G11 profile applies to vehicles passing over marshalling humps, rail brakes or other shunting and stopping devices (see Figure A.2).



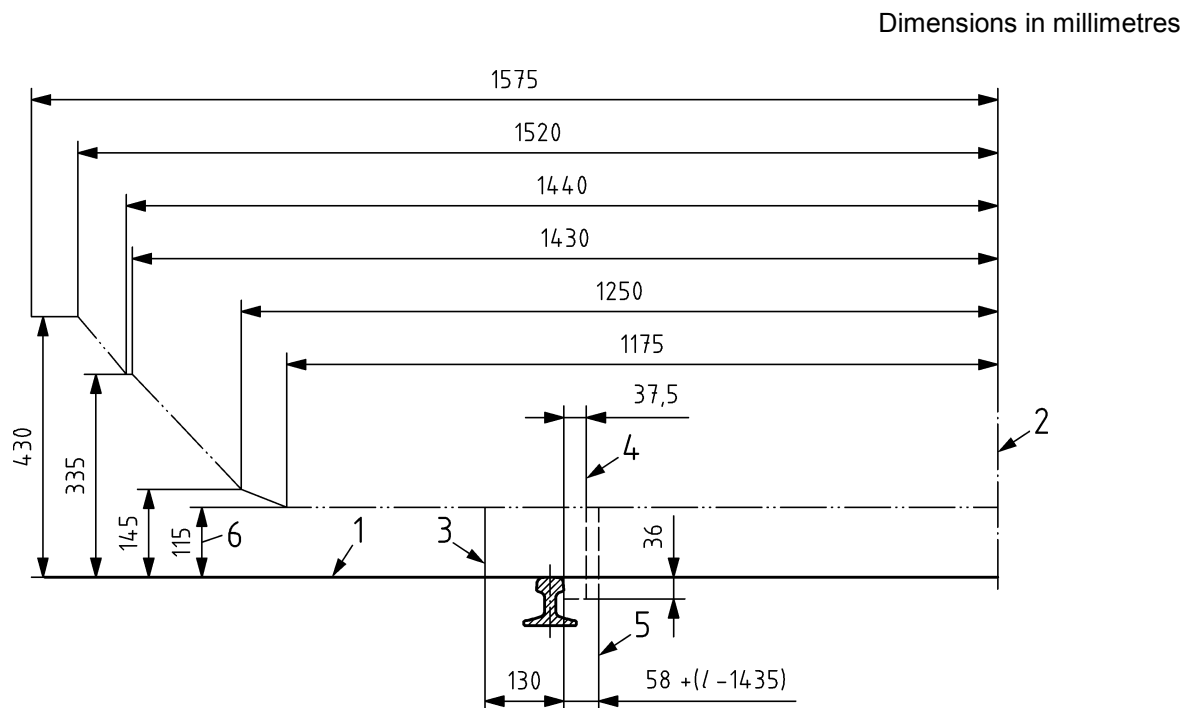
Key

- 1 running surface
- 2 centreline of the reference profile
- 3 limit position of the outer surface of the wheel
- 4 theoretical maximum width of the flange profile, taking into account the possible angle of the wheelsets on the track
- 5 effective position of the inside surface of the tyre when the opposite wheel is in flange contact
- 6 It should be noted that these values can be reduced by 15 mm for unsprung parts. The thus defined bodies can interfere with the deployment zone for combined drag shoes up to a distance of 950 mm from the vehicle centreline (see zone C for kinematic profile G11).

Figure A.2 — Reference profile of the lower parts of static gauge G11

A.2.2.2 Static reference profile G12 of the lower parts

The G12 profile applies to vehicles not passing over marshalling humps or rail brakes in an active position (see Figure A.3).



Key

- 1 running surface
- 2 centreline of the reference profile
- 3 limit position of the outer surface of the wheel
- 4 theoretical maximum width of the flange profile, taking into account the possible angle of the wheelsets on the track
- 5 effective position of the inside surface of the tyre when the opposite wheel is in flange contact
- 6 values which can be reduced by 15 mm for unsprung parts

Figure A.3 — Reference profile of the lower parts of static gauge G12

A.2.3 Associated rules for static gauge G1

A.2.3.1 Usage limits for static gauge G1

The static gauge can be used under the following conditions:

- For all vehicles in which:
 - the vehicle's flexibility coefficient does not exceed $s_{lim} = 0,2$;
 - downward dynamic displacements do not exceed 30 mm for sprung bodies located at a height exceeding 0,430 m and 15 mm for bodies located below this level;

- Additional conditions for wagons:
 - if the clearance to the side bearers does not exceed 5 mm;
 - if there is only a single suspension stage;
 - if the vehicle does not possess a particularly flexible chassis.

For any other cases, a kinematic or dynamic gauge shall be used.

A.2.3.2 Vertical downwards displacements

The vertical displacements to be taken into account to determine the minimum height of parts situated up to 0,43 m above the running surface are:

- wear of wheels and of suspension components;
- suspension displacement under design mass under exceptional load.

Unsprung bodies, or bodies which, after bottoming the suspension, do not undergo oscillations in which bending can exceed the downward reference profile by 15 mm.

All rolling stock which use the G12 profile shall be able to pass over convex or concave transition curves of radius $R_v \geq 500$ m, without any part other than the wheel flange dropping below the running surface.

The height of the rolling stock e_i or e_a shall increase relative to the running surface by the value:

- for the sections located between the end wheelsets or the bogie centres (normal values expressed in metres) by:

$$e_i = \left[\frac{a \cdot n_i - n_i^2 + \frac{p^2}{4}}{1000} - 0,115 \right]_{>0} \quad (\text{A.2})$$

- for the sections located outside of the end wheelsets or the bogie centres (normal values expressed in metres) by:

$$e_a = \left[\frac{a \cdot n_a + n_a^2 - \frac{p^2}{4}}{1000} - 0,115 \right]_{>0} \quad (\text{A.3})$$

A.2.4 Reduction formulae

In this subclause, notes (1) and (2) below as referred to in the formulae shall apply:

- (1) This value is applicable to bodies whose height above the running surface does not exceed 0,430 m and to those which can drop below this level, taking into account wear and vertical displacements, evaluated as shown in A.2.3.2;
- (2) This value is applicable to bodies whose height above the running surface exceeds 0,430 m, except those referred to in footnote (1) above.

A.2.4.1 Sections between the end wheelsets or the bogie centres

$$E_i = \left[\frac{\Delta_i}{500} + \frac{1,465 - d}{2} + q + w + [x_i]_{>0} - \begin{matrix} 0,025(1) \\ 0,075(2) \end{matrix} \right]_{>0} \quad (\text{A.4})$$

where $\Delta_i = \text{Max} \left[\left(a \cdot n_i - n_i^2 + \frac{p^2}{4} \right); \begin{matrix} 5 & (1) \\ 7,5 & (2) \end{matrix} \right]$ (A.5)

and $x_i = \frac{1}{750} \left(a \cdot n_i - n_i^2 + \frac{p^2}{4} - 100 \right)$ (A.6)

A.2.4.2 Sections beyond the end wheelsets or the bogie centres

$$E_a = \left[\frac{\Delta_a}{500} + \left(\frac{1,465 - d}{2} + q + w \right) \frac{2n_a + a}{a} + [x_a]_{>0} - \begin{matrix} 0,025(1) \\ 0,075(2) \end{matrix} \right]_{>0} \quad (\text{A.7})$$

where $\Delta_a = \text{Max} \left[\left(a \cdot n_a + n_a^2 - \frac{p^2}{4} \right); \begin{matrix} 5 & (1) \\ 7,5 & (2) \end{matrix} \right]$ (A.8)

and $x_a = \frac{1}{750} \left(a \cdot n_a + n_a^2 - \frac{p^2}{4} - 120 \right)$ (A.9)

A.3 Kinematic gauge G1

A.3.1 General

Gauge G1 is the gauge used for the railway infrastructure of most of continental Europe.

It is divided into two parts:

- upper part 400 mm above the running surface, common to all vehicles;
- lower part from a point 400 mm and less from the running surface. This part is different according to whether the vehicles have to run over rail brakes and other activated marshalling and stopping devices, particularly for parts below 130 mm relative to the running surface.

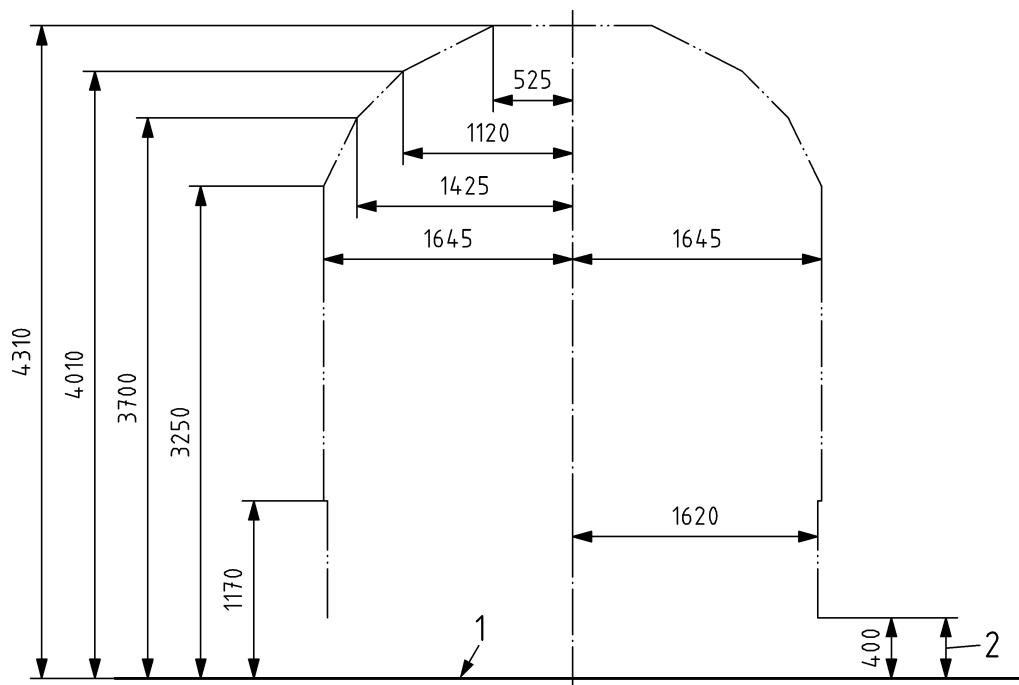
Loaded coaches shall meet the rules of profile GI2 when they run on a track not vertically curved.

Vans and wagons, either loaded or empty, shall comply with profile GI1.

NOTE For the lower part, kinematic gauge GI3 in accordance with Annex D is also available if the infrastructure used is cleared for this gauge.

A.3.2 Reference profiles of the upperparts of gauge G1

Dimensions in millimetres



Key

- 1 running surface
- 2 lower parts according to A.3.3

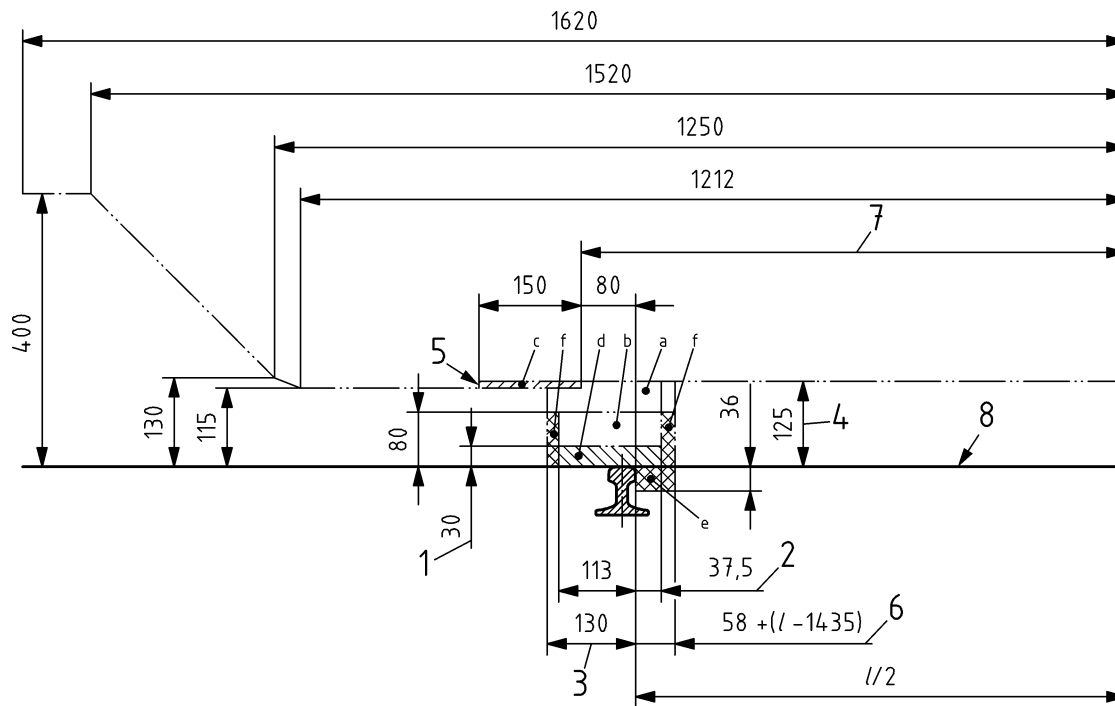
Figure A.4 — Reference profile of kinematic gauge G1

A.3.3 Reference profiles of the lower part of kinematic gauge G1

A.3.3.1 Kinematic reference profile G11

G11: profile of the part below 130 mm for vehicles able to pass over marshalling humps, rail brakes and other activated shunting and stopping devices in an active position (see Figure A.5).

Dimensions in millimetres



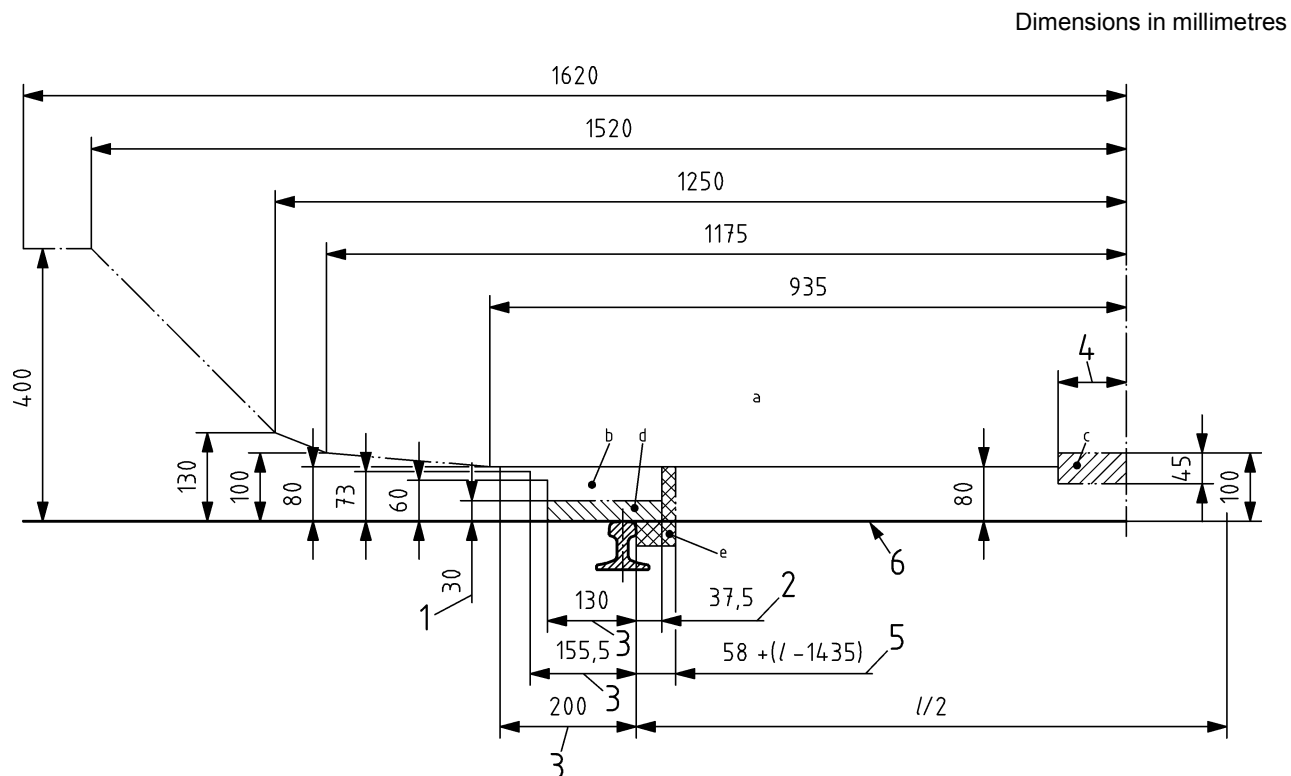
Key

- a zone for parts away from the wheels
- b zone for parts in the immediate proximity of the wheels
- c zone for retraction of standardized retarders
- d zone for wheels and other equipment coming into contact with the rail
- e zone occupied exclusively by the wheels
- f zone for rail brakes in a non-active position
- 1 limit for parts located outside the end wheelsets (guard-irons, sanders, etc.) not to be exceeded for running over detonators. This limit may, however, be disregarded for parts located between the wheels, provided these parts remain within the wheel track
- 2 maximum theoretical width of the flange profile in the case of the check rails
- 3 effective limit position of the wheel outer face and of the parts associated with the wheel
- 4 this dimension also shows the maximum height of standardized retarders used for scotching or slowing the rolling stock
- 5 no part of the rolling stock shall penetrate this zone
- 6 effective limit position of the inside surface of the wheel when the opposite wheel is in flange contact. This dimension varies with track gauge widening position
- 7 widening for retraction of standardized retarders (E_{fri} and E_{fra} see Figure A.13)
- 8 running surface

Figure A.5 — Reference profile of the lower parts of kinematic gauge G11

A.3.3.2 Kinematic reference profile G12

G12: profile of the part below 130 mm for vehicles that shall not pass over rail brakes and other activated shunting and stopping devices (see Figure A.6).



Key

- a zone for parts away from the wheels
- b zone for parts in the immediate proximity of the wheels
- c zone for contact ramp brushes
- d zone for wheels and other equipment coming into contact with the rails
- e zone occupied exclusively by the wheels
- 1 limit for parts located outside the end wheelsets (guard-irons, sanders, etc.) not to be exceeded for running over detonators. This limit may, however, be disregarded for parts located between the wheels, provided these parts remain within the wheel track
- 2 width of clearance area of the flange in the case of check rails
- 3 effective limit position of the wheel outer face and of the parts associated with the wheel
- 4 when the vehicle is in any position whatsoever on a curve of radius $R = 250$ m (minimum radius for contact ramp installation) and a track gauge of 1,465 mm, no part of the vehicle likely to descend to less than 0,100 m above the running surface, except for the contact brush, shall be less than 0,125 m from the track centre line (see explanations under Figure A.12). For bodies mounted under the bogies, the space to be cleared is also fixed at 0,150 m
- 5 effective limit position of the inside surface of the wheel when the opposite wheel is in flange contact. This dimension varies with track gauge widening position
- 6 running surface

Figure A.6 — Reference profile of the lower parts of kinematic gauge G12

A.3.4 Determination of the vehicle heights

For the vehicle or for a given part, these displacements make it possible to determine a minimum height and a maximum height above the running surface; this is particularly the case for:

- parts located near the lower part of the gauge (lower parts);
- the step 1 170 mm from the running surface on the reference profile;
- parts located in the upper part of the vehicles.

A.3.4.1 Determination of the minimum heights above the running surface

The minimum heights above the running surface for parts located close to the step positioned at 1 170 mm and below, are determined taking into account the vertical displacements described in the following subclauses.

A.3.4.1.1 Wear displacements

These displacements concern the following parts:

- wheels: Maximum wear for all types of vehicle or if compensatory adjustments are planned during maintenance: wear surface between adjustments;
- miscellaneous parts: maximum wear - examples: side-bearers, brake rigging, etc, for all vehicles and for each special assembly;
- axle boxes: wear ignored.

A.3.4.1.2 Structure deformation displacement

- wheelsets: sag ignored;
- bogie frame: sag ignored;
- body:
 - a) twist: ignored;
 - b) transverse bending: ignored;
 - c) longitudinal sag: ignored for all vehicles except wagons for which the longitudinal sag has to be taken into account under the effect of a maximum load increased by 30 % to take into account dynamic stresses.

A.3.4.1.3 Suspension displacement

The following displacements of the primary and secondary suspension are to be taken into account:

- a) steel spring and rubber spring:
 - 1) deflection under static load;
 - 2) additional deflection under dynamic stress;
 - 3) deflection due to flexibility tolerances;

b) air spring:

- 1) total deflection with air bags deflated (including back-up suspension when it exists).

For suspension with steel or rubber springs, the following suspension displacement conditions are to be taken into account depending on the type of rolling stock:

- locomotives: suspension displacement with an overload of 30 % of the sprung weight;
- wagons: total displacement (bottoming);
- coaches, vans, special wagons, and motor coaches: displacement with an overload of 30 % of the sprung weight at maximum load.

$\boxed{A_1}$ Calculations may also be made subject to total deflection. $\boxed{A_1}$

A.3.4.1.4 Overall displacements to be taken into account to determine the minimum heights above the running surface

To define the displacement modes of the vehicle bodies, the base of support – zone A in Figure A.7 – is to be taken into account.

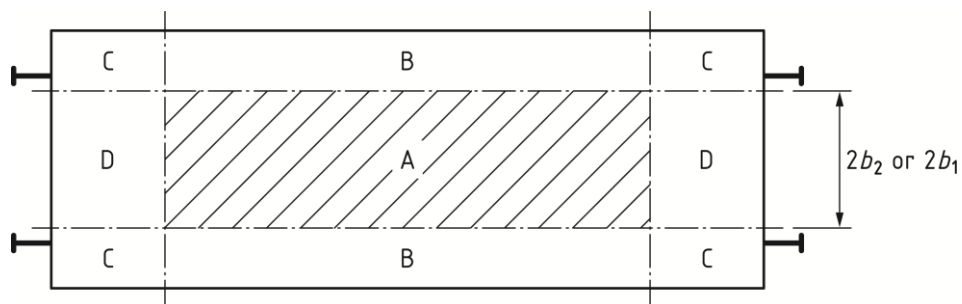


Figure A.7 — Example of body zones influencing displacements

For each zone A, B, C, D in Figure A.7 given as an example, Table A.1 gives displacement values to be taken into account in the calculations in all cases, and to be adapted in relation to the arrangement under study.

Table A.1 — Displacement values

		Locomotives, coaches, motor coaches	Wagons (single suspension level)
	Suspension displacements	Aff	Aff
ZONE A	Clearances to the side bearers	-----	$J \frac{b}{b_G}$
	Wheel wear	U_{sr}	U_{sr}
	Body sag	0	Flc
	Gradient transition	See A.3.4.1.5	
	Suspension displacements	$Aff + 0,1 \cdot s \cdot (b - b_2)$ See Note	$Aff + \Delta Aff \frac{(b - b_1)}{2b_1}$
ZONE B	Clearances to the side bearers	-----	$J \frac{b}{b_G}$
	Wheel wear	U_{sr}	U_{sr}
	Body sag	0	Flc
	Gradient transition	See A.3.4.1.5	
	Suspension displacements	$Max \left(\begin{matrix} Aff + \Delta Aff \cdot \frac{n_a}{a} \\ Aff + 0,1 \cdot s \cdot (b - b_2) \end{matrix} \right)$	$Aff + \Delta Aff \frac{\sqrt{n_a^2 + (b - b_1)^2}}{\sqrt{a^2 + 4b_1^2}}$
ZONE C	Clearances to the side bearers	-----	$J \frac{b}{b_G}$
	Wheel wear	$U_{sr} + \Delta U_{sr} \cdot \frac{n_a}{a}$	$U_{sr} + \Delta U_{sr} \cdot \frac{n_a}{a}$
	Body sag	0	Flc
	Gradient transition	See A.3.4.1.5	

Table A.1 (continued)

		Locomotives, coaches, motor coaches	Wagons
	Suspension displacements	$Aff + \Delta Aff \cdot \frac{n_a}{a}$	$Aff + \Delta Aff \cdot \frac{n_a}{a}$
ZONE D	Clearances to the side bearers	-----	$J \cdot \frac{b}{b_G}$
	Wheel wear	$U_{sr} + \Delta U_{sr} \cdot \frac{n_a}{a}$	$U_{sr} + \Delta U_{sr} \cdot \frac{n_a}{a}$
	Body sag	0	Flc
	Gradient transition	See A.3.4.1.5	

NOTE 1 The flexibility coefficient value “s” covers the remaining suspension displacement possibilities. For instance, if Aff is a bottoming displacement, s can be regarded as zero.

NOTE 2 Depending on the suspension arrangement, parameter b_1 can be replaced with b_2 in the formulae below.

The notations used in the table are:

Aff : suspension displacement value, including spring tolerance as specified in A.3.4.1.3;

ΔAff : difference in suspension displacement, in the longitudinal (zones C and D) and transverse (zones B and C) directions.

In the longitudinal direction, distance between the two bogies or wheelsets; for the first displacement, under maximum static load and for the second displacement according to A.3.4.1.3. This second displacement corresponds to Aff .

In the transverse direction, difference in displacement between the 2 rows of suspensions, for the first displacement under maximum static load and for the second displacement according to A.3.4.1.3. This second displacement corresponds to Aff .

U_{sr} : difference between the original nominal radius and the minimum reprofiled radius less the wear before scrapping the wheelset;

ΔU_{sr} : maximum difference allowed by the maintenance rules between the mean wheel radius of the two bogies (bogie vehicle) or between the wheelset radius (non-bogie vehicle);

Flc : value of the body sag according to A.3.4.1.2 at right angles to the point considered.

A.3.4.1.5 Vertical reduction formulae for passing over gradient transitions (including marshalling humps) and over braking, shunting or stopping devices

— vehicles having to pass over marshalling humps and rail brakes in an active position shall follow the reference profile in Figure A.5 (where $h_{\min} = 0,125$ m and 0,115 m) with its associated rules;

- vehicles having to pass over marshalling humps and rail brakes in a non-active position shall follow the reference profile in Figure A.6 (with $h_{\text{umin}} = 0,080$ m) and the rules associated with the previous case shall be applicable;
- vehicles not having to pass over marshalling humps shall follow the reference profile in Figure A.6 (with $h_{\text{umin}} = 0,080$ m) or the reference profile in A.5 (where $h_{\text{umin}} = 0,125$ m and $0,115$ m), depending on the type of rolling stock.

The formulae given in this clause may also be applied for the calculation of bogie vehicles and related parts: in this case, the value a (vehicle wheelbase) in the formulae is to be replaced by p (bogie wheelbase).

A.3.4.1.5.1 Vehicles having to pass over marshalling humps

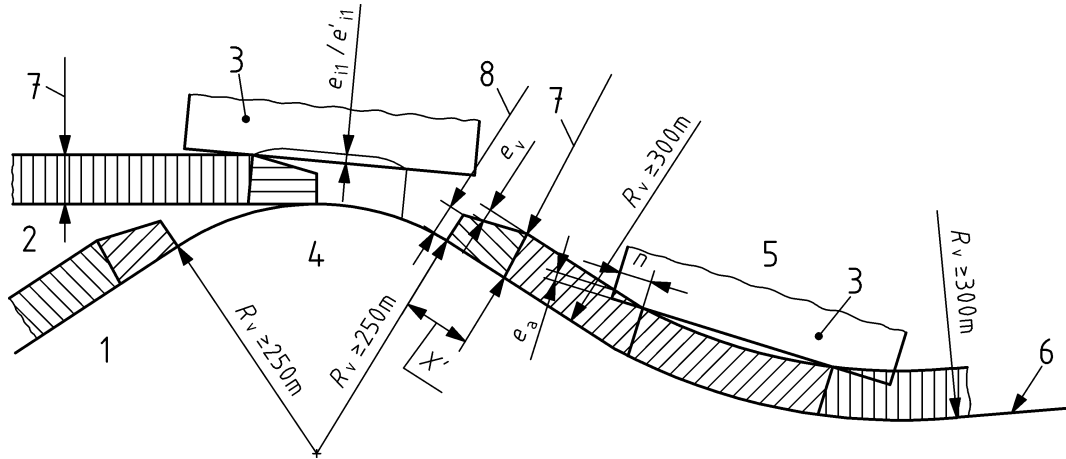
Normal values of the vertical increased reductions e_i or e_a to be taken into account for empty coaches, empty or loaded vans and wagons.

Vehicles, when they can be gravity-shunted, shall be capable of passing over rail brakes in an active position and other shunting or stopping devices located on non-vertically curved track and reaching to $0,115$ m / $0,125$ m above the running surface, up to 3 m from the end of convex transition curves of radius $R_v \geq 250$ m (dimension X').

They shall also be able to pass over such devices located inside or close to concave transition curves of radius $R_v \geq 300$ m.

Vehicles, when they cannot be gravity-shunted, shall be capable of passing over rail brakes in a non-active position located as shown below relative to the convex and concave transition curves and their height is then reduced from $0,115$ m / $0,125$ m to $0,080$ m above the running surface.

Under these conditions, the lower height of these vehicles, taking into account vertical displacements, shall be at least equal to $0,115$ m / $0,125$ m or $0,08$ m increased by the e_i or e_a quantities indicated in Figure A.8.



Key

- X' normal condition $X' = 3$ m; restricted condition $X' = 5$ m;
- 1 classic hump
- 2 shunting gradient
- 3 vehicle
- 4 convex
- 5 concave
- 6 running surface
- 7 (0,115 m or 0,125 m) or 0,080 m
- 8 in normal condition: (0,075 m or 0,085 m) or 0,040 m;
in restricted condition: (0,065 m or 0,075 m) or 0,030 m.

Figure A.8 — Reductions e_i or e_a in concave and convex transitions

e_i or e_a : vertical increase of the lower part of the rolling stock in relation to the height of 0,115 m / 0,125 m or 0,080 m.

e_v : lowering of the rail brakes in relation to the 0,115 m / 0,125 m or 0,080 m dimensions.

For sections between the end wheelsets or bogie centres (values expressed in metres).

NOTE The purpose of the numerical index applied to the e_i and e_i' values is to distinguish the normal values from the reduced values.

In normal condition:

$$e_{i1} = \frac{n_i}{a} \cdot \frac{(a - n_i - 3)^2}{500} \text{ when } a \leq 17,80 \text{ m} \quad \text{and} \quad n_i < \left(\frac{a - 3}{3} \right) \quad (\text{A.10})$$

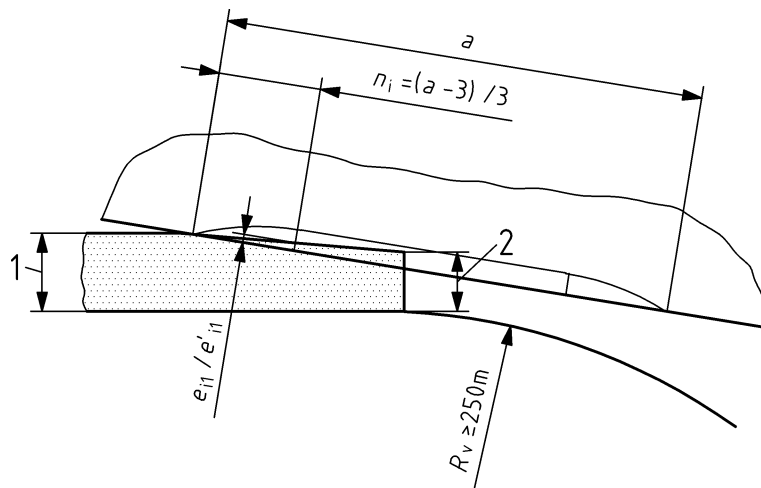
$$e_{i1} = \frac{(a - 3)^3}{3375 \cdot a} \text{ when } a \leq 17,80 \text{ m and} \quad n_i \geq \left(\frac{a - 3}{3} \right)^1 \quad (\text{A.11})$$

$$e_{i1}' = \left(\frac{27}{4} \cdot \frac{n_i}{a - 3} \right) \cdot \left(1 - \frac{n_i}{a - 3} \right)^2 \cdot \left(\frac{a^2}{3375} - 0,04 \right) \quad \text{when } a > 17,80 \text{ m} \quad \text{and} \quad n_i < \left(\frac{a - 3}{3} \right) \quad (\text{A.12})$$

$$e'_{i1} = \frac{a^2}{3375} - 0,04 \quad \text{when } a > 17,80 \text{ m} \quad \text{and} \quad n_i \geq \left(\frac{a-3}{3} \right)^{1)} \quad (\text{A.13})$$

When empty coaches and empty or loaded wagons and vans can be gravity-shunted, they shall also be able to pass over convex transition curves of radius ≥ 250 m, without any part other than the wheel flange dropping below the running surface (see Figure A.9).

This condition, which concerns the central part of the vehicles, comes in addition to those resulting from the e_i formulae for long vehicles.



Key

- 1 0,115 m/0,125 m or 0,080 m
- 2 In normal condition: 0,075 m/0,085 m or 0,040 m
In restricted condition: 0,065 m/0,075 m or 0,030 m

Figure A.9 — Reductions e_{i1} or e'_{i1} for sections between centres or between wheelsets

$$e_i = \left[\frac{a \cdot n_i - n_i^2 + \frac{p^2}{4}}{500} - h_{umin} \right]_{>0} \quad (\text{A.14})$$

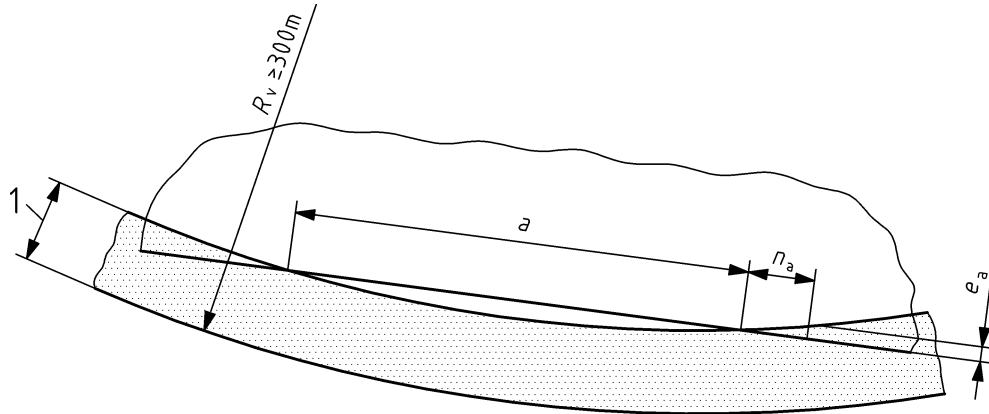
where $h_{umin} = 0,115 \text{ m}/0,125 \text{ m}$ or $0,080 \text{ m}$

For sections located beyond the end wheelsets or bogie centres (values expressed in metres), see Figure A.10. – the influence of the bogie wheelbase is ignored in this case.

$$e_a = \frac{a \cdot n_a + n_a^2}{600} \quad (\text{A.15})$$

1) This formula for $n_i \geq \left(\frac{a-3}{3} \right)$ gives greater or equivalent reductions to those obtained by the formula for

$$n_i < \left(\frac{a-3}{3} \right).$$



Key

1 0,115 m/0,125 m or 0,080 m

Figure A.10 — Increase e_a for sections outside bogie centres or end wheelsets

In restricted condition:

Reduced values for the e_i increase (sections between the end wheelsets or bogie centres) to be considered for certain vehicles for passing over gradient transitions including marshalling humps (see Figure A.9).

These reduced values are only tolerated for certain types of wagon, as they require a larger space than that determined using the normal values. These are, for example, pocket wagons used in rail/road combined traffic and identical or similar designs.

The use of these reduced values requires special precautions to be taken in certain marshalling yards with hump retarders at the base of a shunting gradient.

For these vehicles, the value of dimension X' becomes 5 m.

$$e_{i2} = \frac{n_i}{a} \cdot \frac{(a - n_i - 5)^2}{500} \quad \text{If} \quad a \leq 15,80 \text{ m} \quad \text{and} \quad n_i < \frac{(a - 5)}{3} \quad (\text{A.16})$$

$$e_{i2} = \frac{(a - 5)^3}{3375 \cdot a} \quad \text{If} \quad a \leq 15,80 \text{ m} \quad \text{and} \quad n_i \geq \frac{(a - 5)}{3} \quad (\text{A.17})$$

$$e'_{i2} = \left(\frac{27}{4} \cdot \frac{n_i}{a - 5} \right) \cdot \left(1 - \frac{n_i}{a - 5} \right)^2 \cdot \left(\frac{a^2}{3375} - 0,05 \right) \quad \text{If} \quad a > 15,80 \text{ m} \quad \text{and} \quad n_i < \frac{(a - 5)}{3} \quad (\text{A.18})$$

$$e'_{i2} = \frac{a^2}{3375} - 0,05 \quad \text{If} \quad a > 15,80 \text{ m} \quad \text{and} \quad n_i \geq \frac{(a - 5)}{3} \quad (\text{A.19})$$

2) This formula for $n_i \geq \frac{(a - 5)}{3}$ gives greater or equivalent reductions to those obtained by the formula for

$$n_i < \frac{(a - 5)}{3}.$$

When they can be gravity-shunted, the wagons shall also be able to pass over convex transition curves with a radius greater than or equal to 250 m, without any part other than the wheel flange dropping below the running surface. This condition, which concerns the central part of the wagons, comes in addition to those resulting from the e_i formulae for long wagons (see Figure A.9).

$$e_i = \left[\frac{a \cdot n_i - n_i^2 + \frac{p^2}{4}}{500} - h_{\text{umin}} \right]_{>0} \quad (\text{A.20})$$

where $h_{\text{umin}} = 0,115/0,125$ or $0,080$ m

Table A.2 — Values of e_1 and e'_1 (expressed in mm) according to a and n (expressed in m)

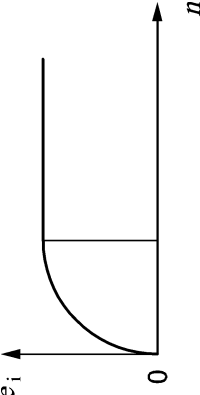
$a \backslash N$	> 6	5,5	5	4,5	4	3,5	3	2,5	2	1,5	1	0,5	0
20	79 69	78 69	78 69	76 68	73 66	69 63	63 59	57 54	49 46	39 37	28 27	15 14	0 0
19,5	73 63	73 63	72 63	71 62	68 61	65 59	60 55	54 50	46 43	37 35	26 25	14 14	0 0
19	67 57	67 57	67 57	66 57	64 56	60 54	56 51	50 46	43 40	35 33	25 24	13 13	0 0
18,5	61 51	61 51	61 51	61 51	59 51	56 49	52 47	47 43	41 37	33 30	23 22	13 12	0 0
18	56 46	56 46	56 46	56 46	54 46	52 45	48 42	44 39	38 34	31 28	22 20	12 11	0 0
17,5	52 41	52 41	52 41	51 41	50 41	48 40	45 38	41 35	36 31	29 26	21 19	11 10	0 0
17	48 36	48 36	48 36	48 36	47 36	45 35	43 34	39 31	34 28	28 23	20 17	11 9	0 0
16,5	44 31	44 31	44 31	44 31	44 31	42 30	40 30	37 28	32 25	26 20	19 15	10 8	0 0
16	41 26	41 26	41 26	41 26	41 26	40 26	38 25	34 24	30 21	25 18	18 13	10 7	0 0
15,5	37 22	37 22	37 22	37 22	37 22	37 22	35 22	32 21	28 19	23 16	17 12	9 6	0 0
15	34 20	34 20	34 20	34 20	34 20	34 20	32 20	30 19	27 17	22 14	16 11	9 6	0 0
14,5	31 18	31 18	31 18	31 18	31 18	31 18	30 17	28 17	25 16	21 13	15 10	8 6	0 0
14	28 15	28 15	28 15	28 15	28 15	28 15	27 15	26 15	23 14	19 12	14 9	8 5	0 0

Table A.2 (continued)

$\frac{N}{a}$	> 6	5,5	5	4,5	4	3,5	3	2,5	2	1,5	1	0,5	0
13,5	25 13	25 13	25 13	25 13	25 13	25 13	25 13	24 13	21 13	18 11	13 8	7 5	0 0
13	23 12	23 12	23 12	23 12	23 12	23 12	23 12	22 12	20 11	17 10	12 8	7 4	0 0
12,5	20 10	20 10	20 10	20 10	20 10	20 10	20 10	20 10	18 10	15 9	12 7	7 4	0 0
12	18 8	18 8	18 8	18 8	18 8	18 8	18 8	18 8	16 8	14 8	11 6	6 4	0 0
11,5		16 7	16 7	16 7	16 7	16 7	16 7	16 7	15 7	13 7	10 5	6 3	0 0
11		14 6	14 6	14 6	14 6	14 6	14 6	14 6	13 6	12 6	9 5	5 3	0 0
10,5			12 5	12 5	12 5	12 5	12 5	12 5	12 5	10 5	8 4	5 2	0 0
10			10 4	10 4	10 4	10 4	10 4	10 4	10 4	9 4	7 3	4 2	0 0
9,5				9 3	9 3	9 3	9 3	9 3	9 3	8 3	6 3	4 2	0 0
9				7 2	7 2	7 2	7 2	7 2	7 2	7 2	6 2	3 1	0 0
8,5					6 1	6 1	6 1	6 1	6 1	6 1	5 1	3 1	0 0
8					5 1	5 1	5 1	5 1	5 1	5 1	4 1	3 1	0 0
7,5						4 1	4 1	4 1	4 1	4 1	3 1	2 1	0 0

Table A.2 (continued)

$\frac{n}{a}$	> 6	5,5	5	4,5	4	3,5	3	2,5	2	1,5	1	0,5	0
7						3	3 0	3 0 0	3 0 0	3 0 0	3 0 0	2 0 0	0 0 0
6,5							2 0 0	2 0 0	2 0 0	2 0 0	2 0 0	1 0 0	0 0 0
6										1 0 0	1 0 0	1 0 0	0 0 0
5,5										1 0 0	1 0 0	1 0 0	0 0 0
5										0 0 0	0 0 0	0 0 0	0 0 0
4,5										0 0 0	0 0 0	0 0 0	0 0 0



e_i

n

$(a-3)/3$ or $(a-5)/3$

1

2

1 normal values

2 reduced values

A.3.4.1.5.2 Vehicles that shall not pass over marshalling humps

When empty coaches, wagons suitable for international traffic and empty or loaded vans are not allowed to pass over marshalling humps on account of their length, they shall however comply with the GI1 profile when placed on a non-vertically curved track, so as to allow for the use of shunting or stopping devices. All other vehicles shall use the GI2 profile.

A.3.4.1.6 All vehicles

All zones located between wheels shall be able to pass over convex or concave transition curves of radius $R_v \geq 500$ m, without any part other than the wheel flange dropping below the running surface.

In the zones on the outside of the wheels, the height e_i or e_a of the rolling stock relative to the running surface shall increase by the value:

- for the sections located between the end wheelsets or the bogie centres (normal values expressed in metres) by:

$$e_i = \left[\frac{a \cdot n_i - n_i^2 + \frac{p^2}{4}}{1000} - h_{u \min} \right]_{>0} \quad (\text{A.21})$$

where $h_{u \min} = 0,08$ m where $h < 0,1$ m

and $h_{u \min} = 0,1$ m where $h \geq 0,1$ m

- for the sections located beyond the end wheelsets or the bogie centres (normal values expressed in metres):

$$e_a = \left[\frac{a \cdot n_a + n_a^2 - \frac{p^2}{4}}{1000} - h_{u \min} \right]_{>0} \quad (\text{A.22})$$

where $h_{u \min} = 0,08$ m where $h < 0,1$ m

and $h_{u \min} = 0,1$ m where $h \geq 0,1$ m

A.3.4.2 Determination of maximum heights above the running surface

The maximum heights above the running surface of an empty vehicle with no wear and its components located close to the upper part of the gauge $h \geq 3,25$ m are determined taking into account the vertical displacements described in the following clauses.

A.3.4.2.1 Bending effect of structures

- body: longitudinal sag disregarded, except for wagons.

A.3.4.2.2 Suspension extension

The extension of the suspensions is taken into account by considering a 10 mm displacement for each level of suspension.

!The vertical component of quasi-static displacements is ignored, except where the upper horizontal part of gauges present a half-width greater than one meter."

A.3.4.2.3 Gradient transitions

The height of the rolling stock relative to the running surface shall be reduced:

- for the sections located between the end wheelsets or the bogie centres (normal values expressed in metres) by:

$$e_i = \left[\frac{a \cdot n_i - n_i^2 + \frac{p^2}{4}}{1000} - h_{\text{omin}} \right]_{>0} \quad (\text{A.23})$$

where $h_{\text{omin}} = 0,100 \text{ m}$

- for the sections located beyond the end wheelsets or the bogie centres (normal values expressed in metres):

$$e_a = \left[\frac{a \cdot n_a + n_a^2 - \frac{p^2}{4}}{1000} - h_{\text{omin}} \right]_{>0} \quad (\text{A.24})$$

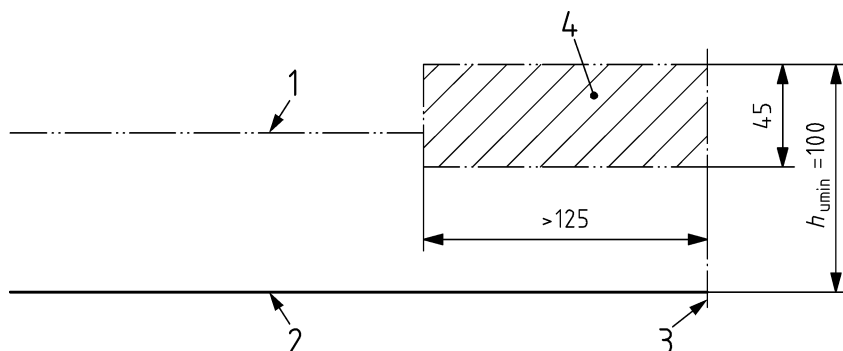
where $h_{\text{omin}} = 0,100 \text{ m}$.

A.3.5 Contact ramps

For vehicles intended to operate on networks fitted with contact ramps, a free space shall be provided in the lower horizontal part of the reference profile at a height $h_{\text{umin}} = 0,100 \text{ m}$.

This free space shall contain only the protrusions that shall come into contact with the ramps.

Dimensions in millimetres



Key

- 1 reference profile
- 2 running surface
- 3 track centreline
- 4 contact ramp zone

Figure A.11 — Contact ramp zone

The contact brush may descend 45 mm into the zone intended for installation of the contact ramps. Taking into account the flexible and deformable character of the contact brush, a portion of the dynamic displacements alone can cause the contact brush to drop below this height.

Vehicle parts likely to descend less than $h_{\min} = 0,10$ m from the running surface shall not be located less than 0,125 m from the track centreline when the vehicle is installed on a curved track of radius $R = 250$ m and track width $l_{\max}$.

The free space of 0,125 m on either side is specified for a contact brush width of 0,128 m.