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Upozornění

V době vydání ČSN EN 15273-1+A1 (28 0340) z května 2017 nebyla k dispozici anglická verze evropské normy. Je nyní převzata touto národní opravou.

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Railway applications - Gauges - Part 1: General - Common rules for infrastructure and rolling stock

Applications ferroviaires - Gabarits - Partie 1 : Généralités - Règles communes à l'infrastructure et au matériel roulant

Bahnanwendungen - Begrenzungslinien - Teil 1: Allgemeines - Gemeinsame Vorschriften für Infrastruktur und Fahrzeuge

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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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
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European Foreword

This document (EN 15273-1:2013+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of an identical text or by endorsement, at the latest by May 2017, and conflicting national standards shall be withdrawn at the latest by May 2017.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 the amendment adopted by the CEN on 25 July 2016.

This document replaces A1⟩ EN 15273-1:2013 ⟨A1.

The start and end of the text added or modified by the amendment is indicated in the text with A1⟩ and ⟨A1 respectively.

A1⟩ This document was drafted as part of a mandate issued to CEN by the European Commission and European Free Trade Association. ⟨A1

A1⟩ *text deleted* ⟨A1

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

This document is the first of a series of three standards that comprise the European Standard covering gauges:

- part 1 covers general principles, phenomena shared by the infrastructure and by the rolling stock, reference profiles and their associated rules;
- part 2 gives the rules for dimensioning the vehicles according to their specific characteristics for the relevant gauge and for the related calculation method;
- part 3 gives the rules for dimensioning the infrastructure in order to allow vehicles built according to the relevant gauge taking into account the specific constraints to operate within it.

This standard defines the gauge as an agreement between infrastructure and rolling stock.

The aim of this standard is to define the space to be cleared and maintained to allow the running of rolling stock, and the rules for calculation and verification intended for sizing the rolling stock to run on one or several infrastructures without interference risk.

This standard defines the responsibilities of the following parties:

- for the infrastructure:
  - gauge clearance;
  - maintenance;
  - infrastructure monitoring.
- for the rolling stock:
  - compliance of the operating rolling stock with the gauge concerned;
  - maintenance of this compliance over time.

This standard includes a catalogue of various railway gauges implemented in Europe, some of which are required to ensure the interoperability, while others are related to more specific applications. This catalogue is not exhaustive and the standard does not preclude the possibility of applying or defining other gauges not included in the catalogue for the specific needs of certain networks.

1 Scope

This European Standard is applicable to authorities involved in railway operation and may also be applied for light vehicles (e.g. trams, metros, etc. running on two rails) and their associated infrastructure, but not for systems such as rail-guided buses.

It allows rolling stock and infrastructures to be dimensioned and their compliance to be checked relative to applicable gauging rules.

For rolling stock and infrastructure, this standard is applicable to new designs, to modifications and to the checking of vehicles and infrastructures already in use.

This document EN 15273-1 covers:

— the general principles;

— the various elements and phenomena affecting the determination of gauges;

— the various calculation methods applicable to the elements shared by the infrastructure and by the rolling stock;

— the sharing rules for elements taken into account in calculations specific to the infrastructure and to the rolling stock;

— a catalogue of European gauges.

This document does not cover:

— conditions to be met to ensure safety of passengers on platforms and of persons required to walk along the tracks;

— conditions to be met by the fixed equipment maintenance machines in active position;

— the space to be cleared for the running track of rubber-tyred metros and other vehicles;

— rules applicable to extraordinary transportation, however some formulae may be used;

— rules applicable to the design of the overhead contact line system;

— rules applicable to the design of the current collection system on a third rail;

— simulation methods for the running of vehicles, however, it does not confirm the validity of existing simulations;

— verification rules of wagon loadings;

— coding methods for combined transportation;

— infrastructure gauges for very small curve radii (e.g. $R < 150$ m for gauge G1).

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 14067-2, *Railway applications — Aerodynamics — Part 2: Aerodynamics on open track*

EN 14067-3, *Railway applications — Aerodynamics — Part 3: Aerodynamics in tunnels*

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

[A1⟩

EN 15273-2:2013,+A1:2016 ⟨A1], *Railway applications — Gauges — Part 2: Rolling stock gauge*

[A1⟩

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

EN 15313, *Railway applications — In-service wheelset operation requirements — In-service and off-vehicle wheelset maintenance*

EN 50367, *Railway applications — Current collection systems — Technical criteria for the interaction between pantograph and overhead line (to achieve free access)*

EN 50119, *Railway applications — Fixed installations — Electric traction overhead contact lines*

3 Terms and definitions

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

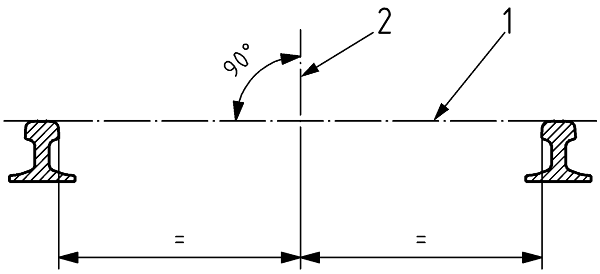
3.1 running surface (of the track)
virtual plane coplanar with the rail tops of a track

3.2 normal co-ordinates
are measured in relation to the orthogonal axes defined in a transverse plane, normal to the longitudinal centreline of the rails in the nominal position on a theoretically perfect track

Note 1 to entry: One of these axes, commonly referred to as the horizontal axis, is the intersection of the transverse plane with the running surface.

Note 2 to entry: The other axis, commonly referred to as the vertical axis, is perpendicular to the running surface and is equidistant from the rails.

Note 3 to entry: For calculation purposes, the vertical axis is used as a common reference for the infrastructure and for the rolling stock (see Figure 1).



Key

1 running surface

2 centreline of the vehicle and of the track

Figure 1 — Reference axes

3.3
gauge
set of rules including a reference profile and its associated calculation rules allowing definition of the outer dimensions of the rolling stock and the space to be cleared by the infrastructure

Note 1 to entry: According to the calculation method implemented, the gauge will be a static, kinematic or dynamic one.

3.4
Reference Profile
RP
line specific to each gauge, representing the cross-section shape and used as a common basis to work out the sizing rules of the infrastructure and of the rolling stock

3.5
upper parts, lower parts
upper parts correspond to the upper zone of the gauge and the lower parts correspond to the lower zone of the gauge

Note 1 to entry: The limit between the two parts is defined for each gauge.

3.6
associated rules
mathematical laws associated with each reference profile in order to size the infrastructure or rolling stock

3.7
static gauge
combination of the specific reference profile and its associated static rules

3.8
kinematic gauge
combination of the specific reference profile and its associated kinematic rules

3.9
dynamic gauge
combination of the specific reference profile and its associated dynamic rules

3.10
absolute gauging method
combination of a directory of the reference position of structures along a given route and of the dynamic rules associated with this route

3.11
comparative gauging method
set of rules allowing the comparing of the swept envelopes of various vehicles on the basis of their dynamic movements

3.12
geometric overthrow
d_{gi} or d_{ga}
difference between the distance, measured parallel to the running surface and in the transverse direction, of a part of the vehicle under consideration to the centre of a curved track with radius R and the distance of this same part, in the same conditions, to the centre of a straight track

Note 1 to entry: See detailed explanation in 5.1.

3.13
flexibility coefficient
s
ratio of the angle η (between the body tilted on its suspension with the plane perpendicular to the running surface) to the angle δ (between the running surface and the horizontal plane with the vehicle stationary on a canted track)

Note 1 to entry: See detailed explanation in 5.2.

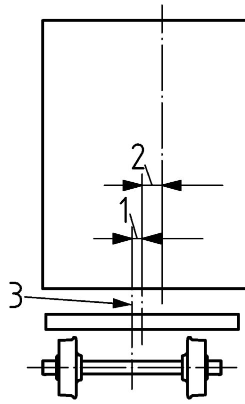
3.14
dissymmetry
η_0
angle η_0 that would be made by the centreline of the body of a stationary vehicle on a level track relative to the vertical in the absence of any friction

Note 1 to entry: See detailed explanation in 5.3.

3.15
clearance between wheelsets and track
$$\frac{l-d}{2}$$
transverse displacement of the wheelset in relation to the track centre

Note 1 to entry: See detailed explanation in 5.4.

3.16
transverse clearance between wheelset and body
$q + w$
sum of the amount "q" at the level of the axle boxes and of the amount "w" between the bogie frame and the body (see Figure 2)



Key

1 transverse clearance "q" between wheelset and bogie frame or between wheelset and body for vehicles not fitted with bogies

2 transverse clearance "w" between body and bogie

3 centre of wheelset

Figure 2 — Transverse clearances q and w

3.17
coefficient of displacement
A
parameter "A" to take into account the orientation of the bogie and body position as a result of the wheelset position on the track

3.18
additional overthrow
S_i or S_a
excess geometric overthrow of the rolling stock beyond the reference profile

Note 1 to entry: See detailed explanation in 5.5.

3.19
roll centre
C
rotational centre of the body

Note 1 to entry: See detailed explanation in 5.6.

3.20
cant, cant deficiency and cant excess
D , D_{th} , I

cant D is the difference in height of the centres of the two rails of a track at the level of the running surface

Note 1 to entry: The theoretical equilibrium cant Dth is the cant for which the resultant of the centrifugal acceleration and gravity is perpendicular to the running surface at a given velocity and track gauge

Note 2 to entry: Cant deficiency I is the difference between the applied cant and the theoretical equilibrium cant:

$$I = D_{th} - D \tag{1}$$

Note 3 to entry: A negative value of cant deficiency denotes cant excess.

3.21
quasi-static roll
corresponds to the roll movements of the vehicle due to the roll of the sprung weight under the effect of the transverse accelerations due to gravity (see Figure 14 a) or to the centrifugal force not compensated by the cant

Note 1 to entry: See Figure 14a and Figure 14b.

Note 2 to entry: This roll is referred to as quasi-static because it is determined for a moving vehicle on the basis of a transverse acceleration considered as steady and taking no account of the additional dynamic or random effects.

3.22
random dynamic movements
additional oscillations of the vehicle, in relation to its quasi-static position, generated by the interaction of the rolling stock and the track resulting from the condition of the latter and the running speed

Note 1 to entry: They are generated by the dynamic reactions of the rolling stock due to some layout defects such as:

— track geometry;

— sudden layout variations in the vicinity of switches and crossings;

— elastic deformation and the degradation of track due to traffic;

— a sequence of rail joints generating resonance phenomena;

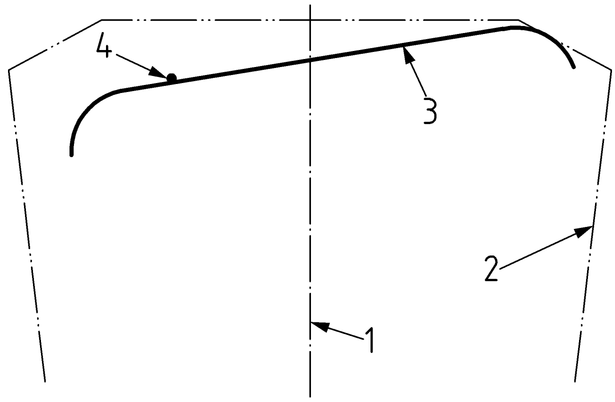
— hunting movements;

— effects of cross winds and aerodynamic phenomena.

3.23
pantograph gauges and interface with the overhead contact line system
specific reference profile combined with specific associated rules allowing verification that the pantograph head remains inside the allotted space, and location of infrastructure structures at

a sufficient mechanical and electrical distance according to the pantograph head type used with live or insulated parts

3.23.1
pantograph gauge
reference profile with its associated rules allowing verification that the pantograph head in a raised position remains within the allotted space (see Figure 3)



Key

1 track centreline

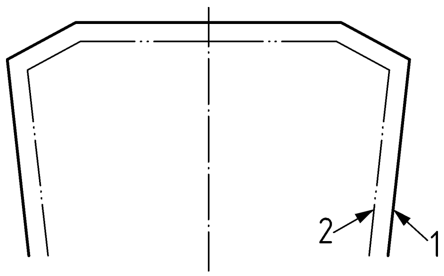
2 pantograph reference profile

3 displaced pantograph head

4 contact wire raised by the pantograph

Figure 3 — Pantograph gauge

3.23.2
mechanical structure gauge
reference profile and its associated rules allowing the definition of the space to be cleared by all the structures in order to ensure passage of the pantograph in its raised position, taking account of the maintenance allowances and of the displacements considered by the infrastructure (see Figure 4)



Key

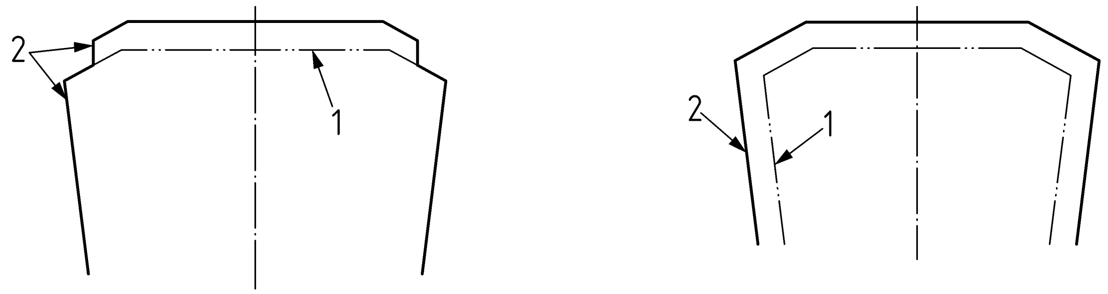
1 mechanical structure gauge

2 pantograph reference profile

Figure 4 — Mechanical structure gauge

3.23.3
electrical insulating allowance
clearance to be maintained between two parts at different potentials in given atmospheric conditions in order to ensure electrical insulation

3.23.4
electrical structure gauge
reference profile and its associated rules allowing the definition of the space to be cleared taking account of the required electrical insulating allowance in relation to the live parts of the pantograph in the raised position (see Figure 5)



a) For pantographs fitted with insulated horns

b) For pantographs fitted with non-insulated horns

Key

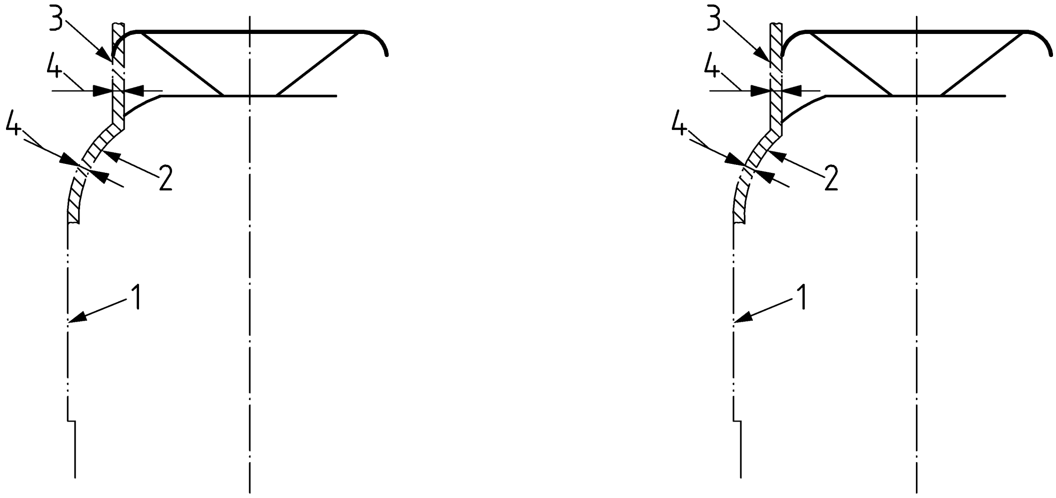
1 pantograph reference profile
2 electrical structure gauge

Live parts are not allowed to penetrate the shaded area.

Figure 5 — Electrical structure gauge

3.23.5 gauge for live roof-mounted parts
reduced gauge in relation to the maximum construction gauge taking account of a sufficient insulating clearance to the non-live parts of the infrastructure (see Figure 6)

Note 1 to entry: Live parts are electrically non-protected parts of the vehicle.



a) Pantograph with insulated horns

b) For pantographs fitted with non-insulated horns

Key

1 maximum construction gauge

2 space which shall not be penetrated by non-insulated parts likely to remain live

3 pantograph gauge

4 electrical insulating clearance

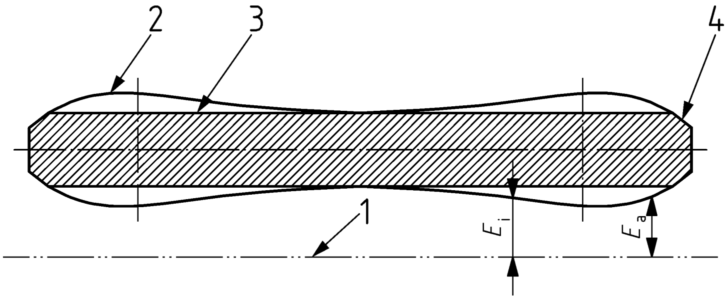
Figure 6 — Gauge for non-insulated live parts on vehicle roof

3.24 reference vehicles

theoretical or actual vehicles the parameters of which are used to establish the rules associated with a reference profile to obtain a gauge

3.25 maximum rolling stock construction gauge

maximum volume obtained by applying the associated rules giving reductions E_i and E_a to be subtracted in relation to the reference profile (see Figure 7)



Key

1 reference profile

2 maximum construction gauge

3 effective construction gauge of the vehicle body

4 tapering

E_i transverse reduction in relation to the reference profile for cross-sections between bogie centres

E_a transverse reduction in relation to the reference profile for cross-sections beyond bogie centres

Figure 7 — Space available for the construction of a vehicle

3.26
structure gauge
the following different interpretations are defined depending on the application (see C in Figure 15, point 6.1)

3.26.1
structure verification limit gauge
defines the space not to be encroached upon at any time and fixes the limit for normal operation.

Note 1 to entry: It is used to ensure that structures allow free passage

Note 2 to entry: Consequently, no structure is allowed to penetrate this space at any time.

3.26.2
structure installation limit gauge
gives the space to be cleared taking into account a maintenance allowance defined according to the line speed and to the track quality at the time of the structure installation

Note 1 to entry: When maintenance allowances have been fully used, a mandatory minimum clearance shall always remain to allow the operation of the vehicles.

3.26.3
structure installation nominal gauge
in addition to maintenance allowances, the structure installation nominal gauge takes account of safety allowances and of reserved allowances defined for the infrastructure, e.g. of the running of special consignments, of line speed increase, strong cross winds, aerodynamic effects.

3.26.4
uniform structure gauge
gauge of constant cross-section used for the infrastructure

3.27
swept envelope
cross-section perpendicular to the running surface encompassing all the points swept by the vehicle under consideration with its dynamic displacements in any possible position combined with running and operating conditions on a track of a given quality

Note 1 to entry: A series of swept envelopes makes it possible to determine the volume swept on a given route.

4 Symbols and abbreviations

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

Table 1 — Symbols and abbreviations

Symbol	Designation	Unit
a	Distance between end wheelsets of vehicles not fitted with bogies or between bogie centres	m
a_r	Distance “a” of the reference vehicle	m
A	Coefficient of displacement	
Abt_0	Reduction allowed on the pantograph displacement value	m
Abt_0	Reduction allowed on the pantograph displacement value at the upper verification point	m
Abt_u	Reduction allowed on the pantograph displacement value at the lower verification point	m
b	Semi-width or distance parallel to the running surface, relative to the centreline of the track or of the vehicle	m
b_{at}	Achieved semi-width	m
b'_q	Actual installation distance of the platforms, measured from the rail running edge	m
b_b	Thickness of the wheel flanges	m
$b_{\mathrm{b\,max}}$	Maximum thickness of the wheel flanges	m

Table 1 *(continued)*

Symbol	Designation	Unit
$b_{\mathrm{b\,min}}$	Minimum thickness of the wheel flanges	m
$b_{\mathrm{CR\,cin}}$	Semi-width of the kinematic reference profile	m
$b_{\mathrm{CR\,dyn}}$	Semi-width of the dynamic reference profile	m
$b_{\mathrm{CR\,st}}$	Semi-width of the static reference profile	m
$b_{\mathrm{f\,max}}$	Maximum back-to-back dimension	m
$b_{\mathrm{f\,min}}$	Minimum back-to-back dimension	m
b_{G}	Semi-spacing of side bearers	m
b_{inf}	Semi-width of the infrastructure	m
$b_{\mathrm{lac\,0}}$	Standard width of the gap between the platform and the step	m
$b_{\mathrm{lac\,réel}}$	Actual width of the gap between the platform and the step	m
b_{q}	Semi-width of the platform installation	m
$b_{\mathrm{q\,0}}$	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
$b_{\mathrm{q\,lim}}$	Minimum semi-width of the platform installation gauge	m
b_{r}	Semi-width of the reference vehicle	m
b_{r1}	Semi-width of reference vehicle No. 1	m
b_{r2}	Semi-width of reference vehicle No. 2	m
$b_{\mathrm{r\,inf}}$	Infrastructure reference semi-width	m
b_{veh}	Semi-width of the vehicle	m
$b_{\mathrm{veh(1)}}$	Semi-width of vehicle 1	m
$b_{\mathrm{veh(2)}}$	Semi-width of vehicle 2	m
b_{w}	Semi-width of the pantograph head	m
c	Calculation constant	
c_w	Width of insulating horn of pantograph	m
C	Roll centre	
CR	Reference profile	

Table 1 *(continued)*

Symbol	Designation	Unit
d	Dimension over wheel flanges	m
dg_a	Geometric overthrow of the vehicle on the outside of the curve	m
$dg_{a\,\mathrm{max}}$	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
$dg_{i\,\mathrm{max}}$	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_0	Fixed cant value taken into account by agreement between the rolling stock and the infrastructure with regard to the kinematic gauge	m
D_{eq}	Equivalent cant	m
$D_{\mathrm{L(1)}}$	Structure limit cant	m
$D_{\mathrm{L(2)}}$	Structure installation limit cant	m
D_{max}	Maximum conventional cant	m
Dpl	Transverse displacement	m
Dpl_{acin}	Transverse displacement towards the outside of the curve, taken into account for the kinematic gauge	m
Dpl_{adyn}	Transverse displacement towards the outside of the curve, taken into account for the dynamic gauge	m
Dpl_{ast}	Transverse displacement towards the outside of the curve, taken into account for the static gauge	m
Dpl_{cin}	Transverse displacement taken into account for the kinematic gauge	m
Dpl_{dyn}	Transverse displacement taken into account for the dynamic gauge	m
$Dpl_{\mathrm{dyn(A)}}$	Transverse displacement of the vehicle A taken into account for the dynamic gauge	m
$Dpl_{\mathrm{dyn(B)}}$	Transverse displacement of the vehicle B taken into account for the dynamic gauge	m

Table 1 *(continued)*

Symbol	Designation	Unit
Dpl_{icin}	Transverse displacement towards the inside of the curve, taken into account for the kinematic gauge	m
Dpl_{idyn}	Transverse displacement towards the inside of the curve, taken into account for the dynamic gauge	m
Dpl_{ist}	Transverse displacement towards the inside of the curve, taken into account for the static gauge	m
Dpl_{st}	Transverse displacement taken into account for the static gauge	m
D_{sup}	Additional cant	m
D_{th}	Theoretical equilibrium cant	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_{por}	Offset of the reference vehicle roof-mounted pantograph at the upper verification point	m
e_{pr}	Offset of the pantograph due to the reference vehicle characteristics	m
e_{pu}	Offset of the pantograph at the lower verification point	m
e_{pur}	Offset of the reference vehicle roof-mounted 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 wheelsets or beyond the bogie centres	m
E_i	Transverse reduction relative to the reference profile for cross-sections between the 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
f_s	Raising of the contact wire	m

Table 1 *(continued)*

Symbol	Designation	Unit
f_{so}	Raising of the contact wire at the lowest temperature, measured in relation to its position for the mean temperature	m
f_v	Contact wire sag. Initial sag including the sag between the hangers	
f_w	Contact wire sag at the highest temperature, measured in relation to its position for the mean temperature	
f_{wa}	Excess geometric overthrow of the contact plane by the pantograph head due to wear on the wiper	m
f_{ws}	Excess geometric overthrow of the contact plane by the pantograph head due to its inclined position	m
F	Fixed value taken into account in the additional overthrows	m
g	Acceleration due to gravity	m/s^2
G	Centre of gravity of the body	
h	Height in relation to the running surface	m
h'_o	Maximum verification height of the pantograph gauge in a raised position	m
h'_u	Minimum verification height of the pantograph gauge in a raised position	m
h_c	Roll centre height	m
h_{c0}	Value of h_c used for the agreement between the rolling stock and the infrastructure	m
h_{CR}	Height of the reference profile	m
h_{eff}	Effective height of the raised pantograph	m
$h_{eff\ elec}$	Effective height of the raised pantograph plus the electrical insulation distance	m
h_f	Height of the contact wire	m
h_{max}	Maximum height available for the infrastructure below the lower horizontal line of the reference profile	m

Table 1 *(continued)*

Symbol	Designation	Unit
$h_{u\,\min}$	Height of the lower horizontal line of the reference profile NOTE This minimum height is specified for the vertical geometric displacements of the rolling stock below the reference profile according to the vertical curve of the track.	m
$h_{u\,\min(1)}$	Height of the lower horizontal line of the special reference profile of the lower parts for vehicles having to pass over marshalling humps and rail brakes in an active position NOTE This minimum height is specified for the vertical geometric displacements of the rolling stock below the reference profile according to the vertical curve of the track.	m
$h_{u\,\min(2)}$	Height of the lower horizontal line of the special reference profile of the lower parts for vehicles having to pass over marshalling humps and rail brakes in a non-active position NOTE This minimum height is specified for the vertical geometric displacements of the rolling stock below the reference profile according to the vertical curve of the track.	m
$h_{\min\,CR}$	Height of the bottom corner of the reference profile	m
h_{nez}	Height of the platform edge coping	m
h_q	Height of the platforms	m
$h_{o\,\min}$	Minimum height specified for the vertical geometric displacements of the rolling stock above the reference profile, according to the vertical curve of the track	m
h_s	Height set for the cow-catcher and the sand-boxes in the wheel area	m
h_t	Installation height of the lower pantograph joint in relation to the running surface	m
h_{veh}	Height of the vehicle	m
I	Cant deficiency	m
I'_c	Intermediate cant deficiency value between 0 and I_c	m
I'_p	Intermediate cant deficiency value taken into account for tilting body vehicles	m

Table 1 *(continued)*

Symbol	Designation	Unit
I_c	Maximum cant deficiency in conventional vehicles used by the infrastructure manager for his routes	m
I_{eq}	Equivalent cant deficiency	m
$I_{L(1)}$	Structure limit cant deficiency	m
$I_{L(2)}$	Structure installation limit cant deficiency	m
I_{max}	Maximum conventional cant deficiency	m
I_0	Fixed cant deficiency value taken into account by agreement between the rolling stock and the infrastructure with regard to the kinematic gauge	m
I'_0	Fixed cant deficiency value taken into account by agreement between the rolling stock and the infrastructure with regard to the kinematic gauge of the pantographs	m
I_p	Cant deficiency of tilting body vehicles	m
I_{sup}	Additional cant deficiency	m
j	Minimum vertical reference clearances 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
k	Factor of safety to take into account track irregularities	
K	Quasi-static roll coefficient taken into account by the infrastructure	
K'	Quasi-static roll coefficient taken into account for the pantograph reference profile	
l	Track gauge, distance between the rail running edges	m
l_b	Width of tyre	m
l_{cr}	Position of the check rail in relation to the rail running edge	m
l_{nom}	Nominal track gauge	m

Table 1 *(continued)*

Symbol	Designation	Unit
l_{max}	Maximum track gauge	m
$l_{réel}$	Actual track gauge	m
L_{dR1}	Developed length of radius R_1	m
l_{orn}	Width of the flangeway in relation to the rail running edge	m
L	Standard distance between the centrelines of the rails of the same track	m
$M_{(1)}$	Mandatory allowance	m
$M_{(1)cin}$	Mandatory allowance with regard to the kinematic gauge	m
$M_{(1)d}$	Part of the mandatory allowance $M_{(1)}$ due to the loading dissymmetry and the suspension adjustment	m
$M_{(1)dyn}$	Mandatory allowance with regard to the dynamic gauge	m
$M_{(1)osc}$	Part of the mandatory allowance $M_{(1)}$ due to the transverse oscillations of the vehicle with regard to the kinematic gauge	m
$M_{(1)st}$	Mandatory allowance with regard to the static gauge	m
$M_{(2)}$	Infrastructure maintenance allowance	m
$M_{(2)cin}$	Usable allowance with regard to the kinematic gauge	m
$M_{(2)D_{cin}}$	Part of the usable allowance $M_{(2)}$ due to the crosslevel errors T_D with regard to the kinematic gauge	m
$M_{(2)D_{dyn}}$	Part of the usable allowance $M_{(2)}$ due to the crosslevel errors T_D with regard to the dynamic gauge	m
$M_{(2)dyn}$	Usable allowance $M_{(2)}$ with regard to the dynamic gauge	m
$M_{(2)st}$	Usable allowance with regard to the static gauge	m
$M_{(2)voie}$	Part of the usable allowance $M_{(2)}$ due to the transverse displacement of the track	m
$M_{(3)}$	Additional infrastructure allowance	m
M_{fb}	Vertical allowance for the passage onto ferries	m
M_i	Electrical insulation allowance	m
$M_{osc(1)}$	Allowance for the dynamic roll due to the oscillations of vehicle No. 1	m

Table 1 *(continued)*

Symbol	Designation	Unit
$M_{osc(2)}$	Allowance for the dynamic roll due to the oscillations of vehicle No. 2	m
M_{v}	Reserve vertical allowance	m
$M_{v(1)}$	Mandatory vertical allowance	m
$M_{v(2)}$	Maintenance vertical allowance	m
$M_{v(3)}$	Additional vertical allowance	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_{ar}	n_{a} of the reference vehicle	m
n_{i}	n for the sections between the wheelsets or bogie centres	m
n_{ir}	n_{i} of the reference vehicle	m
n_{r}	Distance from the section under consideration to the adjacent end wheelset or to the closest centre of the reference vehicle	m
p	Bogie wheelbase	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_{orn}	Depth of the flangeway necessary to allow passage of the wheel flange	m
p_{r}	Reference vehicle bogie wheelbase	m
PT	End lateral point of the reference profile upper face	
PT'	Point reached by point PT during its upward vertical movement	
P_{u}	Reduction at the lower verification point of the pantographs	m
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

Table 1 *(continued)*

Symbol	Designation	Unit
q	Transverse clearance between wheelset and bogie frame, or wheelset and body for vehicles not fitted with bogies	m
q_r	Transverse clearance between wheelset and bogie frame, or wheelset of the reference vehicle	m
qs_a	Displacement due to the quasi-static roll taken into account by the infrastructure outside the reference profile on the outside of the curve.	m
qs_i	Displacement due to the quasi-static roll taken into account by the infrastructure outside the reference profile on the inside of the curve.	m
Q	Displacement due to the complete quasi-static roll	m
r	Reserve	m
R	Horizontal curve radius	m
R_1	Different curve radii used in junction work	m
R_2	Different curve radii used in junction work	m
R_c	Critical curve radius	m
R_{min}	Minimum curve radius	m
R_p	Radius corresponding to the maximum roll of a tilting body vehicle	m
R_{th}	Theoretical curve radius of junction work	m
R_v	Vertical curve radius of longitudinal profile	m
$R_{v\,min}$	Standard minimum 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'_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_r	Flexibility coefficient value of the reference vehicle	
S	Allowed additional overthrow	m
S_0	Standard value of additional overthrow linked to the reference profile	m

Table 1 *(continued)*

Symbol	Designation	Unit
S'_0	Standard value of additional overthrow linked to the pantograph reference profile	m
S'_a	Allowed additional overthrow on the outside of the curve for pantographs	m
S'_i	Allowed additional overthrow on the inside of the curve for pantographs	m
S_a	Allowed additional overthrow on the outside of the curve	m
$S_{a_{cin}}$	Allowed additional overthrow on the outside of the curve with regard to the kinematic gauge	m
$S_{a_{dyn}}$	Allowed additional overthrow on the outside of the curve with regard to the dynamic gauge	m
$S_{a_{st}}$	Allowed additional overthrow on the outside of the curve with regard to the static gauge	m
S_{cin}	Allowed additional overthrow with regard to the kinematic gauge	m
S_{dyn}	Allowed additional overthrow with regard to the dynamic gauge	m
s_{eq}	Equivalent value of the flexibility coefficient	
S_i	Allowed additional overthrow on the inside of the curve	m
$S_{i_{cin}}$	Allowed additional overthrow on the inside of the curve with regard to the kinematic gauge	m
$S_{i_{dyn}}$	Allowed additional overthrow on the inside of the curve with regard to the dynamic gauge	m
$S_{i_{st}}$	Allowed additional overthrow on the inside of the curve with regard to the static gauge	m
S_{st}	Allowed additional overthrow with regard to the static gauge	m
t	Flexibility index of the pantograph head raised to 6,50 m under the influence of a transverse force of 300 N	m
t_r	Reference vehicle pantograph flexibility index	m
T_b	Construction tolerance of the rolling stock in the transverse direction	m
T_{charge}	Angle of dissymmetry, considered in η_{or} for poor load distribution	degree
T_D	Track crosslevel difference between two maintenance periods	m
T_N	Vertical displacement of the track between two periods of maintenance	m

Table 1 *(continued)*

Symbol	Designation	Unit
T_{osc}	Crosslevel difference selected for calculation of oscillations caused by track irregularities	m
T_q	Installation tolerance of the platforms	m
T_{susp}	Angle of dissymmetry, considered in η_{or} for poor suspension adjustment	degree
T_{voie}	Transverse displacement of the track between two periods of maintenance	m
v	Vehicle speed	m/s
V	Vehicle speed	km/h
V'_c	Intermediate value of a non-tilting train speed	km/h
V'_p	Intermediate value of the tilting train speed	km/h
VF	Fixed value	m
$VF_{o_{(I_0)}}$	Fixed value considered at the upper verification point of the pantographs for a cant deficiency I_0	m
$VF_{o_{(I_{max})}}$	Fixed value considered at the upper verification point of the pantographs for a cant deficiency I_{max}	m
$VF_{u_{(I_0)}}$	Fixed value considered at the lower verification point of the pantographs for a cant deficiency I_0	m
$VF_{u_{(I_{max})}}$	Fixed value considered at the lower verification point of the pantographs for a cant deficiency I_{max}	m
w	Transverse clearance between bogie and body	m
$w_{(R)}$	Transverse clearance between bogie and body varying according to the track curve radius	m
$w_{a_{(R)}}$	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_r	Transverse clearance between bogie and body of the reference vehicle	m
x	Distance taken into account from the point of origin O for the calculation of e_v	m

Table 1 *(continued)*

Symbol	Designation	Unit
x'	x value for which the height of bodies protruding from the infrastructure above the rail level shall be reduced when approaching a vertical radius.	m
z	Part of 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_0	[A1) Fixed value available to the rolling stock on the outside of the static reference profile (A1]	m
z_{cin}	Quasi-static roll of the vehicle with regard to the kinematic gauge	m
z_{dyn}	Quasi-static roll of the vehicle with regard to the dynamic gauge	m
$z_{\mathrm{p_{cin}}}$	Quasi-static roll of the tilting body vehicles with regard to the kinematic gauge	m
$z_{\mathrm{p_{dyn}}}$	Quasi-static roll of the tilting body vehicles with regard to the dynamic gauge	m
α	Additional angle of roll of the body due to the clearance to the side bearers	degree
α_{osc}	Angle corresponding to the value T_{osc} expressed in millimetres	degree
α'	Angle of the inclined part of the pantograph head in relation to the horizontal	degree
α''	Angle made by the gangway between the platform and the ferry	degree
β	Switch entry angle of switches and crossings	radian
γ	Centrifugal acceleration	m/s^2
γ'_{D}	Centripetal acceleration due to the cant	m/s^2
γ'_{I}	Centrifugal acceleration resulting from the cant deficiency	m/s^2
Δ_{a}	Fixed term corresponding to: $n_a(a+n_a)-\frac{p^2}{4}$	m^2
Δbi	Additional width on the inside of the curve	m
Δba	Additional width on the outside of the curve	m
ΔD	Cant miss-match	m

Table 1 *(continued)*

Symbol	Designation	Unit
Δh_{dyn}	Vertical movement of the vehicle taken into account for the dynamic gauges	m
Δ_i	[A1) Term corresponding to: $n_i(a+n_i)-\frac{p^2}{4}$ (A1]	m^2
δ	Angle of roll of the canted track	degree
δ_{qa}	Value for the distance to the platform on the outside of the curve in relation to the gauge for the structures in the inclined position of value δ	m
$\delta_{qa_{max}}$	Maximum value of δ_{qa}	m
$\Sigma_{j_{st}}$	Denotes the various indices that can accompany the value Σ with regard to the static gauge	m
$\Sigma_{j_{cin}}$	Denotes the various indices that can accompany the value Σ with regard to the kinematic gauge	m
$\Sigma_{j_{dyn}}$	Denotes the various indices that can accompany the value Σ with regard to the dynamic gauge	
$\Sigma_{1_{cin}}$	Sum of the verification limit values for infrastructure with regard to the kinematic gauge	m
$\Sigma_{2_{cin}}$	Sum of the limit values of the infrastructure allowances with regard to the kinematic gauge	m
$\Sigma_{3_{cin}}$	Sum of the nominal values of the allowances taken into account by the infrastructure with regard to the kinematic gauge	m
$\Sigma_{3_{cin_a}}$	Value Σ_{3cin} taken into account on the outside of the curve	m
$\Sigma_{3_{cin_i}}$	Value Σ_{3cin} taken into account on the inside of the curve	m
$\Sigma'_{1_{cin}}$	Value Σ_{1cin} taken into account for verification of the structures	m
$\Sigma''_{1_{cin}}$	Minimum value of Σ'_{1cin}	m
$\Sigma'_{2_{cin}}$	Value Σ_{2cin} into account for installation of the structures	m
$\Sigma''_{2_{cin}}$	Minimum value of Σ'_{2cin}	m
$\Sigma_{1_{cin(v)}}$	Sum of the verification limit values for the infrastructure with regard to the kinematic gauge in the vertical direction	m
$\Sigma_{2_{cin(v)i}}$	Sum of the limit values of the infrastructure allowances with regard to the kinematic gauge in the vertical direction on the inside of the curve	m

Table 1 *(continued)*

Symbol	Designation	Unit
$\Sigma 2_{cin(v)a}$	Sum of the limit values of the infrastructure allowances with regard to the kinematic gauge in the vertical direction on the outside of the curve	m
$\Sigma 3_{cin(v)i}$	Sum of the nominal values of the infrastructure allowances with regard to the kinematic gauge in the vertical direction on the inside of the curve	m
$\Sigma 3_{cin(v)a}$	Sum of the nominal values of the infrastructure allowances with regard to the kinematic gauge in the vertical direction on the outside of the curve	m
$\Sigma 1_{dyn}$	Sum of the verification limit values for infrastructure with regard to the dynamic gauge	m
$\Sigma 2_{dyn}$	Sum of the limit values of the infrastructure allowances with regard to the dynamic gauge	m
$\Sigma 3_{dyn}$	Sum of the nominal values of the allowances taken into account by the infrastructure with regard to the dynamic gauge	m
Σ_v	Sum of the values of the allowances taken into account by the infrastructure in the vertical direction	m
λ	Angle made by the straight line joining the centre of gravity at the roll centre with the vertical	degree
η	Angle of roll of the vehicle relative to the running surface	degree
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
η_{0r}	Reference angle η_0 taken into account in the agreement	degree
θ	Angle resulting from the suspension adjustment tolerances	radian
θ_r	Angle resulting from the suspension adjustment tolerances of the reference vehicle	radian

Table 1 *(continued)*

Symbol	Designation	Unit
τ	Pantograph construction and installation tolerance	m
τ_r	Reference vehicle pantograph construction and installation tolerance	m

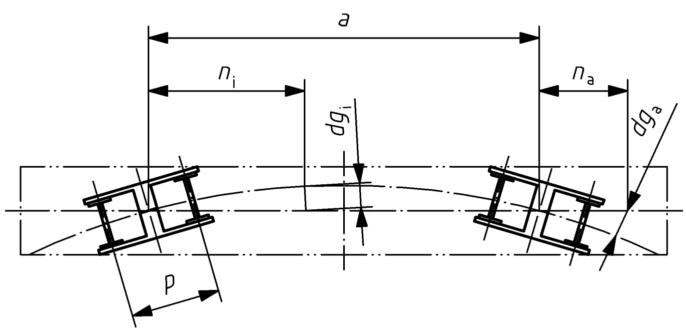
5 Specific considerations for determination of parameters

5.1 Geometric overthrow

5.1.1 Geometric overthrow between the vehicle body

To determine the geometric overthrow, the vehicle is ideally located in the median position on the track.

If a vehicle is located on a curved track, the geometric effect generates a transverse overthrow "dg_i" towards the inside of the curve for the parts between the bogie centres or between the wheelsets and a transverse overthrow "dg_a" towards the outside of the curve for the parts in the overhang (see Figure 8).



Key

a distance between the end wheelsets or between the bogie centres

n_a longitudinal position of the section considered outside the wheelsets or bogie centres

n_i longitudinal position of the section considered between the wheelsets or between the bogie centres

dg_a geometric overthrow at the section position n_a

dg_i geometric overthrow at the section position n_i

p distance between the end wheelsets of the bogie

Figure 8 — Geometric overthrow of the vehicle on a curved track

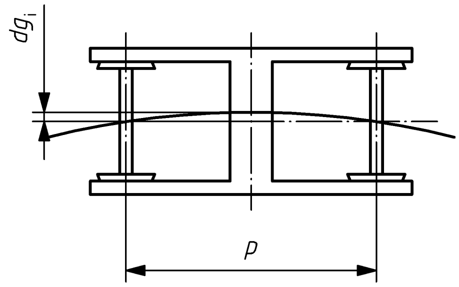
$$dg_a = \frac{an_a + n_a^2}{2R} \quad (2)$$

$$dg_i = \frac{an_i - n_i^2}{2R} \quad (3)$$

NOTE It should be noted that these formulae are slightly simplified, but the error is less than $\frac{n^2(a+n)^2}{8R^3}$, which is negligible taking into account the very high value of R^3.

5.1.2 Additional geometric overthrow due to the bogies

The bogies produce an additional geometric overthrow "dg_i" towards the centre of the curve (see Figure 9).



Key

dg_i geometric overthrow at the bogie centre

p distance between the end wheelsets of the bogie

Figure 9 — Geometric overthrow of the bogie on a curved track

$$dg_i = \frac{p^2}{8R} \quad (4)$$

Generally,

The geometric overthrow on the inside of the curve

$$dg_i = \frac{an_i - n_i^2 + \frac{p^2}{4}}{2R} \quad (5)$$

The geometric overthrow on the outside of the curve

$$dg_a = \frac{an_a + n_a^2 - \frac{p^2}{4}}{2R} \quad (6)$$

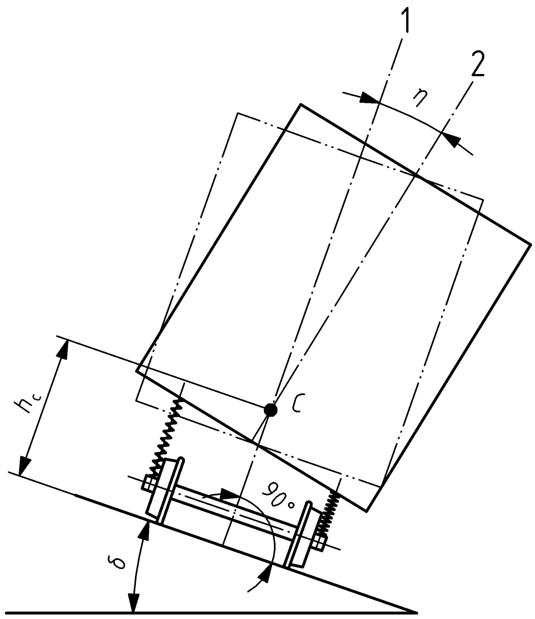
NOTE These same formulae may also be used in the vertical plane to determine "dg_{iv}" and "dg_{av}".

5.2 Flexibility coefficient

The flexibility coefficient

$$s = \frac{\eta}{\delta} \tag{7}$$

Figure 10 shows the roll due to the flexibility of the suspension.



Key

1 normal to the running surface

2 centreline of the inclined body under the effect of a cant

C roll centre

δ angle of roll of the canted track

h_c roll centre height

η angle of roll of the vehicle relative to the running surface

Figure 10 — Roll due to the flexibility of the suspension

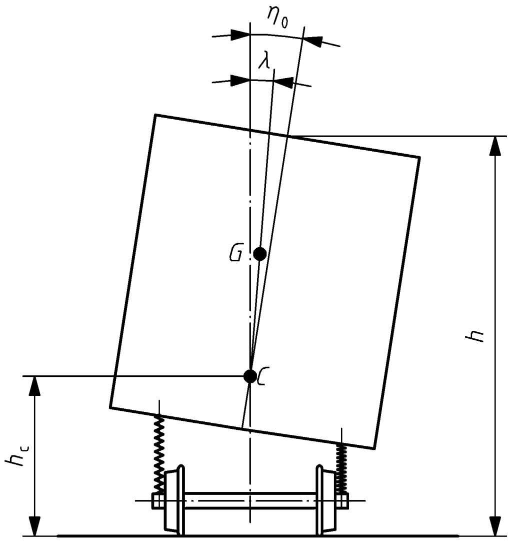
5.3 Dissymmetry

The dissymmetry taken into account for calculating the roll of the rolling stock is:

$$\eta_0 = (1 + s)\lambda \tag{8}$$

The dissymmetry of the vehicle corresponds to angle λ and may be due to a structural imperfection, to poor adjustment of the suspension (set-up tolerances, pneumatic levelling valve, etc.) and to an offset of the load (see Figure 11).

Angle λ is the angle made by the straight line joining the centre of gravity to the roll centre with the vertical.



Key

C roll centre

h height in relation to the running surface

h_c roll centre height

G centre of gravity of the body

λ angle made by the straight line joining the centre of gravity to the roll centre with the vertical

η_0 angle of dissymmetry due to construction tolerances, to suspension adjustment and to offset load distributions

Figure 11 — Illustration of dissymmetry

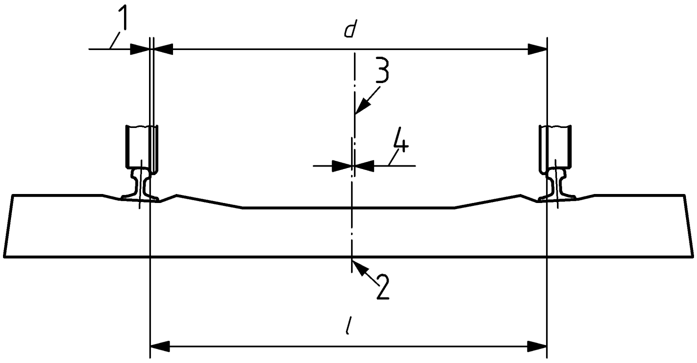
5.4 Clearance between the wheelsets and the track

Consider:

the value “ l ” of the track gauge is measured between the rail running edges 14 mm below the running surface and the value “ d ” of the dimension over wheel flanges at the limit of wear is measured 10 mm below the wheel tread.

The values, d and l may vary from one network to another.

The values d , l_{nom} , l_{max} relative to each case under study are listed in the catalogue of gauges standardized in Annex B, Annex C, Annex D and Annex E.



Key

1 clearance between the wheelset and the track

2 track centreline

3 centre of wheelset

4 transverse displacement of the wheelset in relation to the track centre. $\frac{l-d}{2}$

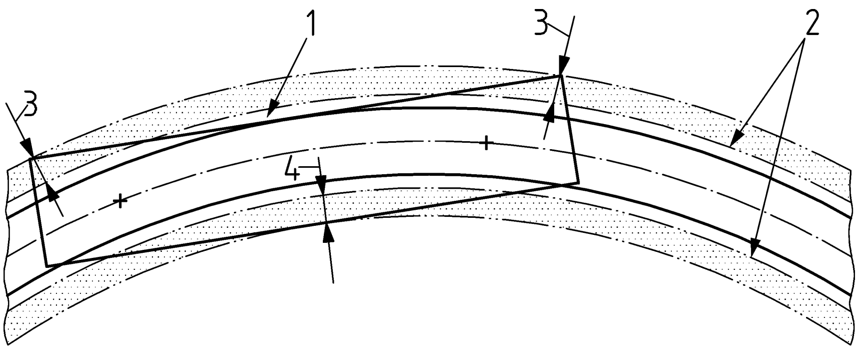
d dimension over wheel flanges

l track gauge, distance between the rail running edges

Figure 12 — Relative position between the wheelset and the track

5.5 Additional overthrow

Figure 13 shows the space reserved for additional overthrows S_i and S_a in relation to the reference profile.



Key

1 reference vehicle

2 reference profile

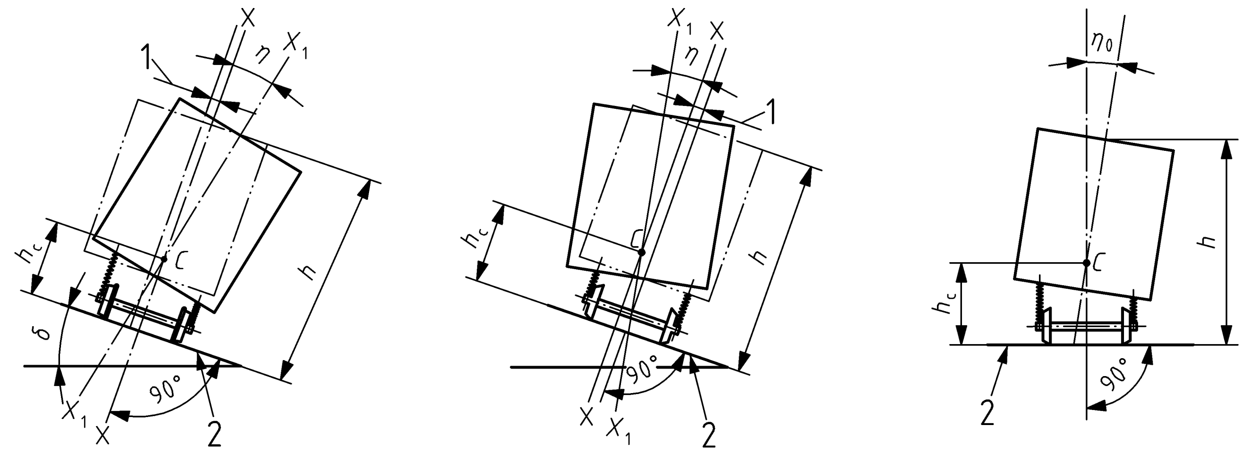
3 additional overthrow S_a towards the outside of the track

4 additional overthrow S_i towards the inside of the track

Figure 13 — Additional overthrows in a curve

5.6 Roll centre

The transverse displacement of the body makes it possible to determine a centreline XX. When the body rolls, the centreline XX takes a position X_1X_1. The roll centre C is located at the intersection of centrelines XX and X_1X_1 and its height h_C in relation to the running surface is referred to as the height of the roll centre. The position of the roll centre may vary according to the load.



a) Stationary vehicle on a canted curve **b) Moving vehicle with cant deficiency** **c) Vehicle with dissymmetry**

Key

1 transverse displacement of the body

2 running surface

C roll centre

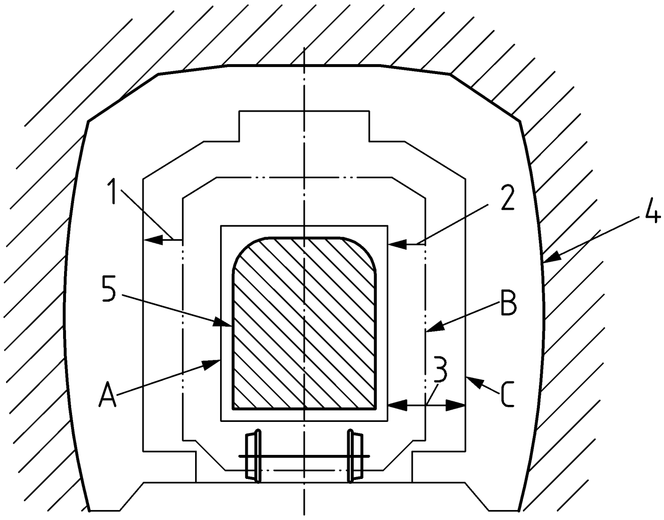
Figure 14 — Roll of a vehicle around its roll centre

6 Gauges and gauging methods

6.1 General

6.1.1 Introduction

A gauge is an agreement for the division of responsibilities between the rolling stock and the infrastructure (see Figure 15).



Key

A maximum construction gauge for the rolling stock

B reference profile

C structure gauge

1 widenings comprising S, qs, z_0, M1, M2, M3 established for the infrastructure

2 reductions E_i or E_a established for the rolling stock

3 sum of the rolling stock displacements and of the phenomena interacting with the infrastructure

4 structures

5 vehicle

Figure 15 — General illustration of the gauges

The basic elements required to establish an agreement are:

— a reference profile;

— one or more reference vehicles;

— distribution of responsibilities to take into account the phenomena between the infrastructure and the rolling stock;

— the gauging rules for the infrastructure and for the rolling stock;

— the allowed additional overthrows "*S*" for the rolling stock outside the reference profile.

Each agreement specifies that:

For the rolling stock, the construction maximum gauge is obtained by reducing the reference profile by a value

$$E = Dpl - S \ , \qquad (9)$$

knowing that the rolling stock undergoes displacements "Dpl" and that the infrastructure authorizes additional overthrows "S" outside of the reference profile.

For the infrastructure, the structure limit gauge is obtained by adding the additional overthrows "S" and taking into account phenomena not included in the reference profile. In order to simplify matters, the infrastructure may also decide to apply a **uniform structure installation gauge**.

The three types of agreement generally applied are commonly referred to as **"static gauge"**, **"kinematic gauge"** and **"dynamic gauge"**.

6.1.2 Static gauge

For the **"static gauge"**, the infrastructure takes into account fixed allowances to cover certain dynamic displacements of the vehicle. The use of this type of gauge is restricted to vehicles in which the flexibility of the suspension is limited.

The static gauging method only applies to vehicles in which the quasi-static roll "z_{cin}" is not greater than the value "z_0" specified below, the value of which is given in Annex B.

Thus, for the rolling stock:

— the semi-width "b_{veh}" of the vehicle under study is calculated on the basis of a static reference profile "$b_{\mathrm{CR\,st}}$" to which is added the corresponding static additional overthrow "S_{st}" and from which are subtracted the static displacements "Dpl_{st}";

$$b_{\mathrm{veh}} \leq b_{\mathrm{CR\,st}} + S_{\mathrm{st}} - Dpl_{\mathrm{st}} \tag{10}$$

— the rolling stock takes no account of the dynamic uplift of the suspension.

For the infrastructure:

— the enlargement for dynamic uplift and drop shall be taken into account by respectively adding to or subtracting from the height of the static reference profile.

The semi-width "b_{inf}" is defined by taking into account the fixed allowances established by the infrastructure.

These fixed allowances shall be adequate to cover all the dynamic displacements of the rolling stock not included inside the static reference profile.

Considering that $qs_{\mathrm{i}} = Q_{\mathrm{D>D_0}}$ and $qs_{\mathrm{a}} = Q_{\mathrm{I>I_0}}$, it is possible to verify that the allowances are adequate by applying the following formula:

$$b_{\mathrm{inf}} \geq b_{\mathrm{CR\,st}} + S_{\mathrm{st}} + z_0 + \left\lfloor qs_{\mathrm{i}}{}^{ou} qs_{\mathrm{a}} \right\rfloor + M_{(1)\mathrm{d}} + M_{(1)\mathrm{osc}} + M_{(2)\mathrm{voie}} + M_{(2)\mathrm{D}} + M_{(3)} \tag{11}$$

The infrastructure specifies a vertical allowance to take account of the dynamic uplift of the suspension.

6.1.3 Kinematic gauge

For the **"kinematic gauge"**, the infrastructure takes into account the dynamic displacements of the vehicle not exceeding certain values specified in the agreement. Any exceeding of the standard values is borne by the rolling stock.

Quasi-static roll is partially taken into account in the displacement "Dpl_{cin}" inside the reference profile.

The value "z_{cin}" considered for this purpose inside the reference profile varies according to the vehicle suspension flexibility and characteristics under consideration. The calculation is based on a fixed cant or cant deficiency "D_0 or I_0" taken into account by the rolling stock.

As far as it is concerned, the infrastructure clears the complementary quasi-static roll qs_{i} or qs_{a} on the basis of the parameters of the reference vehicles included in the agreement and in the local track characteristics.

Consequently, the kinematic gauging method is applicable to every vehicle irrespective of its suspension flexibility.

Thus

— the semi-width "b_{veh}" of the vehicle under study is calculated on the basis of a kinematic reference profile "$b_{\text{CR cin}}$" to which is added the corresponding kinematic additional overthrow "S_{cin}" and from which are subtracted the kinematic displacements "Dpl_{cin}";

$$b_{\text{veh}} \leq b_{\text{CR cin}} + S_{\text{cin}} - Dpl_{\text{cin}} \quad (12)$$

— the semi-width "b_{inf}" of the corresponding infrastructure is calculated on the basis of the reference profile "$b_{\text{CR cin}}$" by adding the kinematic additional overthrow "S_{cin}", the quasi-static roll qs_{i} or qs_{a}, the additional dynamic roll "$M_{(1)\text{cin}}$", the usable maintenance allowances "$M_{(2)\text{cin}}$" and a possible reserve "$M_{(3)}$".

$$b_{\text{inf}} \geq b_{\text{CR cin}} + S_{\text{cin}} + \left\lfloor qs_{\text{i}} \,^{ou}\, qs_{\text{a}} \right\rfloor + M_{(1)\text{d}} + M_{(1)\text{osc}} + M_{(2)\text{voie}} + M_{(2)\text{D}} + M_{(3)} \quad (13)$$

6.1.4 Dynamic gauge

For the **"dynamic gauge"**, the infrastructure does not take into account the vehicle displacements. All the displacements are managed by the rolling stock on the basis of a track quality defined in the agreement.

In the dynamic gauging method, all the displacements "Dpl_{dyn}" of the rolling stock are determined by considering an equivalent cant "$D_{\text{eq}} \geq D_{\text{max}} + D_{\text{sup}}$" or a cant deficiency "$I_{eq} \geq I_{\text{max}} + I_{\text{sup}}$" and are taken into account inside the dynamic reference profile.

The values of D_{sup} and I_{sup} are calculated in order to include the effects of the oscillations "$M_{(1)osc}$" and the dynamic part $s\frac{T_D}{L}(h-h_{c0})_{>0}$ of the crosslevel error "$M_{(2)D}$" inside the reference profile.

The additional values D_{sup} and I_{sup} correspond to the sum "T_{osc} + T_D" with the possibility of varying the values dependent on the infrastructure criteria according to the track quality, speed and according to whether it is a matter of cant or cant deficiency.

As far as it is concerned, the infrastructure takes into account the allowances $M_{(1)d}$ and $M_{(2)dyn}$ outside the dynamic reference profile.

Therefore, the dynamic gauging method is applicable to all vehicles and enables their width to be optimized depending on the flexibility of their suspensions.

Thus:

— the semi-width "b_{veh}" of the vehicle under study is calculated on the basis of a dynamic reference profile "$b_{CR\,dyn}$" to which is added the corresponding static additional overthrow "S_{dyn}" and from which are subtracted the static displacements "Dpl_{dyn}".

$$b_{veh} \leq b_{CR\,dyn} + S_{dyn} - Dpl_{dyn} \tag{14}$$

— The semi-width "b_{inf}" of the corresponding infrastructure is calculated on the basis of the reference profile "$b_{CR\,dyn}$" by adding the dynamic additional overthrow "S_{dyn}", the margin $M_{(1)d}$ to cover the dissymmetry η_0, the margin $M_{(2)dyn}$ to cover the transverse displacement of the track $M_{(2)voie}$ and the geometric part $h\frac{T_D}{L}$ of the cant degradation $M_{(2)D}$ as well as a possible reserve $M_{(3)}$.

$$b_{inf} \geq b_{CR\,dyn} + S_{dyn} + M_{(1)d} + M_{(2)dyn} + M_{(3)} \tag{15}$$

6.1.5 Uniform structure gauge

The uniform structure gauge results from a numerical application officially comprising the maximum additional overthrows, the maximum allowed quasi-static effects and the infrastructure allowances.

The uniform structure gauge is a nominal gauge to which the infrastructure does not add any additional overthrow or quasi-static effect.

It is reserved solely for the infrastructure and the rolling stock running on it shall be sized according to one of the static, kinematic or dynamic gauges.

Generally, uniform gauges have a greater allowance between the rolling stock and the structures in the large radii and on a straight track. This explains why zones reserved for the installation of the platforms may be located inside uniform gauges.

6.1.6 Gauges and interoperability

Static, kinematic and dynamic gauges ensure various levels of interoperability for the vehicles on all the infrastructures that have cleared the gauges of the same name.

— The static gauge ensures interoperability of vehicles in which the roll due to the flexibility of the suspensions does not exceed a limit value specified in the agreement.

— The kinematic gauge ensures interoperability of all types of vehicles.

— The dynamic gauge ensures interoperability of vehicles on infrastructures that comply with the track quality specified in the agreement.

6.1.7 Illustration and comparison of static and kinematic gauges in the transverse direction

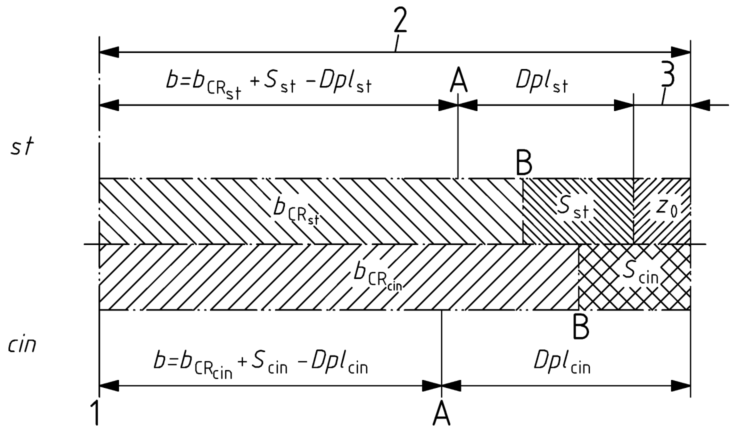
In spite of an equivalent composition of the constituents of a static gauge and a kinematic gauge of the same name, if the infrastructure allowances are limited, it is possible that they will not ensure that rolling stock constructed to the kinematic gauge will be able to operate (see Figure 16 and Figure 17).

For networks wanting to ensure full compatibility of their infrastructure, this comparison of static and kinematic gauges makes it possible to define a structure installation limit gauge on the basis of an existing static gauge.

It shall be noted that the kinematic gauge applied by the infrastructure also allows the operation of vehicles constructed according to the static gauge.

The kinematic reference profile corresponding to the original static gauge is obtained by the following relationship:

$$b_{CR\,\mathrm{cin}} = b_{CR\,\mathrm{st}} + S_{st} - S_{\mathrm{cin}} + Z_0 \qquad (16)$$



Key

A maximum construction gauge for the rolling stock

B reference profile

1 track centreline

2 composition of constituents

3 zone z_0 of the infrastructure, made available to the rolling stock with regard to the static gauge

Figure 16 — Equivalence of the composition of constituents of static gauges and the corresponding kinematic gauges

The structure gauge allows interoperability to be achieved by including the roll qs_i or qs_a and the allowances according to the flexibility coefficient s_0 used for the kinematic gauge.

In the case of non-interoperable routes, it is recommended to adopt the same principle, with the limit flexibility coefficient s_{lim} corresponding to the value z_0.

The allowances $M_{(1)_{cin}}$, $M_{(2)_{cin}}$ and $M_{(3)}$ take into account various random phenomena that mean:

The infrastructure manager adopts the method of his choice:

— either, fixed values based on his experience, his operational and maintenance rules;

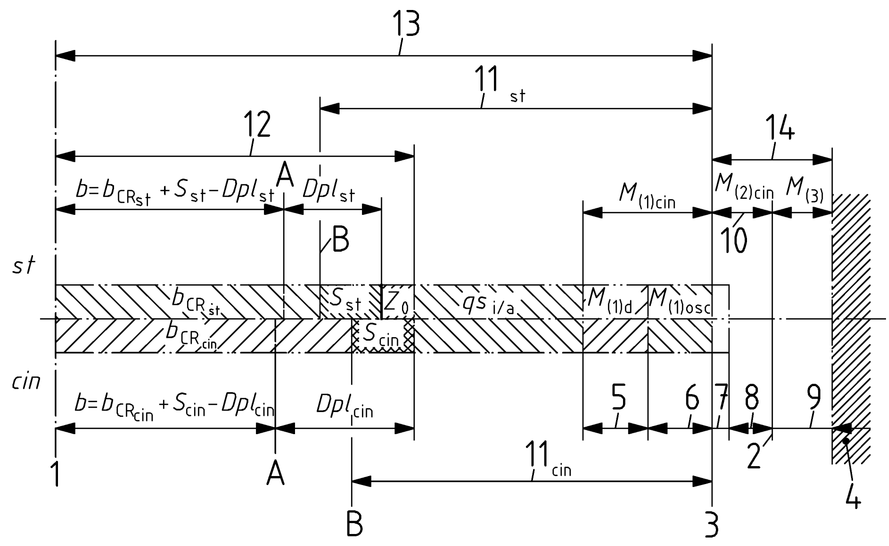
— or, a Gaussian probability and a security coefficient based on local running conditions;

  — Σ_{1cin}, the sum of the random elements taken into account for the verification limit;

  — Σ_{2cin}, the sum of the random elements taken into account for the structure installation limit gauge;

  — Σ_{3cin}, the sum of the random elements taken into account for the structure installation nominal gauge;

the recommended values given in the Annex to EN 15273-3.



Key

A maximum construction gauge for the rolling stock

B reference profile

1 track centreline

2 structure installation limit gauge

3 envelope of the reference vehicle without using the maintenance allowances

4 structure installation nominal gauge

5 mandatory allowance $M_{(1)d}$

6 mandatory allowance $M_{(1)osc}$

7 usable allowance $M_{(2)D_{cin}}$

8 usable allowance $M_{(2)voie}$

9 reserve allowance $M_{(3)}$ (this reserve may contain the aerodynamic allowances)

10 usable allowance $M_{(2)_{cin}}$ between the installation limit gauge and verification limit gauge.

11 constituent determined by the infrastructure manager

12 constituent determined by the rolling stock manager

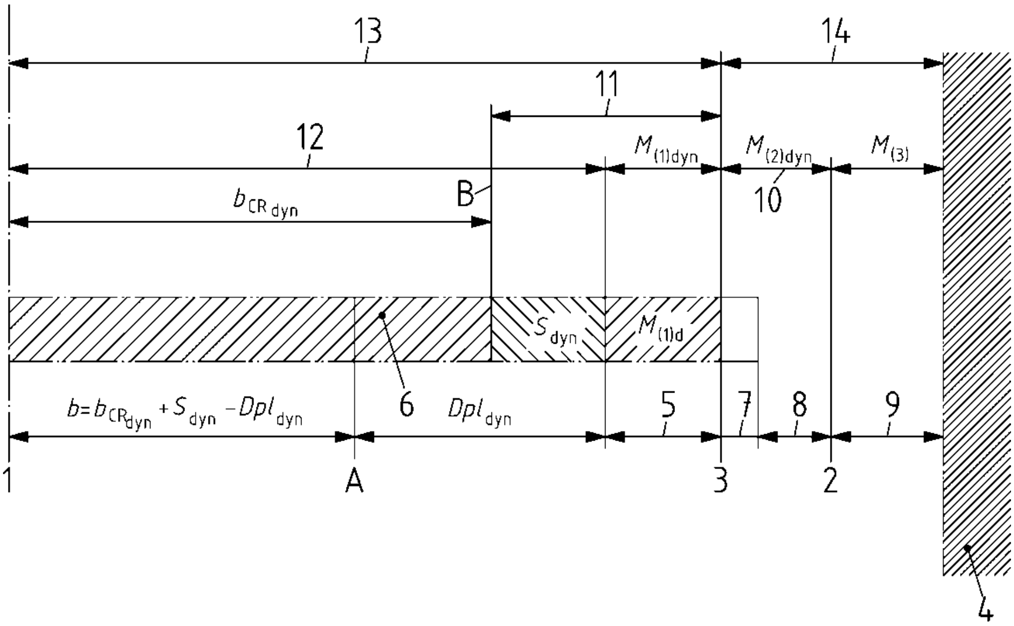
13 structure verification limit gauge for a defined track quality and a given speed

14 infrastructure manager reserve

Figure 17 — Illustration and comparison of the static and kinematic gauges

6.1.8 Illustration of the dynamic gauge

Figure 18 illustrates the dynamic gauge.



Key

A maximum construction gauge for the rolling stock
B reference profile
1 track centreline
2 structure installation limit gauge
3 envelope of the reference vehicle without using the maintenance allowances
4 structure installation nominal gauge
5 mandatory allowance $M_{(1)\mathrm{d}}$
6 full quasi-static roll Q and mandatory allowance "$M_{(1)\mathrm{osc}}$" in $b_{CR_{\mathrm{dyn}}}$
7 usable allowance $M_{(2)D_{\mathrm{dyn}}}$
8 usable allowance $M_{(2)\mathrm{voie}}$
9 reserve allowance $M_{(3)}$ (this reserve may contain the aerodynamic allowances)
10 usable allowance $M_{(2)_{\mathrm{dyn}}}$ between the installation limit gauge and limit position
11 constituent determined by the infrastructure manager
12 constituent determined by the rolling stock manager
13 structure limit position for a defined track quality and a given speed
14 infrastructure manager reserve

NOTE The same principle may be applied in the vertical direction.

Figure 18 — Illustration of the dynamic gauge

6.2 Other gauging methods: General

The following gauging methods do not use a reference profile nor an agreement between the rolling stock and the infrastructure. Therefore, they are not gauges.

These methods are reserved for vehicles dedicated to specific routes.

The **“dynamic gauge”** calculation formulae may be used for these applications.

6.3 Absolute gauging method

For the absolute gauging method, the rolling stock relies on the position of the structures to define its own maximum construction gauge (see Figure 19).

The minimum value of the allowances to be specified in relation to the actual semi-width of the infrastructure corresponds to the values taken into account by the infrastructure with respect to the dynamic gauge.

The dynamic envelope of the vehicle under consideration is defined by a swept envelope according to the local running conditions, taking into account the corresponding dynamic displacements “Dpl_{dyn}”.

Thus

— The semi-width “b_{veh}” of the vehicle under study is calculated on the basis of the semi-width of the infrastructure reference “$b_{r\,\text{inf}}$” by subtracting the margins taken into account in the infrastructure and the dynamic displacements “Dpl_{dyn}”;

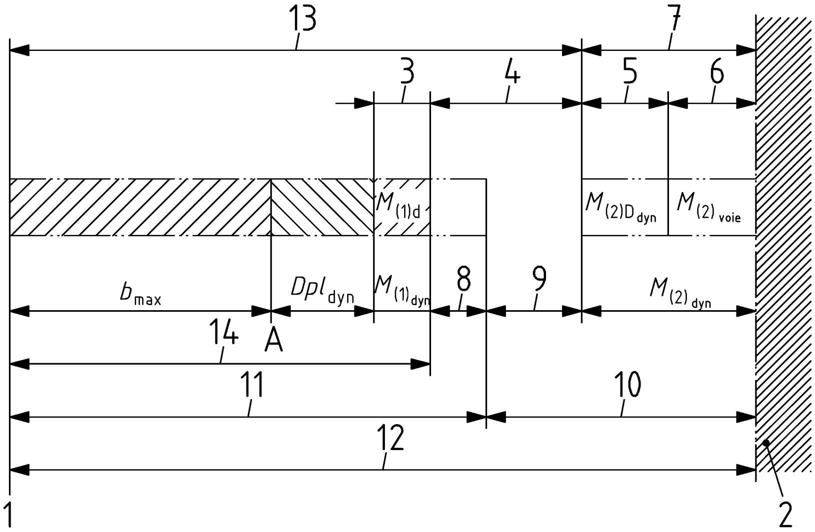
$$b_{\text{veh}} \leq b_{\text{r inf}} - Dpl_{\text{dyn}} - M_{(1)_{\text{d}}} - M_{(2)_{\text{dyn}}} - M_{(3)} \tag{17}$$

— the minimum semi-width “b_{inf}” permissible for the infrastructure is calculated on the basis of the reference semi-width “b_{rinf}” by subtracting the usable allowance “$M_{(2)\text{dyn}}$” and a possible reserve $M_{(3)}$.

$$b_{\text{inf}} \geq b_{\text{r inf}} - M_{(2)\text{dyn}} - M_{(3)} \tag{18}$$

NOTE 1 If specified, the aerodynamic part of the allowance $M_{(3)}$ is not taken into account by the infrastructure in b_{inf}, it depends on the rolling stock.

NOTE 2 In certain cases, the absolute gauging method may also be used for the pantographs.



Key

A maximum construction gauge for the rolling stock

1 track centreline

2 structures

3 mandatory allowance $M_{(1)\mathrm{d}}$ for the dissymmetry

4 reserve allowance $M_{(3)}$

5 usable allowance $M_{(2)D_{\mathrm{dyn}}}$ for crosslevel errors

6 usable allowance $M_{(2)\mathrm{voie}}$ for track tolerances and wear

7 usable allowance $M_{(2)_{\mathrm{dyn}}}$ for infrastructure maintenance

8 aerodynamic allowance

9 infrastructure manager reserve

10 constituent determined by the infrastructure manager

11 constituent determined by the rolling stock manager

12 infrastructure reference semi-width $b_{\mathrm{r\,inf}}$

13 structure limit gauge for a specified track quality

14 swept envelope

NOTE The same principle may be applied in the vertical direction.

Figure 19 — Illustration of the absolute gauging method

6.4 Comparative gauging method

In the comparative gauging method, the rolling stock relies on an existing vehicle already running on a given route to define the maximum construction gauge of a new vehicle under consideration.

The comparative gauging method makes it possible to ensure that the envelope swept by a vehicle 1 is no bigger than that swept by a reference vehicle 2 already running on a specified route.

Thus

$$b_{\text{veh(1)}} \leq b_{\text{veh(2)}} + Dpl_{\text{dyn(2)}} - Dpl_{\text{dyn(1)}} \tag{19}$$

7 Elements involved in the determination of a gauge

7.1 Introduction

This clause lists the elements to be taken into account to avoid any interference between the rolling stock and the infrastructure and between rolling stock.

7.2 General

7.2.1 In the transverse direction

Table 2 gives the elements to be taken into account for the transverse direction.

Table 2 — Elements to be taken into account for the transverse direction

	Static		**Kinematic**		**Dynamic**	
	Content	Infra	Content	Infra	Content	Infra
the semi-width of the vehicle "b_{veh}" at the point under consideration	6.1.2		6.1.3		6.1.4	
the transverse position of the structure "b_{inf}"		6.1.2		6.1.3		6.1.4
the track centres EA		EN 15273-3		EN 15273-3		EN 15273-3
the vehicle construction tolerances	EN 15273-2		EN 15273-2		[A1) EN 15273-2 (A1]	
the geometric overthrow "dg_{i} or dg_{a}" of the point under consideration according to the track curvature	3.12		3.12		3.12	

Table 2 *(continued)*

	Static		Kinematic		Dynamic	
	Content	Infra	Content	Infra	Content	Infra
the effects of the transverse clearances between the body and bogie according to the curve radius $A \cdot w_{(R)}$	7.3.1.11		7.3.1.12		7.3.1.13	
the effects of the transverse clearances between wheelset and bogie $A \cdot q$	7.3.1.11		7.3.1.12		7.3.1.13	
the effects of the transverse clearances of the wheelsets on the track $A\left(\frac{l_{max} - d}{2}\right)$	7.3.1.11		7.3.1.12		7.3.1.13	
the effect of track gauge widening $\frac{l_{réel} - l_N}{2}$		7.3.1.1.1		7.3.1.1.1		7.3.1.1.1
the effect of roll "η_0" due to vehicle dissymmetry		3.14	3.14	3.14	3.14	3.14
the effects of the roll of tilting vehicles			7.3.1.14		7.3.1.14	
the effect of the roll due the vertical clearance "J" at the position of the side bearers			7.3.1.4.2.2		7.3.1.4.2.3	
the horizontal component of the vehicle roll due to the excess cant or cant deficiency "Q"		7.3.1.4.2	7.3.1.4.2.2	7.3.1.4.2.2	7.3.1.4.2.3	
crosslevel error due to defects and tolerances "T_D"		7.3.1.4.2	7.3.1.4.2.2	7.3.1.4.2.2	7.3.1.4.2.3	7.3.1.4.2.3
the transverse bending of the body	EN 15273-2		EN 15273-2		EN 15273-2	
the infrastructure construction tolerances		EN 15273-3		EN 15273-3		EN 15273-3
the dynamic roll "$M_{(1)osc}$" due to oscillations generated by the irregularities of the track for a reference quality and speed		7.3.1.5		7.3.1.5	7.3.1.5	
the transverse displacement of the track between two maintenance periods "T_{voie}"		7.3.1.6		7.3.1.6		7.3.1.6.

7.2.2 In the vertical direction

Table 3 gives the elements to be taken into account for the vertical direction.

Table 3 — Elements to be taken into account for the vertical direction

	Static		Kinematic		Dynamic	
	Content	Infra	Content	Infra	Content	Infra
Geometric						
8 the height of the point under consideration on the vehicle	EN 15273-2		EN 15273-2		EN 15273-2	
9 the vertical position of the structure under consideration		EN 15273-3		EN 15273-3		EN 15273-3
10 the vertical geometric overthrow “dg_{iv} or dg_{av}” of the point under consideration according to the track curvature	7.3.2.2.3.	7.3.2.2.3.	7.3.2.2.3.	7.3.2.2.3.	7.3.2.2.3.	7.3.2.2.3.
Tolerances						
11 rolling stock construction tolerances	EN 15273-2		EN 15273-2		EN 15273-2	
12 tolerance on the adjustment of the suspension (air, etc.)	EN 15273-2		EN 15273-2		EN 15273-2	
13 Transverse displacement of the track between two periods of maintenance “T_{voie}”		EN 15273-3		EN 15273-3		EN 15273-3
14 Track crosslevel difference between two maintenance periods “T_D”		7.3.2		7.3.2	7.3.2	7.3.2
15 Vertical displacement of the track between two periods of maintenance “T_N”		7.3.2		7.3.2	7.3.2	7.3.2
16 tolerances on the installation of the structures		EN 15273-3		EN 15273-3		EN 15273-3
Wear down to the maintenance limits						
17 wear of the wheels	EN 15273-2		EN 15273-2		EN 15273-2	
18 wear of the rails		EN 15273-3		EN 15273-3		EN 15273-3
19 wear of the axle boxes	EN 15273-2		EN 15273-2		EN 15273-2	

Table 3 *(continued)*

	Static		Kinematic		Dynamic	
	Content	Infra	Content	Infra	Content	Infra
20 wear of the suspension	EN 15273-2		EN 15273-2		EN 15273-2	
Vertical displacements						
21 deformation of the structures	EN 15273-2		EN 15273-2		EN 15273-2	
22 suspension displacement	EN 15273-2	EN 15273-3	EN 15273-2		EN 15273-2	
23 dynamic uplift of the suspension		EN 15273-3	EN 15273-2		EN 15273-2	
Vertical displacements due to the roll of the vehicle and of the track						
24 the vertical component of the vehicle roll due to the cant excess or to the cant deficiency		7.3.2.2.1.		7.3.2.2.1.	7.3.2.2.1.	
25 the effect of the vehicle dissymmetry "η_0"		EN 15273-3	ignored	EN 15273-3	EN 15273-2	
26 the effect of the roll "$J - j$" of the frame due to the clearance of the side bearers		EN 15273-3	7.3.1.4.2.3		7.3.1.4.2.4	

7.3 Detailed analysis of the details to be shared between rolling stock and infrastructure depending of the method of determination of each of the gauges

7.3.1 In the transverse direction

7.3.1.1 Additional overthrows

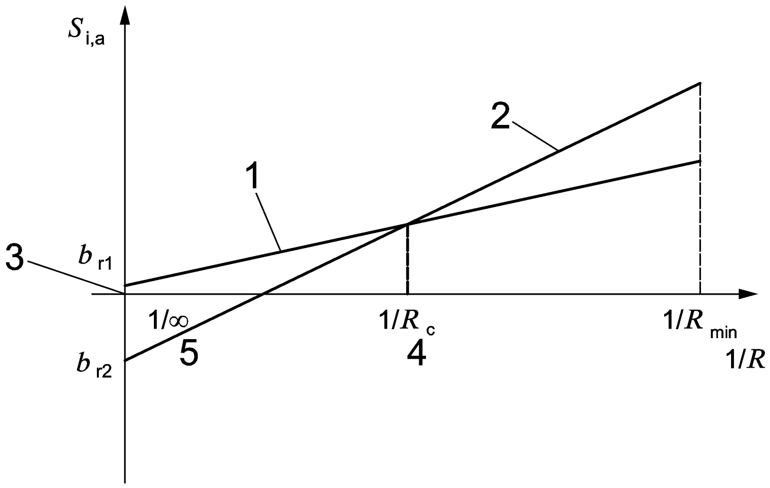
7.3.1.1.1 General rules

The additional overthrows "S_i" allowed towards the inside of the curve may have different values to the additional overthrows "S_a" allowed towards the outside of the curve.

Figure 20 illustrates the development of the additional overthrows in relation to the horizontal curve.

It should be noted that according to the agreement, the value *F* either includes or not the clearances "*q* + *w*" of the reference vehicle in the semi-width *br*. In this case, the value *F* will be zero in the formulae for determination of the additional overthrow.

The number of reference vehicles depends on the agreement associated with each gauge.



Key

1 reference vehicle n° 1 in which the semi-width corresponds to *br*1

2 reference vehicle n° 2 in which the semi-width corresponds to *br*2

3 semi-width of the reference profile or semi-width of the reference vehicle

4 $1/R_c$ corresponds to a critical radius where the reference vehicle changes

5 1/∞ corresponds a straight line track

Figure 20 — Example of illustrating the development of the additional overthrows in relation to the horizontal curve for a gauge using two reference vehicles

According to the agreement associated with the gauge under examination, static, kinematic or dynamic, the value of the additional overthrow allowed at the outside of the reference profile takes into account the following values if they are not already included in the reference profile.

The additional overthrows comprise three variable parts:

— the geometric overthrows of the reference vehicle $dg_{i\ ou}\, dg_a = \frac{(a_r n_r \pm n_r^2) \pm \frac{p_r^2}{4}}{2R}$;

— a permanent [A1] *deleted text* [A1] value "$F = (A)q_r + (A)w_r + (A)\frac{l_N - d}{2}$" already present on a straight track to take into account the transverse clearances $q_r + w_r$ and the position of the wheelsets on the track;

— a variable part $\frac{l_{réel} - l_{nom}}{2}$ depending on the curve dimension.

This leads to the following general formulae:

— for the static gauge,

$$S_{\mathrm{i\,st}} = b_{\mathrm{r}} + \frac{(a_r n_{\mathrm{ir}} - n_{\mathrm{ir}}{}^2) + \frac{p_r^2}{4}}{2R} + F + \frac{l_{\mathrm{réel}} - l_{\mathrm{nom}}}{2} - b_{CR\,\mathrm{st}} \quad (20)$$

$$S_{\mathrm{a\,st}} = b_{\mathrm{r}} + \frac{(a_{\mathrm{r}} n_{\mathrm{ar}} + n_{\mathrm{ar}}{}^2) - \frac{p_r^2}{4}}{2R} + F + \frac{l_{\mathrm{réel}} - l_{\mathrm{nom}}}{2} - b_{CR\,\mathrm{st}} \quad (21)$$

[A1) The value F is to be taken into consideration on the outside of the static reference profile as a fixed value (see Annex B). (A1]

— for the kinematic gauge.

The upper part of the kinematic reference profile also includes a value z_0 relative to a part of the quasi-static roll.

— Thus

$$S_{\mathrm{i\,cin}} = b_{\mathrm{r}} + \frac{(a_{\mathrm{r}} n_{\mathrm{ir}} - n_{\mathrm{ir}}{}^2) + \frac{p_r^2}{4}}{2R} + F + \frac{l_{\mathrm{réel}} - l_{\mathrm{nom}}}{2} + z_0 - b_{CR\,\mathrm{cin}} \quad (22)$$

$$S_{\mathrm{a\,cin}} = b_{\mathrm{r}} + \frac{(a_{\mathrm{r}} n_{\mathrm{ar}} + n_{\mathrm{ar}}{}^2) - \frac{p_{\mathrm{r}}{}^2}{4}}{2R} + F + \frac{l_{\mathrm{réel}} - l_{\mathrm{nom}}}{2} + z_0 - b_{CR\,\mathrm{cin}} \quad (23)$$

— for the dynamic gauge,

$$S_{\mathrm{i\,dyn}} = b_{\mathrm{r}} + \frac{(a_{\mathrm{r}} n_{\mathrm{ir}} - n_{\mathrm{ir}}{}^2) + \frac{p_{\mathrm{r}}{}^2}{4}}{2R} + F + \frac{l_{\mathrm{réel}} - l_{\mathrm{nom}}}{2} - b_{CR\,\mathrm{dyn}} \quad (24)$$

$$S_{\mathrm{a\,dyn}} = b_{\mathrm{r}} + \frac{(a_{\mathrm{r}} n_{\mathrm{ar}} + n_{\mathrm{ar}}{}^2) - \frac{p_{\mathrm{r}}{}^2}{4}}{2R} + F + \frac{l_{\mathrm{réel}} - l_{\mathrm{nom}}}{2} - b_{CR\,\mathrm{dyn}} \quad (25)$$

It should be noted that to define new additional overthrows, these formulae shall be applied successively to each of the reference vehicles in order to take into account the largest additional overthrow values according to the radius.

7.3.1.1.2 Value of the additional overthrows applicable for the rolling stock

The transition from one rule-set to the other as shown in Figure 20 corresponds to a critical radius that shall be checked when sizing new vehicles to be constructed.

When the coefficient of displacement $A \geq 1$, the rolling stock has to take into account the maximum value l_{max} to include the increase in the transverse displacements due to the clearance of the wheelsets on the track. (Example l_{max} = 1,465 m for l_{nom} = 1,435 m).

7.3.1.1.3 Value of the additional overthrows applicable to the infrastructure

7.3.1.1.3.1 Additional overthrows on the track

The additional overthrows are those defined in 7.3.1.1.1 above.

7.3.1.1.3.2 Additional overthrows in the points and crossing

In the additional overthrows defined in 7.3.1.1.1 above, a geometric overthrow is considered.

$dg_i = \frac{(a_r n_{i_r} - n_{i_r}{}^2) + \frac{p_r{}^2}{4}}{2R}$ for the value of S_i and $dg_a = \frac{(a_r n_{a_r} + n_{a_r}{}^2) - \frac{p_r{}^2}{4}}{2R}$ for the value of S_a and a value "b_r" for the respective semi-width of each reference vehicle.

In the switches and crossings, the additional overthrow value aligns with the maximum values of "$dg_i + b_r$" or "$dg_a + b_r$" determined below.

In order to obtain the value for the additional overthrow, the value "$dg_i + b_r$" or "$dg_a + b_r$" shall be replaced with the new value in the calculation formula for the additional overthrows set forth in 7.3.1.1.1. These values are determined by using the worst case theoretical or actual reference vehicle parameters.

The geometric overthrow depends on the exact shape of each type of switch or crossing.

In the switches and crossings, the two lines of rail are not exactly parallel and the trajectory of the vehicles may be defined in different ways.

To find the maximum geometric overthrows "dg_i" and "dg_a", reference should be made to the track centreline or to the rail line corresponding to the greatest crossing angle "β".

The zone corresponding to the geometric displacements "dg_a" under consideration corresponds to the overall envelope of the three curves $\Delta_{a(1)}$, $\Delta_{a(2)}$ and $\Delta_{a(3)}$ of the 3 reference vehicles.

On the inside of the curve, "dg_i" is determined using the maximum wheelbase value "a_r" for the various reference vehicles according to the geometry of each type of rail vehicle. EN 15273-3 provides several examples, on the basis of graphical solutions.

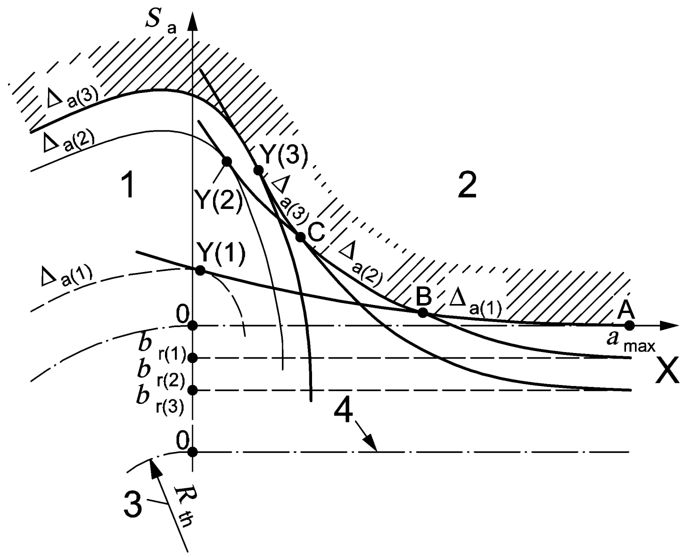
On the outside of the curve, "dg_a" of each reference vehicle corresponds to a constant value $\Delta_a = a_r n_r + n_r{}^2$.

(It should be noted that the value p is disregarded for this application)

The most critical value of the overhang "n_r" and corresponding wheelbase "a_r" shall be determined for each reference vehicle.

$$n_r = \frac{-a_r + \sqrt{a^2{}_r + 4\Delta_a}}{2} \qquad (26)$$

Figure 21 provides a practical illustration with 3 reference vehicles for a curve exit. The change of reference vehicle corresponds to points A, B, C and Y.



Key

1 zone swept by the rolling stock

2 installation zone of the platforms and structures in general

3 R_{th} = theoretical radius of the switch or crossing or of the actual track

4 track centreline

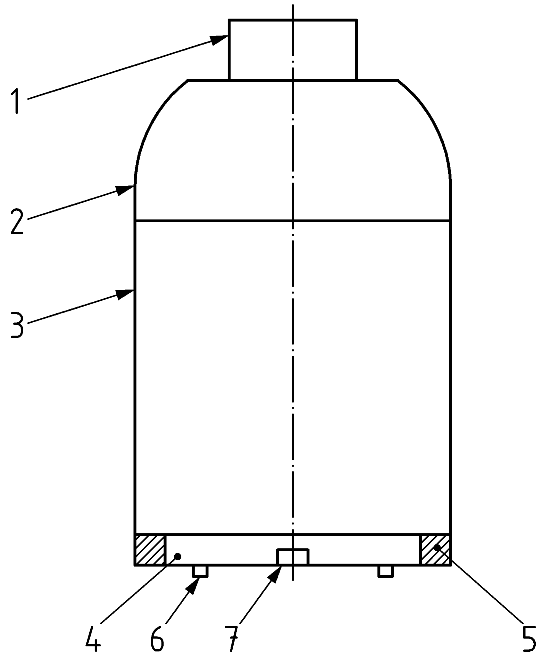
Figure 21 — Example of space to be cleared in the switch or crossing

7.3.1.2 Reference profile

The reference profile is the interface that is used as a basis for determining the infrastructure dimensions and the rolling stock dimensions (see Figure 22).

A reference profile generally comprises several parts each linked respectively to their own rules.

A distinction is generally made between the lateral parts, the upper parts, the lower parts, the pantograph zone, the contact ramp zone and the wheel zone.



Key

1 pantograph zone

2 upper area

3 lateral part

4 lower part

5 third rail zone

6 wheel zone

7 contact ramp zone

Figure 22 — Parts of the reference profile

7.3.1.3 Flexibility coefficient(s) value

EN 14363 gives the method for measuring the flexibility coefficient of vehicles.

7.3.1.4 Quasi-static roll value

7.3.1.4.1 Basic theory relating to transverse acceleration

The roll of the vehicle is due to the effect of the transverse acceleration on the suspension flexibility (see Figure 23).

Centrifugal acceleration is linked to the running speed and the curve radius. Displacements *linked* to them depend solely on the part of the acceleration not compensated by the cant.

Any vehicle running in a curve radius R at speed v is subjected to a centrifugal acceleration $\gamma = \frac{v^2}{R}$ the effect of which has to be limited.

By giving a cant "D" on the track, the centrifugal acceleration effect is reduced by setting against it a gravity component "$-\gamma'_D$".

The resulting "γ'_I" corresponds to the quantity

$$I = \frac{v^2 L}{gR} - D \qquad (27)$$

called "cant deficiency" as this is the value by which the cant is less than that required to compensate exactly for the centrifugal acceleration.

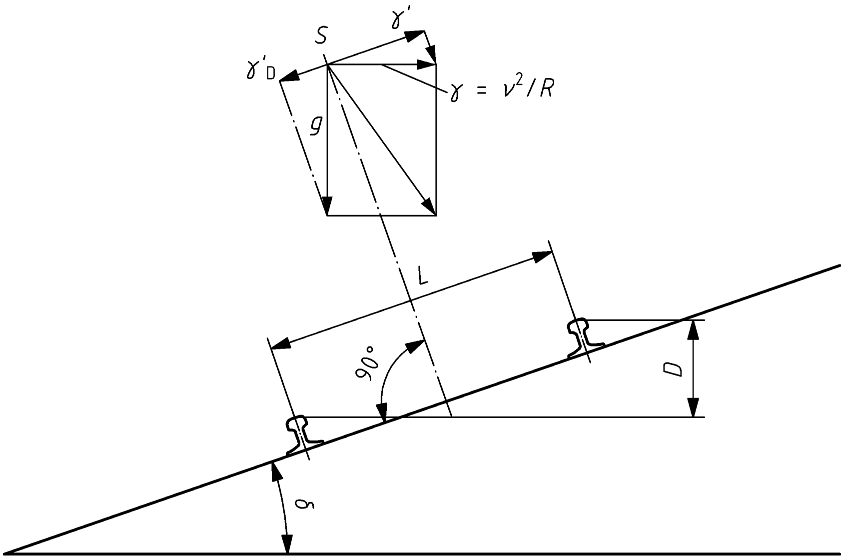


Figure 23 — Cant deficiency

The formulae above are valid when the parameters are expressed in uniform units, i.e.:

— D, I, L, R in m;

— v in m/s;

— g, γ, γ' in m/s².

Expressing V in km/h gives $v_{(m/s)} = V_{(km/h)} \frac{1000}{3600}$.

The relation

$$I + D = \frac{v^2 L}{gR} \qquad \text{becomes} \qquad I + D = 0{,}00786 \frac{V^2 L}{R} \qquad (28)$$

7.3.1.4.2 Lateral overthrow due to body roll

7.3.1.4.2.1 General

The roll to be taken into account is the sum of:

— the quasi-static roll due to the transverse acceleration

A1⟩

$$Q = s \cdot \frac{E_{ou} I}{1.5} \cdot (h - h_C) \quad (29)$$ ⟨A1

— the roll due to the dissymmetry and the side bearer clearance is given by the expression

$$\tan \eta_0 \cdot (h - h_c)_{>0} \quad (30)$$

— the roll due to track defects corresponds to the sum of

$$M_{(1)\mathrm{osc}} = \frac{s_0}{L} T_{\mathrm{osc}} (h - h_{\mathrm{c}0})_{>0} \quad (31)$$

and $$M_{(2)\mathrm{D}} = (h \cdot \frac{T_{\mathrm{D}}}{L}) + s_0 \cdot \frac{T_{\mathrm{D}}}{L} \cdot (h - h_{c0})_{>0} \quad (32)$$

7.3.1.4.2.2 Taking into account the roll with regard to the static gauge

For the static gauge, it is agreed that:

— the displacement Q corresponding to the transverse acceleration, expressed in the form of

$$Q = z_0 + (qs_i \overset{ou}{} qs_a) \quad (33)$$

is taken into account totally in the infrastructure allowances;

— the roll due to the dissymmetry and to the side bearer clearances is taken into account by the infrastructure in the allowance $M_{(1)d}$:

— the roll due to track defects is taken into account by the infrastructure in the fixed allowances $M_{(1)osc}$ and $M_{(2)D}$.

Overall:

the infrastructure takes into account $Q + M_{(1)d} + M_{(1)osc} + M_{(2)D}$ in the fixed allowances specified by the network manager;

the rolling stock does not take into account the roll.

7.3.1.4.2.3 Taking into account the roll with regard to the kinematic gauge

For the kinematic gauge, it is agreed that:

— the displacement Q corresponding to the transverse acceleration, expressed in the form of $Q = z + (qs_i \overset{ou}{} qs_a)$ is shared between the rolling stock and the infrastructure.

Thus

— The value

$$qs_{\mathrm{i}} = \frac{s_0}{L}\left[D - D_0\right]_{>0}\left[h - h_{\mathrm{c}0}\right]_{>0} \tag{34}$$

or

$$qs_{\mathrm{a}} = \frac{s_0}{L}\left[I - I_0\right]_{>0}\left[h - h_{\mathrm{c}0}\right]_{>0} \tag{35}$$

is taken into account by the infrastructure outside the reference profile.

— The value

$$z = \left\{\frac{s\left(D_0 \overset{ou}{} I_0\right)}{L}\right\}(h - h_c)_{>0} + \left[\frac{s\left((D_{\max} - D_0)^{ou}(I_{\max} - I_0)\right)}{L}(h - h_c)_{>0} - \frac{s_0\left((D_{\max} - D_0)^{ou}(I_{\max} - I_0)\right)}{L}(h - h_{c0})_{>0}\right]_{>0} \tag{36}$$

is taken into account by the rolling stock running inside the kinematic reference profile.

— The roll due to the dissymmetry and to the side bearer clearances is shared between the infrastructure that takes into account a fixed value in its mandatory allowance

$$M_{(1)d} = \tan \eta_{0r} \left(h - h_{c0}\right)_{>0} \tag{37}$$

— and the rolling stock that takes into account $\tan\left(\eta_0 - \eta_{0r}\right)\left(h - h_{c0}\right)_{>0}$. It should be noted that in the cases of wagons or vehicles fitted with side bearers, η_0 is calculated with the formula

$$\eta_0 = \eta'_0 + \left[\arctan \frac{(J - j)_{>0}}{b_G}\right] \cdot (1 + s) \tag{38}$$

— where the angle η'_0 corresponds to the dissymmetry of the vehicles in which the side bearer clearances do not exceed the value "*j*";

— The roll due to the track defects is shared between the infrastructure which takes into account the

$$M_{(1)_{osc}} = \frac{s_0}{L} T_{osc} \left(h - h_{c0}\right)_{>0} \tag{39}$$

and

$$M_{(2)D} = (h \cdot \frac{T_D}{L}) + s_0 \cdot \frac{T_D}{L} \cdot (h - h_{C0})_{>0} \tag{40}$$

Overall:

the infrastructure takes into account $(qs_i{}^{ou} qs_a) + M_{(1)d} + M_{(1)osc} + M_{(2)D}$;

the rolling stock takes into account:

$$z_{cin} = \frac{s(D_0{}^{ou} I_0)}{L}(h - h_c)_{>0} + \left\{\tan\left[\eta_0 - \eta_{0r}\right]_{>0}\right\}\left|h - h_c\right| + \left[\frac{s\left(I_{\max} - I_0\right)}{L}(h - h_c)_{>0} - \frac{s_0\left(I_{\max} - I_0\right)}{L}(h - h_{c0})_{>0}\right]_{>0} \tag{41}$$

and in the case of wagons fitted with side bearers, the rolling stock takes into account:

$$z_{cin} = \frac{s(D_0{}^{ou} I_0)}{L}(h - h_c)_{>0} + \left\{\tan\left[\eta_0 + \left(\arctan\frac{(J - j)_{>0}}{b_G}\right)(1 + s) - \eta_{0r}\right]_{>0}\right\}\left|h - h_c\right| + \left[\frac{s\left(I_{\max} - I_0\right)}{L}(h - h_{c0})_{>0} - \frac{s_0\left(I_{\max} - I_0\right)}{L}(h - h_{c0})_{>0}\right]_{>0} \tag{42}$$

The term z_{pcin} relating to tilting trains and those subjected to $I_p \geq I_c$, is defined in EN 15273-2 with no amendment being made to the infrastructure.

7.3.1.4.2.4 Taking into account roll with regard to the dynamic gauge

For the dynamic gauge, it is agreed that:

— roll Q corresponding to the transverse acceleration, expressed in the form of

$$Q = s \cdot \frac{D_{ou} I}{L} \cdot \left|h - h_c\right| \tag{43}$$

is entirely taken into account by the rolling stock;

— the roll due to the dissymmetry and to the side bearer clearances is shared between the infrastructure that takes into account a fixed value in its mandatory allowance

$$M_{(1)_d} = \tan \eta_{0r} \left|h - h_{c0}\right| \tag{44}$$

and the rolling stock that takes into account $\left[\tan(\eta_0 - \eta_{0r})\right] \cdot \left|h - h_{c0}\right|$. It should be noted that in the cases of wagons or vehicles fitted with side bearers, η_0 is calculated with the formula

$$\eta_0 = \eta'_0 + \left[\arctan\frac{(J - j)_{>0}}{b_G}\right] \cdot (1 + s) \tag{45}$$

where the angle η'$_0$ corresponds to the dissymmetry of the vehicles in which the side bearer clearances do not exceed the value "*j*".

The roll due to the track defects is shared between the infrastructure which takes into account the direct effect of the defect $(h \cdot \frac{T_D}{L})$ and the rolling stock which takes into account the amplification of the effect of the track defects $s \cdot \frac{T_D}{L} \cdot (h - h_{c0})_{>0}$ due to the flexibility of the suspensions and the oscillations

$$M_{(1)osc} = \frac{s_0}{L} T_{osc} \left(h - h_{c0}\right)_{>0} \tag{46}$$

In the calculation of the roll z_{dyn} taken into account by the rolling stock, an additional cant $D_{\sup}$ or cant deficiency $I_{\sup}$ corresponding to the effect of the track defects is added to the value D or I to obtain an equivalent cant

$$D_{eq} = D + D_{\sup} \tag{47}$$

or an equivalent cant deficiency

$$I_{eq} = I + I_{\sup} \tag{48}$$

Overall:

the infrastructure takes into account $M_{(1)d} + (h \frac{T_D}{L})$;

the rolling stock takes into account:

$$z_{dyn} = \left\{ \frac{s\left(D_{eq} \ or \ I_{eq}\right)}{L} + \tan\left[\eta_0 - \eta_{0r}\right]_{>0} \right\} \left| h - h_{c0} \right| \tag{49}$$

and in the case of wagons fitted with side bearers, the rolling stock takes into account:

$$z_{dyn} = \left\{ \frac{s\left(D_{eq} \ ou \ I_{eq}\right)}{L} + \tan\left[\eta_0 + \left(\arctan \frac{(J - j)_{>0}}{b_G} \right)(1 + s) - \eta_{0r} \right]_{>0} \right\} \left| h - h_{c0} \right| \tag{50}$$

The term $z_{p_{dyn}}$ relating to tilting trains and those subjected to $I_p \geq I_c$, is defined in EN 15273-2 with no amendment being made to the infrastructure.

7.3.1.5 Mandatory allowance $M_{(1)}$

The allowance $M_{(1)}$ comprises:

— the allowance $M_{(1)d}$ corresponding to the roll η_{0r} due to the dissymmetry and to the side bearer clearances;

$$M_{(1)d} = \tan \eta_{0r} \left(h - h_{c0}\right)_{>0} \tag{51}$$

with $$\eta_{0r} = T_{charge} + T_{susp} \tag{52}$$

— with the allowance $M_{(1)osc}$ corresponding to the oscillations depending on the speed and quality of the track.

$$M_{(1)_{osc}} = \frac{s_0}{L} T_{osc} \left(h - h_{c0}\right)_{>0} \tag{53}$$

The allowance $M_{(1)osc}$ may be calculated on the basis of an angle "α_{osc}" expressed in millimetres of cant or additional cant deficiency, chosen by the infrastructure as a function of the track quality criteria, running speed and flexibility coefficient "s_0" agreed.

Where

$$\alpha_{osc} = \frac{s_0}{L} T_{osc} \tag{54}$$

For example:

If L = 1,500 m, and if s_0 = 0,4

$$\tan 0{,}6° \cdot (h - h_{c0}) = \frac{0{,}4}{1{,}5} \cdot 0{,}039 \cdot (h - h_{c0}) \tag{55}$$

where T_{osc} = 0,039 m and

$$\tan 0{,}1° \cdot (h - h_{c0}) = \frac{0{,}4}{1{,}5} \cdot 0{,}007 \cdot (h - h_{c0}) \tag{56}$$

where T_{osc} = 0,007 m

i.e.:

that a crosslevel error T_{osc} = 0,039 m results in an oscillation of 0,6°;

that a crosslevel error T_{osc} = 0,007 m results in an oscillation of 0,1°.

The recommended values for T_{charge}, T_{susp} and T_{osc} are given in EN 15273-3. It should be noted that for dynamic gauges, the value T_{osc} is included in the value D_{sup} or I_{sup}.

For static gauges,

$$M_{(1)st} = M_{(1)cin} \tag{57}$$

is between the fixed allowances established by the infrastructure.

For kinematic gauges,

$$M_{(1)_{cin}} = M_{(1)_d} + M_{(1)_{osc}} = (\tan \eta_0 + \frac{s_0}{L} T_{osc})(h - h_{c0})_{>0} \tag{58}$$

is supported by the infrastructure.

For dynamic gauges,

$$M_{(1)_{dyn}} = M_{(1)_d} = \tan \eta_0 (h - h_{c0})_{>0} \tag{59}$$

is supported by the infrastructure;

$$M_{(1)_{osc}} = \frac{s_0}{L} T_{osc}.(h - h_{c0})_{>0} \tag{60}$$

is taken into account by the rolling stock in the roll z_{dyn}.

7.3.1.6 Usable allowance $M_{(2)}$

The allowance $M_{(2)}$, fixed by the infrastructure manager, covers the displacements due to the allowable degradation of the track between two maintenance periods.

These displacements are due to:

transverse displacement "T_{voie}" of the track in relation to its nominal position;

the dynamic and geometric effects of the cant deficiencies "T_D" in relation to the theoretical value (for curves) or crosslevel for a stretch of track compared to the other (for straight segments).

The values "T_D" are fixed by the infrastructure according to the type of laying and quality of the track and the line speeds.

For example:

T_D = 0,015 m for $V > 80$ km/h

T_D = 0,020 m for $V \leq 80$ km/h

For static gauges,

$$M_{(2)st} = M_{(2)cin} \tag{61}$$

is between the fixed allowances established by the infrastructure.

For kinematic gauges,

$$M_{(2)cin} = T_{voie} + h \cdot \frac{T_D}{L} + s_0 \cdot \frac{T_D}{L} \cdot (h - h_{c0})_{>0} \quad (62)$$

is supported by the infrastructure,

where

$$M_{(2)Dcin} = h \cdot \frac{T_D}{L} + s_0 \cdot \frac{T_D}{L} \cdot (h - h_{c0})_{>0} \quad (63)$$

For dynamic gauges,

$$M_{(2)dyn} = T_{voie} + h \cdot \frac{T_D}{L} \quad (64)$$

is supported by the infrastructure, while

$$M_{(2)Ddyn} = h \cdot \frac{T_D}{L} \quad (65)$$

The complement

$$s \cdot \frac{T_D}{L} \cdot (h - h_{c0})_{>0} \quad (66)$$

is taken into account by the rolling stock in the roll z_{dyn}.

7.3.1.7 Supplementary allowance $M_{(3)}$

The allowance $M_{(3)}$, fixed by the infrastructure manager, covers specific aspects regarding the use of vehicles or loads larger than those allowed by the gauge.

Any additional values imposed by another regulation specific to the infrastructure may be included in this allowance.

For high speed and very high speed lines, aerodynamic allowances may be taken into account.

The aerodynamic allowances are fixed by the infrastructure based on the information in EN 14067-2 in the open air and in EN 14067-3 in tunnels and the consequences on the rolling stock.

In the specific case of the absolute gauging method, the aerodynamic allowance is taken into account by the rolling stock.

7.3.1.8 Values to be cleared by the infrastructure with regard to the static gauge

In the static method, the infrastructure generally applies fixed allowances depending on experience.

However, in order to ensure adequate clearance, these allowances may be verified according to the following method:

Each height level of the reference profile corresponds to an equivalent flexibility coefficient

$$s_{\text{eq}} = \frac{z_0 L}{(h - h_{\text{c0}})(D_0 {}^{\text{ou}} I_0)} \tag{67}$$

whose minimum value corresponds to the limit flexibility s_{lim} not to be exceeded by the rolling stock in order for it to remain compatible with the infrastructure.

Thus, in addition to the clearance of the additional static overthrow and the value z_0, the allowances $M_{(1)}$ and $M_{(2)}$ and the inclusion of the roll $\left[qs_i{}^{ou} qs_a\right]$ may be determined with the kinematic formulae.

7.3.1.9 Values to be cleared by the infrastructure with regard to the kinematic gauge

7.3.1.9.1 Phenomena to be taken into consideration

Three phenomena shall be taken into account:

quasi-static roll, $qs_i{}^{ou} qs_a$

the effects of oscillations $\frac{s_0}{L} T_{osc} \left(h - h_{c_0}\right)_{>0}$.

Crosslevel errors $\frac{T_D}{L} h + s_0 \frac{T_D}{L} \left(h - h_{c0}\right)_{>0}$

the dissymmetry effects $\left[\left(\tan T_{charge}\right)^2 + \left(\tan T_{susp}\right)^2\right]\left(h - h_{c0}\right)_{>0}$

As these three movements are rotations around the same axis, their effects can be grouped under a term dependent on flexibility.

7.3.1.9.2 Taking the quasi-static effect into account

A coefficient K shall be defined in relation to the height to be considered:

$$K = \frac{s_0}{L} \left(h - h_{c0}\right)_{>0} \tag{68}$$

The value $qs_i{}^{ou} qs_a$ which shall then be considered is equal to $K\left[\left(D - D_0\right)^{ou} \left(I - I_0\right)\right]$

For $h \le h_{c0}$, the quasi-static effect is entirely taken into account by the rolling stock.

7.3.1.9.3 Taking oscillations and dissymmetry into account

7.3.1.9.3.1 General

The effects of oscillation and dissymmetry are both considered random phenomena to be considered on an individual basis, for

the installation of obstacles at a nominal distance

the installation of obstacles at a limit distance with a maintenance allowance

the verification that the limit distance is always complied with after using the maintenance allowance.

7.3.1.9.3.2 Nominal values

For the nominal installation of obstacles, the infrastructure shall cumulate margins M_{1cin} M_{2cin} and M_{3cin} as shown in Figure 17.

These values can be fixed or calculated such as to take into consideration the simultaneous manifestation of the different phenomena in an overall value:

$$\Sigma_{3cin(i/a)} = T_{voie} + \left[\frac{T_D}{L} h + s_0 \frac{T_D}{L} \left(h - h_{c0}\right)_{>0}\right] + \left[\tan T_{susp} + s_0 \frac{T_{osc}}{L} + \tan T_{charge}\right]\left(h - h_{c0}\right)_{>0} \quad (69)$$

The values are given in EN 15273-3 and are generally different for the inside and outside of the curve.

Another possibility is to consider a reserve margin $M_{(3)}$ relative to the limit installation values defined below.

In this case,

$$\Sigma_{3cin(i/a)} = M_{(3)} + \Sigma_{2cin(i/a)} \quad (70)$$

7.3.1.9.3.3 Limit values

7.3.1.9.3.3.1 General rules

For the nominal installation of obstacles, the infrastructure applies margins M_{1cin} and M_{2cin} as shown in Figure 17.

The value of these margins can be fixed or calculated in accordance with EN 15273-3 so as to take into consideration that the simultaneous manifestation of extreme values for all of the phenomena provided for in the kinematic method is very unlikely.

The calculation method applied in [A1) EN 15273-3:2013+A1:2016 (A1]; Annex A allows the calculation of allowances to be optimized by using allowances which are never used simultaneously.

The infrastructure then selects a coefficient ($k \geq 1$) in order to obtain the desired level of safety for the random values.

Without a maintenance allowance, for the verification limit gauge,

$$\Sigma'_{1cin(i/a)} \geq k\sqrt{\left[\left(\frac{s_0}{L}(T_{osc})\right)^2 + \left(\tan T_{charge}\right)^2 + \left(\tan T_{susp}\right)^2\right]\left((h-h_{c0})_{>0}\right)^2} \quad (71)$$

With a usable maintenance allowance for the installation of obstacles at the limit position,

$$\Sigma_{2cin(i/a)} = k\sqrt{T_{\text{voie}}^2 + \left[\frac{T_{\text{D}}}{L}h + s_0\frac{T_{\text{D}}}{L}\left[h-h_{\text{C0}}\right]_{>0}\right]^2 + \left[tg\left(T_{\text{susp}}\right)\left[h-h_{\text{C0}}\right]_{>0}\right]^2 + \left[tg\left(T_{\text{charge}}\right)\left[h-h_{\text{C0}}\right]_{>0}\right]^2 + \left[\frac{s_0}{L}\left(T_{\text{osc}}\right)\left[h-h_{\text{C0}}\right]_{>0}\right]^2} \quad (72)$$

The values are given in EN 15273-3 and are generally different for the inside and outside of the curve.

7.3.1.9.3.3.2 Taking the oscillations into account

Figure 24 is a schematic representation of the limit location for obstacles according to D or I. The effect of the additional overthrows is not shown.

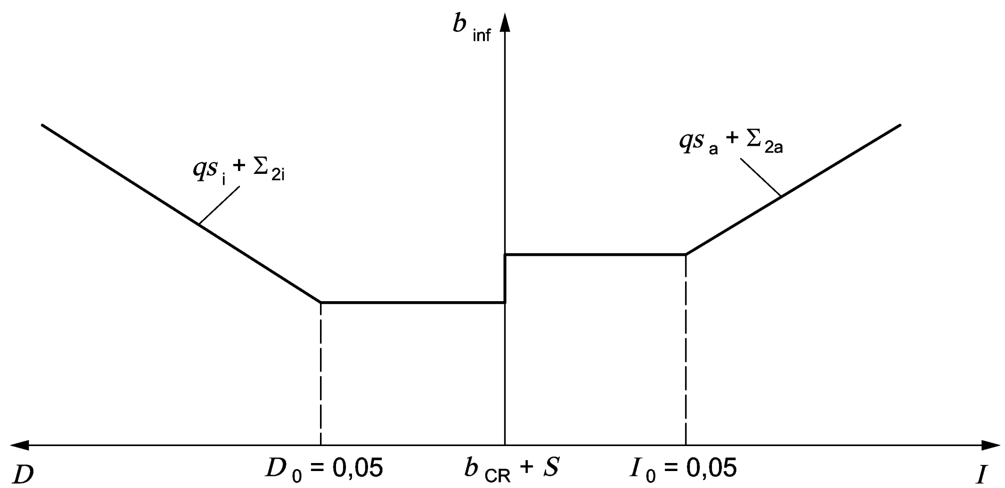


Figure 24 — Taking oscillations into account in the semi-width b_{inf}

Figure 24 shows that at a given height h, where $qs_i = qs_a$, value Σ_{2a} is greater than value Σ_{2i}, mainly due to the oscillations which are greater on the outside of the curve due to the running speed:

Tests have shown that account should be taken:

— on the inside of the curve, of a maximum oscillation angle of 0,2° for vehicles running at low speed;

— on the outside of the curve, of a maximum oscillation angle of 1° for des vehicles running at full speed;

— for tracks that have been especially well maintained, the maximum oscillation angle may be reduced to 0,6° on the outside of the curve and on a straight track and to 0,1° on the inside of the curve.

On a straight track, two aspects are notable:

— A discontinuity occurs, which causes interpretation difficulties;

— In the $D < D_0$ or $I < I_0$ zone, the quasi-static effect does not decrease further as the vehicles in reality roll less than when *I* or *D* are respectively equal to I_0 or D_0.

7.3.1.9.3.3.3 Recovery of the quasi-static effect where I or D < 50 mm

Consider the movements of the most critical reference vehicle on a straight track with flexibility s_0 = 0,4.

In Figure 24, the vehicle corresponds to the curve of the gauge for the obstacles b_{inf} at point $I = I_0$.

The semi-width b_{at} which can be achieved by any vehicle is determined using the following formula:

$$b_{at} = b_{CR} + S_{i^{ou}a} + qs_{i^{ou}a} + \Sigma_{2,i^{ou}a,cin} \tag{73}$$

$$b_{at,a} = b_{CR} + S_a + \frac{sI}{L}(h - h_c) + \Sigma_{2,a,cin} \tag{74}$$

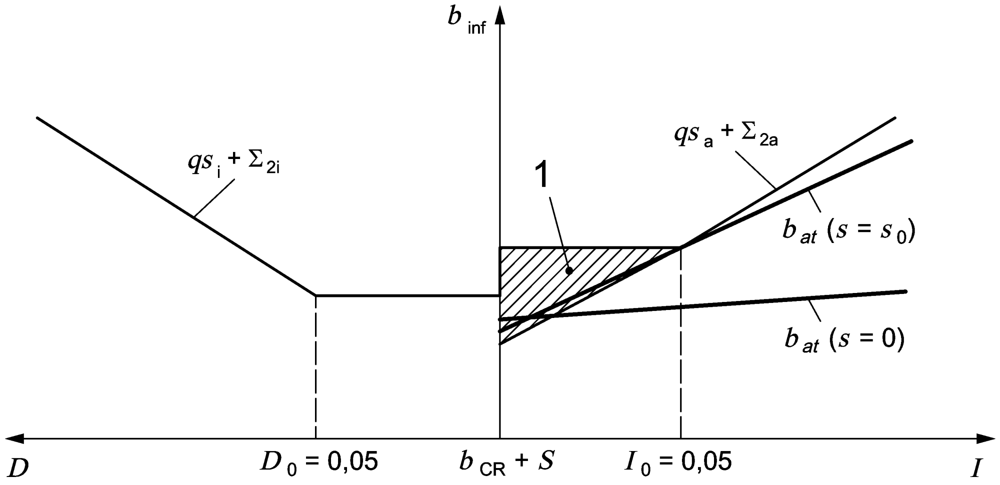
$$b_{at,i} = b_{CR} + S_i + \frac{sD}{L}(h - h_c) + \Sigma_{2,i,cin} \tag{75}$$

The value $\Sigma'_{2,i^{ou}a,cin}$ is the sum of the random displacements by the vehicle under consideration. This value is determined stochastically, as for the reference vehicle, but in this case it is calculated using the actual parameters of the vehicle under consideration rather than the reference parameters.

$$\Sigma'_{2,\mathrm{i/a,cin}} = k\sqrt{T_{\mathrm{voie}}^2 + \left[\frac{T_\mathrm{D}}{L}h + s\ \frac{T_\mathrm{D}}{L}\left[h - h_{\mathrm{C0}}\right]_{>0}\right]^2 + \left[tg\left(T_{\mathrm{susp}}\right)\left[h - h_{\mathrm{C0}}\right]_{>0}\right]^2 + \left[tg\left(T_{\mathrm{charge}}\right)\left[h - h_{\mathrm{C0}}\right]_{>0}\right]^2 + \left[\frac{s}{L}\left(T_{\mathrm{osc}}\right)\left[h - h_{\mathrm{C0}}\right]_{>0}\right]^2} \tag{76}$$

The quasi-static effect is also calculated according to the actual value *s* rather than the standard value s_0.

The shaded area in Figure 25 shows the space which is not utilised by the rolling stock between the semi-width $b_{at(s_0)}$ generated by the infrastructure on the basis of the reference vehicle, i.e. $s = s_0$, and the semi-width $b_{at(s)}$ actually utilised by less flexible vehicles.



Key

1 space not utilised by the rolling stock

Figure 25 — Achieved semi-width b_{at} and space not utilised by the rolling stock

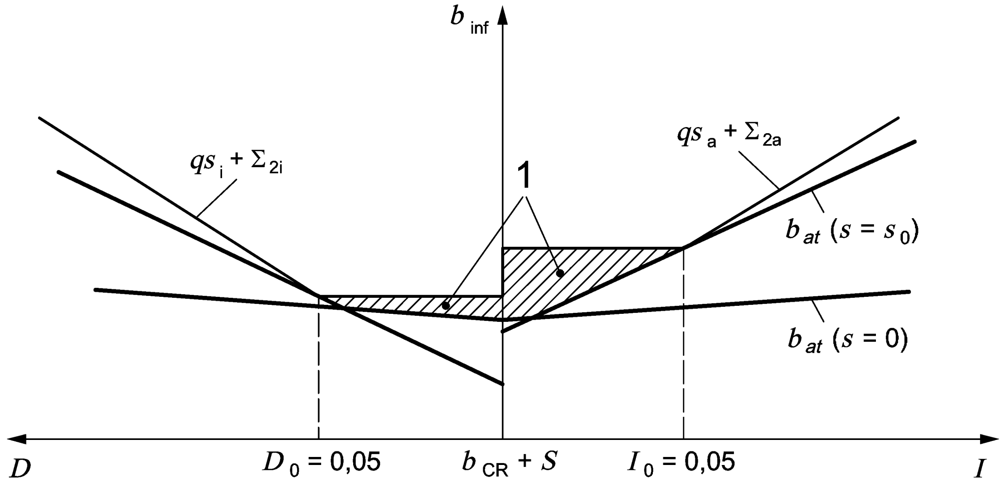
When considering a more rigid vehicle, the maximum values of T_{osc}, T_{charge} or T_{susp} for the reference vehicle may not be considered with s_0, but rather the proportional intermediate values for $\frac{s}{s_0}$, as a flexible vehicle will oscillate and roll more than a rigid vehicle.

Thus:

$$T_{osc_{(s)}} = \frac{s}{s_0} T_{osc_{(s0)}} \qquad T_{charge_{(s)}} = \frac{s}{s_0} T_{charge_{(s0)}} \qquad T_{susp_{(s)}} = \frac{s}{s_0} T_{susp_{(s_0)}}$$

The value $\Sigma'_{2,i^{ou}a,cin}$ to be taken into account for a specific flexible vehicle s is:

$$\Sigma'_{2,i/a,cin} = k\sqrt{T_{voie}^2 + \left[\frac{T_D}{L}h + s\ \frac{T_D}{L}\left[h - h_C\right]_{>0}\right]^2 + \left[tg\left(\frac{s}{s_0}T_{susp,0}\right)\left[h - h_C\right]_{>0}\right]^2 + \left[tg\left(\frac{s}{s_0}T_{charge,0}\right)\left[h - h_C\right]_{>0}\right]^2 + \left[\frac{s}{L}\left(\frac{s}{s_0}T_{osc}\right)\left[h - h_C\right]_{>0}\right]^2}$$



Key

1 space not utilised by the rolling stock

2 minimum value for $b_{at(s)}$

Figure 26 — Limit values for the achieved semi-width b_{at} according to flexibility

The minimum value for $b_{at(s)}$ is obtained with the formula

$$b_{\text{at}} = b_{CR} + S_{i/a} + qs_{i/a} + \Sigma'_{2,cin,i/a} \quad (77)$$

where $qs + \Sigma'_{2,cin}$ becomes $\Sigma''_{2,cin}$ and $\Sigma''_{2,cin} = k\sqrt{T_{\text{voie}}^2 + \left[\frac{T_{\text{D}}}{L}h\right]^2}$

In areas $D < D_0$ or $I < I_0$ close to the straight track, where vehicles are practically moving in a state of equilibrium, the same value $qs + \Sigma'_{2,cin}$ shall be taken into account on both sides of the vehicle.

Therefore the 'inside of the curve', i.e. a minor cant, is considered to be a situation where I = 0, corresponding to the passage of the vehicle along a straight line at maximum speed.

In practice, this means that the effect at maximum speed is prolonged on the left in the diagram above right at the intersection with the left-hand curve.

7.3.1.9.3.3.4 Conclusion

In Figure 26, we see that the allowance in the shaded area is not used by any vehicle.

Therefore, this shaded area can be recovered for the limit installation for obstacles on the outside of the curve provided that:

$$b_{\text{inf}} > b_{at,a_{(s_0)}} \text{ and } > b_{at,a_{(s)}}$$

where

$$b_{\mathrm{inf,a}} > b_{CR} + S_a + \max\left[K(I - I_0) + \Sigma'_{2,cin,a}; \Sigma''_{2,cin}\right]$$

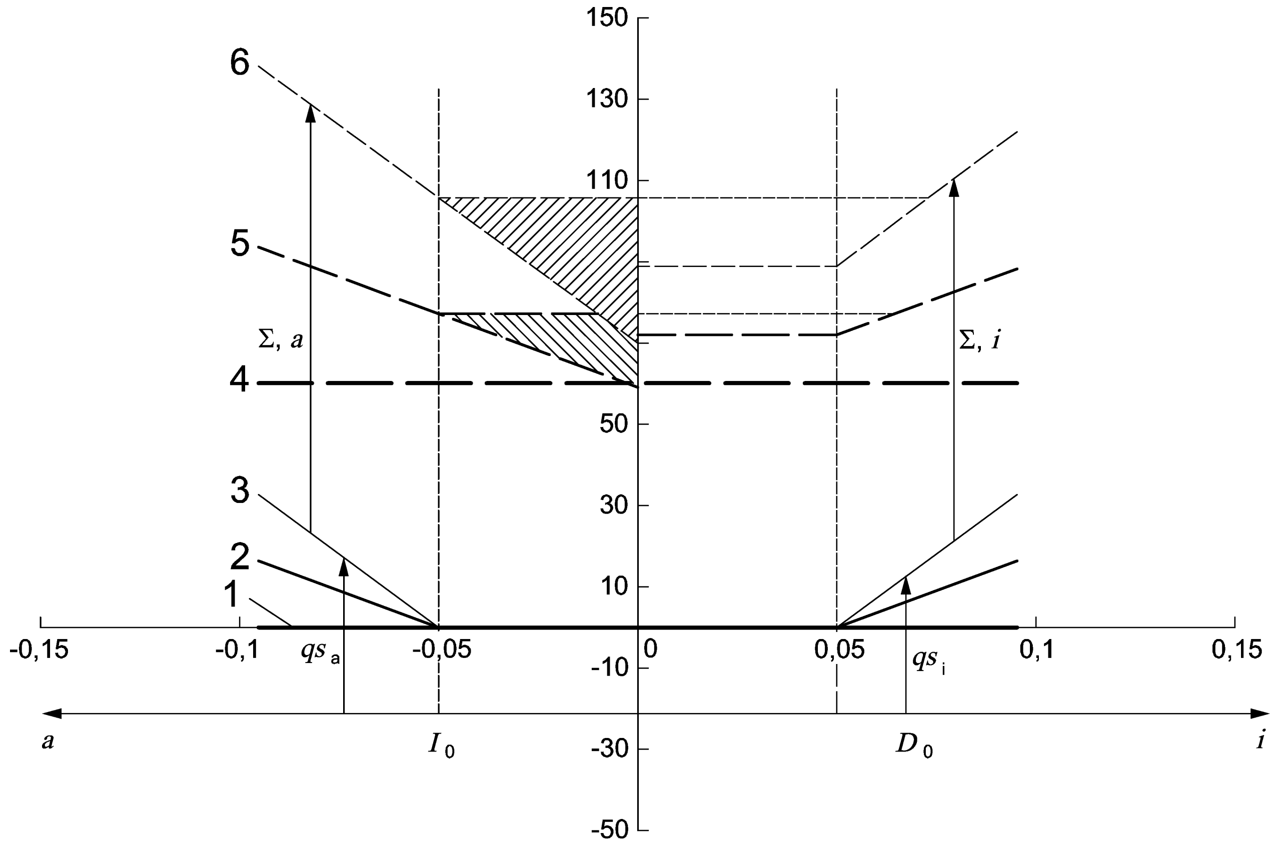
on the inside of the curve where I = 0, the following shall therefore also be considered:

$$b_{\mathrm{inf}} > b_{at,i_{(s_0)}} \text{ and } > b_{at,i_{(s)}} \text{ and } > b_{at,i_{(s_0)et(I=0)}}$$

where

$$b_{\mathrm{inf,i}} > b_{CR} + S_i + \max\left[K(D - D_0) + \Sigma'_{2,i,cin}; \Sigma''_{2,cin}; -KI_0 + \Sigma'_{2,a}\right]$$

For example, for a height of 3.25 m, the result is the following curve:



Key

1 s = 0

2 s = 0,2

3 s = 0,4

4 +Σ (s = 0)

5 +Σ (s = 0,2)

6 +Σ (s = 0,4)

Figure 27 — Limit values for the achieved semi-width b_{at} for different values of *s*

7.3.1.9.3.3.5 Verification limit gauge

The same considerations can be used when calculating the verification limit gauge.

The value of $\Sigma''_{1,kin}$ will however always be zero as there are no tolerances at the level of the position of the track ($T_D = T_{voie} = 0$).

In this case, it is assumed that the oscillations are always proportional to the flexibility of the vehicle, but for load dissymmetry as well as adjustments to the suspension, this assumption appears to be an oversimplification. These two parameters are therefore retained for safety reasons.

7.3.1.10 Value of the random phenomena $\Sigma_{1\text{dyn}}$, $\Sigma_{2\text{dyn}}$ and $\Sigma_{3\text{dyn}}$ to be cleared by the infrastructure with regard to the dynamic method

7.3.1.10.1 Nominal values

For the nominal installation of structures, the infrastructure applies the allowances $M_{(1)\text{dyn}}$, $M_{(2)\text{dyn}}$ and $M_{(3)\text{dyn}}$. The simultaneous expression of the various phenomena is considered according to the following formulae:

$$\Sigma_{3dyn(i/a)} = M_{(3)} + \Sigma_{2dyn(i/a)} \qquad (78)$$

7.3.1.10.2 Limit value

For the structure installation limit value, the infrastructure applies the reduced fixed allowances $M_{(1)\text{dyn}}$ and $M_{(2)\text{dyn}}$. The simultaneous appearance of extreme values for all phenomena is considered to be unlikely.

Compared to the random values, the infrastructure selects a coefficient ($k \geq 1$) to obtain the safety level it wishes.

Without a maintenance allowance, for the verification limit gauge:

$$\Sigma_{1dyn} = k\sqrt{\left[\left(\tan T_{charge}\right)^2 + \left(\tan\left(T_{susp}\right)\right)^2\right]\left(\left(h - h_{c0}\right)_{>0}\right)^2} \qquad (79)$$

For the structure installation limit gauge with usable allowance for maintenance:

$$\Sigma_{2dyn} = k\sqrt{T_{voie}^2 + \left[\frac{T_D}{L}h\right]^2 + \left[\left(\tan T_{charge}\right)^2 + \left(\tan T_{susp}\right)^2\right]\left(\left(h - h_{c0}\right)_{>0}\right)^2} \qquad (80)$$

The values given in EN 15273-3 are generally different for the inside and outside of the curve.

7.3.1.11 Displacement value for the static gauging method

The displacement Dpl_{st} comprises:

— geometric displacement;

— clearance of the wheelsets on the track;

— transverse clearances.

Towards the inside of the curve:

$$Dpl_{i\,st} = \frac{an_i - n_i^{\,2} + \frac{p^2}{4}(A)}{2R} + \frac{l_{\max} - d}{2}(A) + q(A) + w_{i(R)}(A) \qquad (81)$$

Towards the outside of the curve:

$$Dpl_{a\,st} = \frac{an_a + n_a^{\,2} - \frac{p^2}{4}(A)}{2R} + \frac{l_{\max} - d}{2}(A) + q(A) + w_{i(R)}(A) + w_{a(R)}(A) \qquad (82)$$

7.3.1.12 Displacement value for the kinematic gauging method

The displacement Dpl_{cin} comprises:

- geometric displacement;
- clearance of the wheelsets on the track;
- transverse clearances;
- the quasi-static displacement.

Towards the inside of the curve:

$$Dpl_{i\,cin} = \frac{an_i - n_i^{\,2} + \frac{p^2}{4}(A)}{2R} + \frac{l_{\max} - d}{2}(A) + q(A) + w_{i(R)}(A) + z_{cin} \qquad (83)$$

Towards the outside of the curve:

$$Dpl_{a\,cin} = \frac{an_a + n_a^{\,2} - \frac{p^2}{4}(A)}{2R} + \frac{l_{\max} - d}{2}(A) + q(A) + w_{i(R)}(A) + w_{a(R)}(A) + z_{cin} \qquad (84)$$

7.3.1.13 Displacement value for the dynamic gauging method

7.3.1.13.1General

The displacement taken into account in the dynamic gauging method may be considered in two different ways.

The conventional gauging that considers the maximum values increased to the extreme and simulation gauging that takes into account the actual behaviour of the vehicle in precise hypothetical operating cases.

7.3.1.13.2 Conventional gauging

The displacement Dpl_{dyn} comprises:

— geometric displacement;

— clearance of the wheelsets on the track;

— dynamic transverse clearance;

— the quasi-static displacement;

— the consideration of allowances $M_{(1)osc}$ and $M_{(2)D}$ by a value added to the cant or to the cant deficiency.

Towards the inside of the curve:

$$Dpl_{i\,dyn} = \frac{an_i - n_i^2 + \frac{p^2}{4}(A)}{2R} + \frac{l_{\max} - d}{2}(A) + q(A) + w_{i(R)}(A) + z_{dyn} \qquad (85)$$

Towards the outside of the curve:

$$Dpl_{a\,dyn} = \frac{an_a + n_a^2 - \frac{p^2}{4}(A)}{2R} + \frac{l_{\max} - d}{2}(A) + q(A) + w_{i(R)}(A) + w_{a(R)}(A) + z_{dyn} \qquad (86)$$

7.3.1.13.3 Simulations

Simulations are used to predict vehicle displacements more realistically than by calculation of the maximum geometric displacements.

This allows the shape of the vehicle to be optimized.

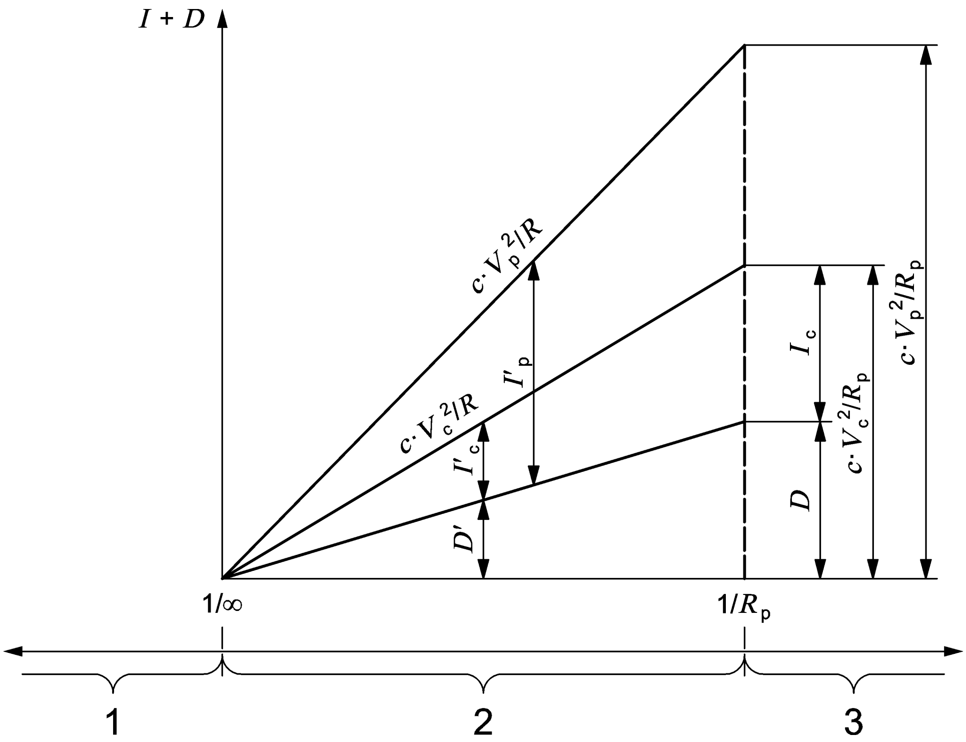
This dynamic simulation gives a matrix of statistical data relating to the displacement of the vehicle in relation to the track centreline in various combinations of curve radius, cant deficiency according to speed and track quality.

7.3.1.14 Tilting trains

Gauge compliance shall be checked individually for each line.

The operation of tilting trains is dependent on a series of infrastructure parameters, a risk analysis of the behaviour of the vehicle in degraded mode and an examination of the behaviour during operation on transition curves.

The basic principle of tilting vehicles and vehicles subjected to $I_p > I_c$ is shown in Figure 28.



Key

1 straight track

2 transition zone

3 radius considered constant

Figure 28 — Cant and cant deficiency

The cant deficiency I_p corresponds to the maximum allowable value for tilting body trains.

The values D', I'_c and I'_p are intermediate values generally attained in large radii.

Radius R_p is the radius from which the maximum values are obtained, in the knowledge that they remain constant if the radius continues to decrease.

The infrastructures to be covered impose the value D, I_p maximum for the track stability and the minimum limit value $\frac{I_c}{I_p}$ to be met by the rolling stock in the curve so that

$$\frac{I'_c}{I'_p} \geq \left(\frac{I_c}{I_p}\right)_{\min} \tag{87}$$

with for example $\left(\frac{I_c}{I_p}\right)_{\min}$ = 0,6 whereas this value = 1 for non-tilting vehicles.

This is justified by the fact that:

For a non-tilting train,

$$V'_c = \sqrt{(I'_c + D')\frac{R}{c}} \qquad (88)$$

where

$$c = \frac{L^2}{3{,}6^2 g} \text{ and } I + D = \frac{cV^2}{R} \qquad (89)$$

For a tilting train,

$$V'_p = \sqrt{(I'_p + D')\frac{R}{c}} \qquad (90)$$

Hence

$$\frac{V'_p}{V'_c} = \sqrt{\frac{I'_p + D'}{I'_c + D'}} \qquad (91)$$

and

$$V'_p = V'_c \sqrt{\frac{I'_p + D'}{I'_c + D'}} \qquad (92)$$

It is generally considered that

$$\frac{I'_p}{I_p} = \frac{I'_c}{I_c} \approx \frac{D'}{D} \qquad (93)$$

The first part of the formula translates the rolling stock behaviour with constant $\frac{I_p}{I_c}$.

The second part of the formula holds true in wide radius curves and for parabolic connections.

In large radii and special connections, the proportionality is no longer ensured.

It is stated that:

$$V'_p = V'_c \sqrt{\frac{I_p \frac{D'}{D} + D'}{I_c \frac{D'}{D} + D'}} \qquad (94)$$

from which is deduced that:

$$V'_p = V'_c \sqrt{\frac{I_p + D}{I_c + D}} \qquad (95)$$

and that $\sqrt{\frac{I_p + D}{I_c + D}}$ is a fixed value for each network.

EXAMPLE If D = 0,160 m I_c = 0,153 m I_p = 0,275 m

$$\sqrt{\frac{I_p + D}{I_c + D}} = 1{,}18 \text{ therefore, } V'_p = 1{,}18 V'_c \quad (96)$$

and

$$\left(\frac{I_c}{I_p}\right)_{\min} = 0{,}556$$

7.3.2 In the vertical direction

7.3.2.1 Vertical displacements

Certain displacements relate to the rolling stock or infrastructure alone and others are caused by the track-vehicle interaction.

The way in which these displacements are taken into account depends on the gauging method used.

Elements relating to the rolling stock are covered by EN 15273-2 and elements relating to the infrastructure are covered by EN 15273-3.

Account is to be taken:

— of the wear of the wheels and various parts of the rolling stock;

— of the static or dynamic suspension displacement;

— of the deformation of the vehicle structure;

— of the variations in height as a result of vehicle roll;

— of the dynamic uplift of the suspension, except for static gauges where it is covered by the vertical allowances for the infrastructure;

— of the other vertical displacements linked to specific technologies;

— of the vertical geometric overthrow in gradient transitions (see 7.3.4.);

— of the vertical effects of the roll due to quasi-static effects;

— of a mandatory vertical allowance $M_{v(1)}$ to take account:

— of the dynamic uplift of the suspension in the case of static gauges;

- of the displacement of the track when the vehicle passes over it;
- of the vertical geometric overthrows in the gradient transitions (see 7.3.4.);
- of the vertical effects of the roll due to random effects T_D, T_{osc} and η_0;

In addition to the items above, on electrified lines, the mandatory vertical allowance $M_{v(1)}$ takes into account:

- vertical displacements of the overhead contact line according to the temperature and the temperature rise due to the current;
- dynamic oscillations of the overhead contact line as the pantographs pass along;
- electrical insulating distances;
- a usable vertical allowance $M_{v(2)}$ to take into account:
  - rail wear;
  - vertical displacements of the track T_N between two maintenance periods;
  - local displacement of the track;
  - differential settlement of the track;
- a reserve vertical allowance $M_{v(3)}$ according to local particularities taking account:
  - of the structural tolerances;
  - of the track-laying tolerances;
  - of the aerodynamic effects.

7.3.2.2 Taking the quasi-static roll into account

7.3.2.2.1 Upper part

For static gauges:

for the lateral part and upper part of the reference profile, the rolling stock does not take into account the effects of the roll.

The roll is taken into account in the vertical allowances of the infrastructure upwards, outside the static reference profile.

The infrastructure takes into account the uplift of the vehicles and the vertical addition calculated with regard to the kinematic gauge.

For the kinematic gauge:

the infrastructure takes into account a vertical addition to take into account the rolls.

The following phenomena shall be taken into account:

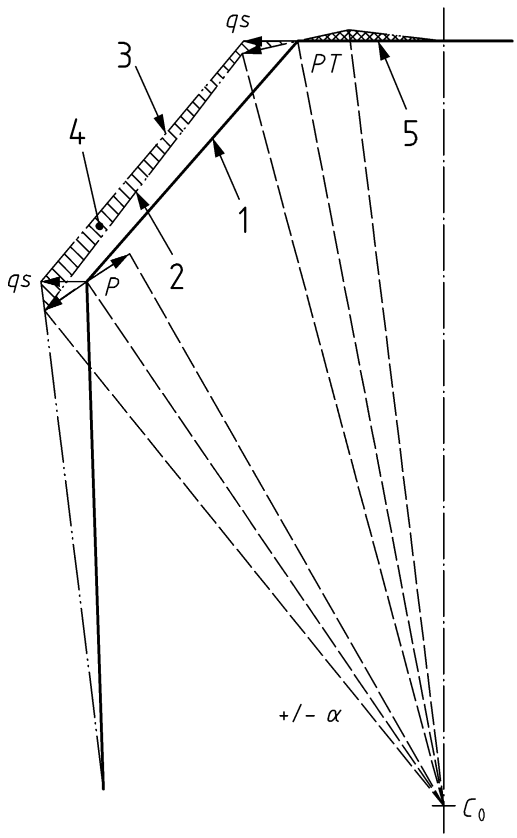
on the outside of the curve and straight track

$$T_N + \left(T_D \frac{b_{CR} + \frac{L}{2}}{L} \right) + \frac{b_{CR}}{L} s_0 \left(D - D_0 + T_D + T_{osc} \right) + b_{CR} (\tan T_{susp} + \tan T_{charge}) \quad (97)$$

on the inside of the curve

$$T_N + \left(T_D \frac{b_{CR} - \frac{L}{2}}{L} \right) + \frac{b_{CR}}{L} s_0 \left(I - I_0 + T_D + T_{osc} \right) + b_{CR} (\tan T_{susp} + \tan T_{charge}) \quad (98)$$

The coordinates of the point under consideration displaced in the swept zone by the roll effect shall be compared to the initial reference profile displaced transversely by qs_i or qs_a and the transverse allowances Σ_{1cin}, Σ_{2cin} or Σ_{3cin} with T_{voie} = 0 to determine the vertical supplement to be provided by the infrastructure to take account of the roll (see Figure 29).



Key

1 profile defined by $b_{CR} + S$

2 displacement envelope

3 profile $b_{CR} + S + qs$

4 non-utilized allowance

5 reserve to be taken into account by the infrastructure

6 angle – α of roll towards the outside

7 angle + α of roll towards the inside

Figure 29 — Addition to be cleared for the roll of the upper part of the gauge

The vertical allowances shall take account of:

$$\sum\nolimits_{3cin(v)i} = T_N + \frac{T_D}{L}\left(b_{CR} - \frac{L}{2}\right) + s_0 b_{CR}\left[\frac{T_D}{L} + \frac{T_{osc}}{L}\right] + b_{CR}\tan\eta_{0r} \qquad (99)$$

$$\sum\nolimits_{3cin(v)a} = T_N + \frac{T_D}{L}\left(b_{CR} + \frac{L}{2}\right) + s_0 b_{CR}\left[\frac{T_D}{L} + \frac{T_{osc}}{L}\right] + b_{CR}\tan\eta_{0r} \qquad (100)$$

$$\sum\nolimits_{1cin(v)} = k\sqrt{T_N{}^2 + \left[\left(\frac{s_0}{L}T_{osc}\right)^2 + \left(\tan T_{charge}\right)^2 + \left(\tan T_{susp}\right)^2\right] b_{CR}{}^2} \qquad (101)$$

For the structure installation limit gauge with usable allowance for maintenance:

$$\sum\nolimits_{2cin(v)i} = k\sqrt{\left(\left((1+s_0)b_{\mathrm{CR}} - \frac{L}{2}\right)\frac{T_{\mathrm{D}}}{L}\right)^2 + \left(b_{\mathrm{CR}}\frac{s_0}{L}T_{\mathrm{osc}}\right)^2 + b_{\mathrm{CR}}^2\tan^2(T_{\mathrm{charge}}) + b_{\mathrm{CR}}^2\tan^2(T_{\mathrm{susp}}) + T_{\mathrm{N}}^2} \qquad (102)$$

$$\sum\nolimits_{2cin(v)a} = k\sqrt{\left(\left((1+s_0)b_{\mathrm{CR}} + \frac{L}{2}\right)\frac{T_{\mathrm{D}}}{L}\right)^2 + \left(b_{\mathrm{CR}}\frac{s_0}{L}T_{\mathrm{osc}}\right)^2 + b_{\mathrm{CR}}^2\tan^2(T_{\mathrm{charge}}) + b_{\mathrm{CR}}^2\tan^2(T_{\mathrm{susp}}) + T_{\mathrm{N}}^2} \qquad (103)$$

For the dynamic gauge:

the total roll is taken into account by the rolling stock inside the dynamic reference profile.

7.3.2.2.2 Lower parts

For the static gauge:

as the flexibility coefficient of vehicles constructed according to a static gauge is limited, the vertical effect of the roll in the lower parts is negligible.

For the kinematic gauge:

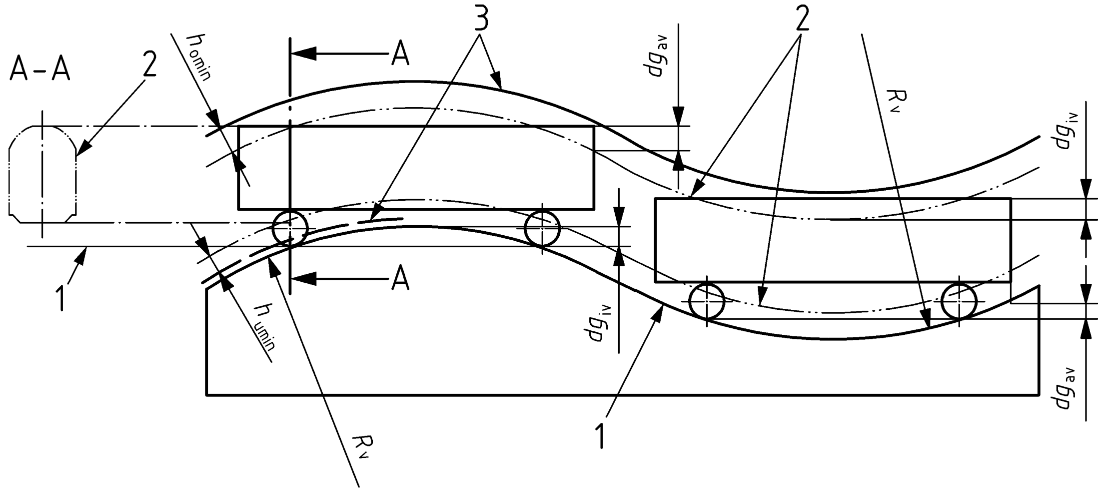
the total roll is taken into account by the rolling stock inside the kinematic reference profile up to a conventional value $D_{\max}$ or $I_{\max}$ equivalent, the roll for $I > D_{\max}$ being negligible.

For the dynamic gauge:

the total roll is taken into account by the rolling stock inside the dynamic reference profile.

7.3.2.2.3 Gradient transitions on the line

The longitudinal section, the vertical geometry of the track and the concave and convex gradient transitions result in vertical geometric overthrows (see Figure 30).



Key

1 running surface

2 reference profile

3 infrastructure limit

Figure 30 — Illustration of the vertical geometric overthrow

$$dg_{iv} = \frac{an_i - n_i^2 + \frac{p^2}{4}}{2R_{v\min}} \tag{104}$$

$$dg_{av} = \frac{an_a + n_a^2 - \frac{p^2}{4}}{2R_{v\min}} \tag{105}$$

Generally, all the vehicles shall be capable of passing over gradient transitions of main lines, secondary lines and hump-avoiding lines without any part other than the wheel flanges dropping below the running surface.

Also, with regard to the upper part of the gauge, the height of the structures shall be adapted to allow the operation of non-tilting vehicles without any specific precautions being taken.

This is why, on these “main” lines, the convex or concave vertical radius is never less than $R_{v\min}$ and the lower part of the reference profile has a minimum height $h_{\min}$.

7.3.2.2.4 Upper vertical geometric overthrow

The upper vertical geometric overthrow is taken into account by the infrastructure up to the maximum allowable value of dg_{iv} or dg_{av} corresponding to the value $h_{o\min}$ generated by the worst case reference vehicle that operates unhindered along the vertical radius $R_{v\min}$.

Compared to the upper part of the reference profile, the infrastructure shall raise the structures by a value equal to:

$$\frac{h_{o\min} R_{v\min}}{R_v} \tag{106}$$

If for special vehicles, dg_{iv} or dg_{av} exceeds the value $h_{o\min}$ agreed with the infrastructure, the height of the rolling stock shall be reduced by

$$e_i = dg_{iv} - h_{o\min} \tag{107}$$

or

$$e_a = dg_{av} - h_{o\min} \tag{108}$$

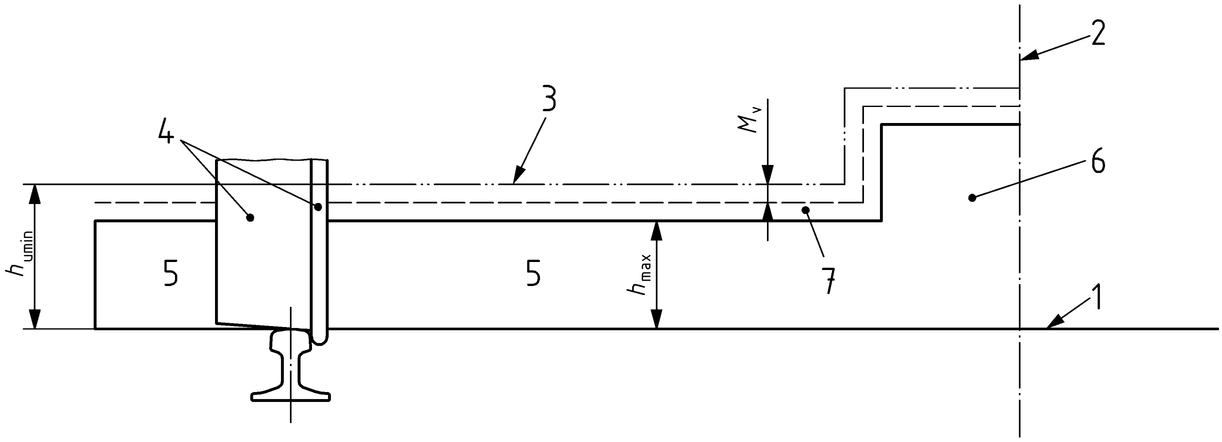
7.3.2.2.5 Lower vertical geometric overthrow

The lower vertical geometric overthrow is taken into account in the sizing of the rolling stock (see Figure 31).

Generally, when a reference profile is used for sizing the rolling stock, the lower horizontal of the profile of the lower parts is located at a minimum height $h_{u\min}$ corresponding to the value dg_{av} or dg_{iv} of the worst case reference vehicle.

The infrastructure shall refrain from installing fixed structures likely to affect the lower parts of the rolling stock in the gradient transition zones or in the section of radii less than $R_{v\min}$.

On a flat track or if $R_v \geq R_{v\min}$, the remaining free space below the vehicle outside the wheel zone is reserved for the infrastructure to install in it parts that, to ensure their operation, have to exceed the level of the rail.



Key

1 running surface
2 track centreline
3 reference profile
4 wheel zone
5 space reserved for the infrastructure if $R_v \geq R_{v\min}$
6 contact ramp zone
7 reduction in height $h_{\max}$ in relation to the vertical radius of the track, equivalent to $\frac{h_{u\min} R_{v\min}}{R_v}$

Figure 31 — Infrastructure zone above the running surface

Thus, taking into account a reserve "M_v" for the assembly tolerances and rail wear, in the vertical radii $R_v \geq R_{v\min}$, the infrastructure has a maximum height

$$h_{\max} = h_{u\min} - \frac{h_{u\min} R_{v\min}}{R_v} - M_v \tag{109}$$

in the horizontal lower part of the reference profile.

For special vehicles, if dg_{iv} or dg_{av} exceeds the value $h_{u\min}$, the rolling stock shall raise the lower part of the vehicle by

$$e_i = dg_{iv} - h_{u\min} \tag{110}$$

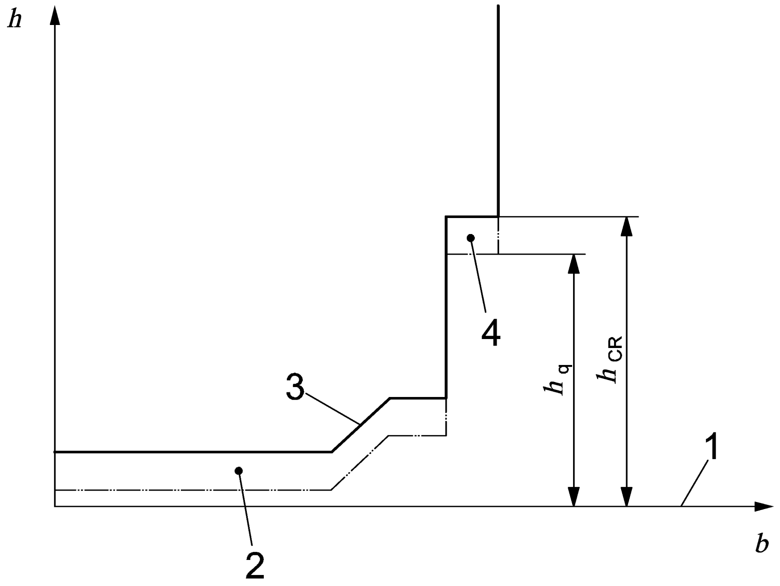
or

$$e_a = dg_{av} - h_{u\min} \tag{111}$$

to ensure that no part, other than the wheel flanges, falls below the running surface when $R_v = R_{v\min}$.

For static gauges, it is assumed that the unsprung parts of the vehicles extend downwards by a value specified in Annex B.

The same is true for low platforms, loading platforms and other structures installed below the steps in the reference profile as shown in Figure 32.



Key

1 running surface

2 track centreline

3 reference profile

4 wheel-brake interference zone into which no rolling stock part may penetrate

Figure 32 — Maximum height of the lower parts

The height of the platforms shall be adapted to meet the requirement:

$$h_q \leq h_{CR} - \frac{h_{u\,\min} R_{v\,\min}}{R_v} - M_v \qquad (112)$$

7.3.2.3 Access to ferries

In order to be authorised to run a link span between a quayside and a ferry, it shall be ensured that no part of the rolling stock body falls below a minimum height defined according to the requirements of EN 15273-2, taking into account displacements and a vertical allowance M_{fb} and considering that the infrastructure shall ensure that no part extends beyond the running surface and that the angle at the ends of the ramp between the quayside and the ferry does not exceed the values of " α'' " given in Annex F.

7.3.2.4 Marshalling humps

7.3.2.4.1 Special marshalling hump reference profile

The rules concerning vertical transitions on marshalling humps are also regulated by the formulae for dg_{iv} and dg_{av} and height $h_{u\,\min}$ of the lower part of the reference profile.

The rail brakes installed close to the marshalling humps in the concave vertical radius shall extend beyond the running surface to ensure they function correctly.

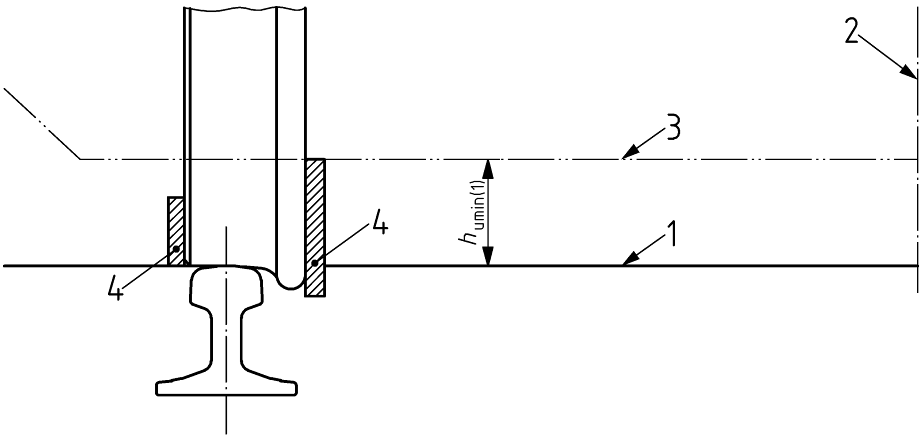
In the activated position, the height $h_{\max}$ of the rail brakes is determined on the basis of a special reference profile with $h_{u\,\min(1)}$.

In the released position, the height $h_{\max}$ of the rail brakes is determined on the basis of a special reference profile with $h_{u\,\min(2)}$.

Thus:

for vehicles having to pass over marshalling humps and rail brakes in an active position, a special reference profile with $h_{u\,\min(1)}$ shall be applied with its associated rules (see Figure 33),

for vehicles having to pass over marshalling humps and rail brakes in a non-active position, a reference profile with $h_{u\,\min(2)}$ shall be applied with the same associated rules (see Figure 34).



Key

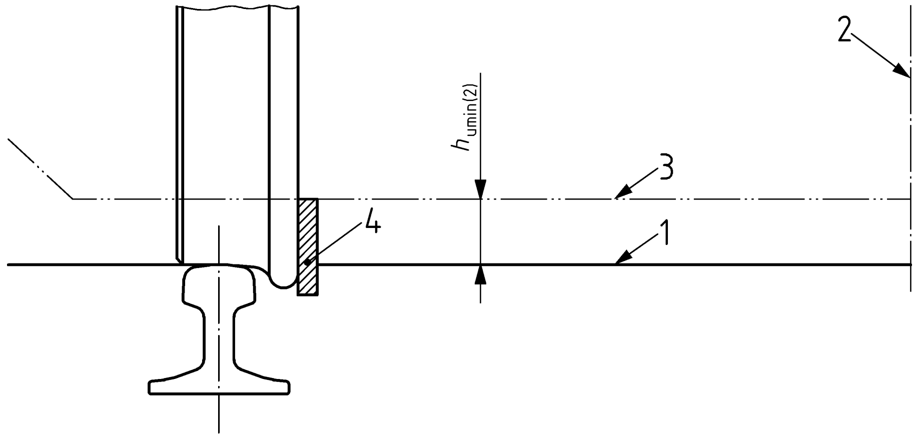
1 running surface

2 track centreline

3 reference profile

4 wheel-brake interference zone into which no rolling stock part may penetrate

Figure 33 — Special reference profile of the lower parts for vehicles having to pass over marshalling humps and rail brakes in an active position



Key

1 running surface

2 track centreline

3 reference profile

4 wheel-brake interference zone into which no rolling stock part may penetrate

Figure 34 — Special reference profile of the lower parts for vehicles having to pass over marshalling humps and rail brakes in a non-active position

7.3.2.4.2 General rule to be observed by the infrastructure in the zone directly enclosing the marshalling hump

No fixed structure may extend beyond the running surface in the convex radius zone R_v constituting the top of the hump.

At the entry and exit of this convex radius, in the zone of the concave radii and tracks linked to the hump, the infrastructure has a maximum height h_{max} above the running surface to install the rail brakes and the parts that shall extend beyond the running surface to ensure that they function correctly.

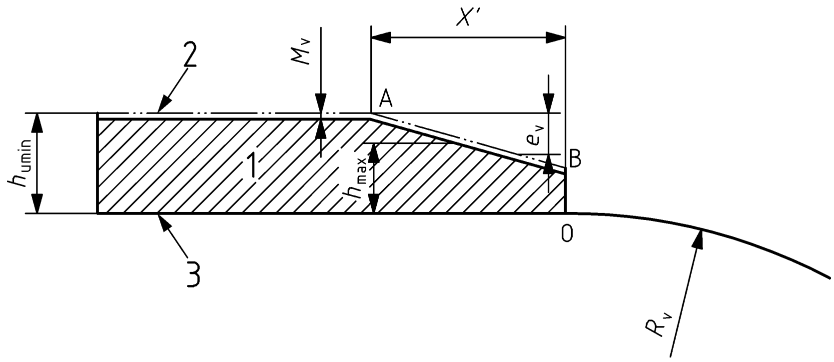
In the final metres to the approach of the point of origin of the transition "O" with the convex radius of the top of the hump, the height h_{max} intended for the infrastructure is reduced progressively by a value "e_v" over a distance "x'" between points A and B.

The distance "x'" may vary depending on the planned usage for the marshalling hump and the gauge to which it is linked.

For certain gauges, it may have been agreed that the infrastructure should not use the zone between points A and B; in this case, the infrastructure stops at A whilst keeping an adequate distance "x'".

Generally, whilst considering a vertical allowance "M_v", in the tracks enclosing the marshalling hump, the infrastructure has a maximum height h_{max} (see Figure 35).

$$h_{max} = h_{u\,min} - e_v - M_v \tag{113}$$



Key

1 free zone for infrastructure parts

2 lower horizontal of the reference profile

3 running surface

Figure 35 — Zone enclosing the marshalling humps

The value e_v depends on the type of hump and the wheelbase a_r of the reference vehicle under consideration.
Annex F gives the formulae to be applied for the calculation of e_v according to the type of hump.

7.3.2.4.3 General rule to be observed by the rolling stock and by the infrastructure

For large-dimension vehicles in which the values dg_{iv} and dg_{av} exceed the value $h_{u\,min}$ agreed on the basis of the selected reference vehicle, the rolling stock shall raise the parts below the frame by a value e_i or e_a to ensure that no part, other than the wheel flanges, falls below the running surface on the top of the hump and does not come into conflict with the parts installed by the infrastructure in the zones adjacent to the marshalling hump.

Generally, compared to the lower horizontal of the reference profile located at height $h_{u\,min}$, after taking into account all the displacements, to cross the top of the hump, the rolling stock shall raise the parts below the frame by a value

$$e_i = dg_{iv} - h_{u\,min} \qquad (114)$$

where

$$dg_{iv} = \frac{an_i - n_i^2 + \frac{p^2}{4}}{2R_{v\,min}} \qquad (115)$$

and in order not to hit fixed installations in the concave radii R_v enclosing the hump, the rolling stock shall raise the overhanging parts by a value

$$e_a = dg_{av} \qquad (116)$$

where

$$dg_{av} = \frac{an_a + n_a{}^2 - \frac{p^2}{4}}{2R_{v\min}} \tag{117}$$

In addition, with regard to the parts between the wheelsets or bogie centres, there shall be an extra check to access networks where the infrastructure uses the zone between points A and B.

This is the case with gauges G1, G2, GA, GB, GB1, GB2, GC, FR3.3, BE1, BE2, BE3; the lower parts shall be raised by the value

$$e_i = dg_{iv} - e_v \tag{118}$$

if this is positive.

The vertical geometric overthrow "dg_{iv}" measured at a distance "*x*" from the origin "*O*" of the convex curve transition is calculated according to the formulae below, if n < a/2, in relation to wheelset *M* (see Figure 36).

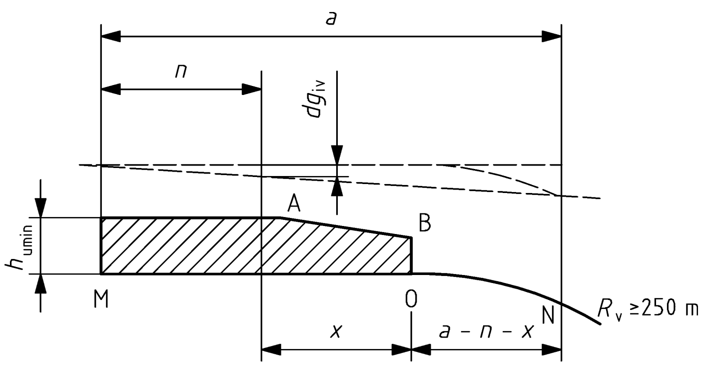


Figure 36 — Calculation in relation to wheelset M

$$dg_{iv} = \frac{(a-n-x)^2}{2R_v}\frac{n}{a} \tag{119}$$

If $n > a/2$, relative to the axle *N* (see Figure 37).

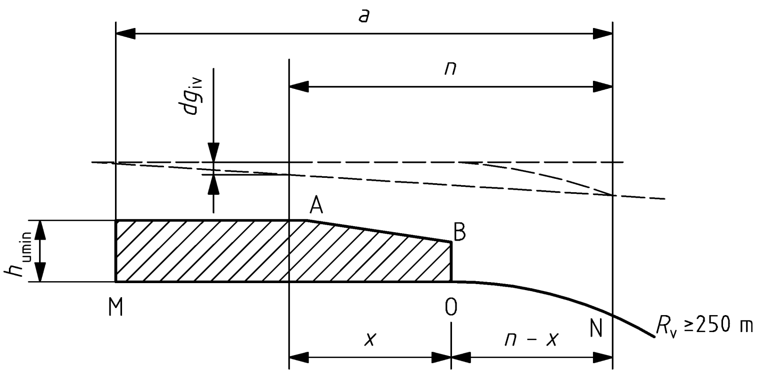


Figure 37 — Calculation in relation to wheelset *N*

$$dg_{iv} = \frac{(n-x)^2}{2R_v}\frac{a-n}{a} \qquad (120)$$

For passing over the top of the hump with no risk of contact under the frame, the rolling stock shall apply:

$$e_i = \frac{a^2+p^2}{8R_v} - R_v + \sqrt{R_v^{\ 2} - (\frac{a}{2} - n_i)^2} - h_{u\,\min} \qquad (121)$$

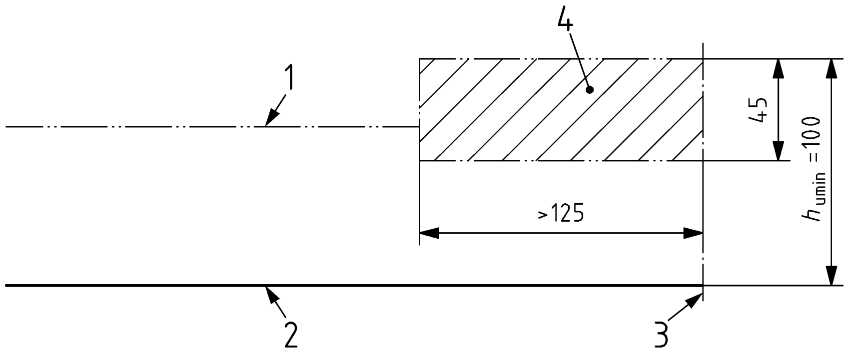
The values are given in Annex F.

7.3.3 Contact ramps

7.3.3.1 General

For vehicles intended to run on networks with contact ramps, a free space is specified in the lower horizontal of the reference profile at a height $h_{u\,\min}$ = 100 mm (see Figure 38).

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



Key

1 reference profile

2 running surface

3 track centreline

4 contact ramp zone

Figure 38 — Contact ramp zone

7.3.3.2 For the infrastructure

The contact ramps shall remain within a zone 0,250 m wide, centred on the track centreline and are never installed in curves of horizontal radius "*R*" less than 250 m and vertical radius "R_v" less than 500 m.

The maximum height h_{max} available for installing the contact ramps takes into account a vertical allowance M_v for the assembly tolerances, rail wear and the vertical radius R_v.

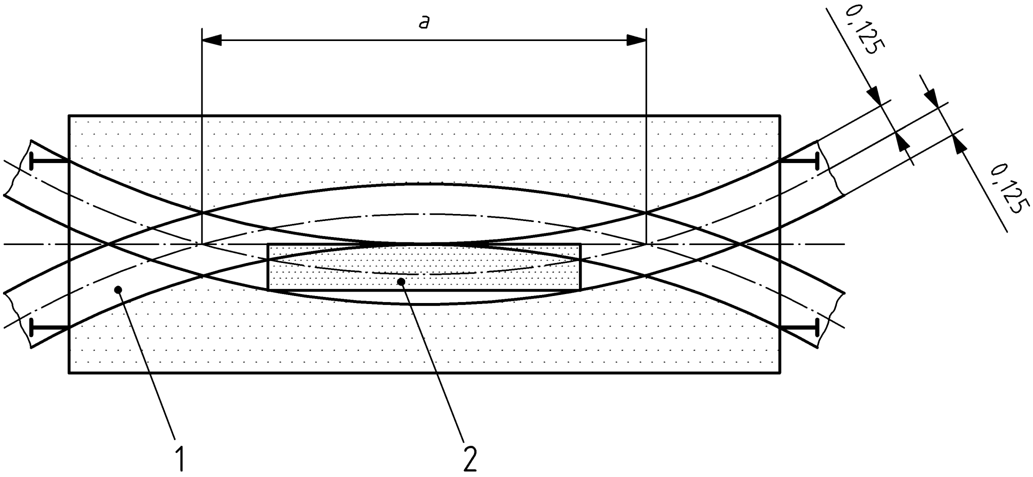
$$h_{max} = h_{u\,min} - \frac{h_{u\,min} R_{v\,min}}{R_v} - M_v \qquad (122)$$

7.3.3.3 For the rolling stock

The contact brush may drop down to 0,045 m in the zone specified for installing the contact ramps (see Figure 39).

No part of the vehicle likely to fall to at least $h_{u\,min}$ = 0,100 m from the running surface shall be located at least 0,125 m from the track centreline, when the vehicle is installed on a track of curve radius *R* = 250 m and gauge l_{max} .

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



Key

1 zone of vehicle incapable of falling more than 0,100 m from the running surface

2 contact ramp

Figure 39 — Space for contact ramps below vehicles

7.3.4 Rail and rail brake zone

7.3.4.1 Rail zone

7.3.4.1.1 Measuring references

The dimensions of the parts of the gauge constituting the rail and wheel contact zone are measured:

— for the infrastructure, on the active surface of the rail, as it is this surface that determines the end position of the wheels;

— for the vehicle, at a vertical passing through the active point of the wheel (in principle 0,01 m below the running surface).

7.3.4.1.2 Zone swept by the wheel

The space swept by the wheel is determined on the basis of the standard flanges of which the minimum thickness is fixed at a value “b_b” and of the minimum wheel pressing dimension $b_{f\ min}$ defined in EN 15313.

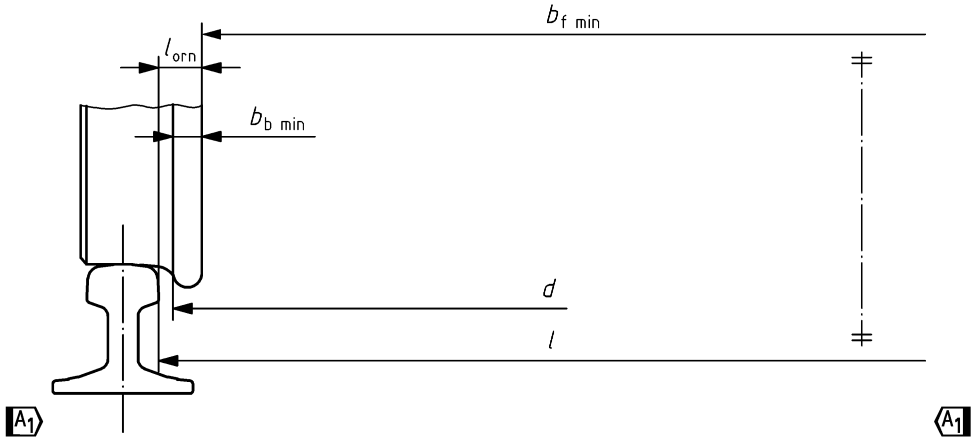


Figure 40 — Maximum flangeway width

The maximum flangeway width "l_{orn}" that the internal surface of a wheel may attain relative to the active surface of the wheel is equal to:

$$l_{orn} = \frac{l_{nom}}{2} - \frac{b_{f\,\min}}{2} - b_{b\,\min} + \frac{l_{réel} - l_{nom}}{2} \qquad (123)$$

7.3.4.1.3 Position of the check rails

By their function, the check rails operate to guide the wheels; therefore, they may partially occupy the flangeway defined above (see Figure 41).

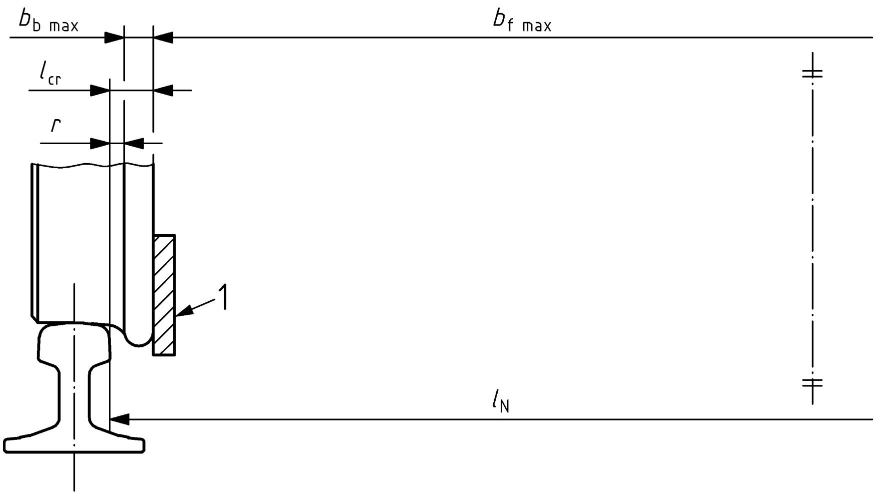
To determine the minimum distance to be maintained between the check rail and the rail running edge, it shall be noted that the wheels of 2-axle and rigid-frame long vehicles take on a certain angle relative to the rail and also that for all the vehicles with more than two wheelsets, a certain allowance shall be reserved for installing median wheelsets.

The maximum distance shall be selected so that the crossing nose of a switch or crossing does not risk being blunted by the wheel flanges.

The check rails shall be positioned at a distance "l_{cr}" relative to the rail running edge.

With the values $b_{f\,\max}$ defined in EN 15313.

$$l_{cr} = \frac{l_{nom}}{2} - \frac{b_{f\,\max}}{2} - b_{b\,\max} - r \qquad (124)$$



Key

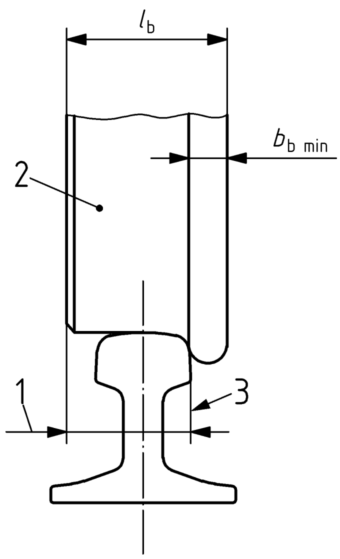
1 check rail

Figure 41 — Position of the check rail

7.3.4.1.4 Projection on the outside of the rail

Depending on the network and the type of gauge used, the projection of the wheel tyre on the outside of the rail corresponds to $l_b - b_{b\,\min}$ relative to the rail running edge (see Figure 42).

In the case of bogies with three or more wheelsets, the projection determined in the agreement shall also take into account the geometric overthrow of the intermediate wheelsets.



Key

1 projection relative to the rail running edge

2 wheel

3 rail running edge

Figure 42 — Projection of the wheel on the outside of the rail

7.3.4.1.5 Occupation of the space in the path of the wheel

In the zones close to the wheels, the rolling stock parts may fall below the lower horizontal of the reference profile located at height $h_{u\,\min}$ as long as they are within the wheel profile both in a curve and on straight track, failing which they would risk coming into contact with the fixed structures, particularly the junction work check rails. In addition, outside the end wheelsets, the parts connected to the traction unit, such as guard-irons or sanders, shall not extend below h_s in order to not to risk making contact with the warning detonators.

7.3.4.2 Rail brakes and shunting devices

The rail brakes installed in the marshalling yards are of various designs.

Generally, deceleration is attained by clamping the tyre between two jaws at the highest point possible.

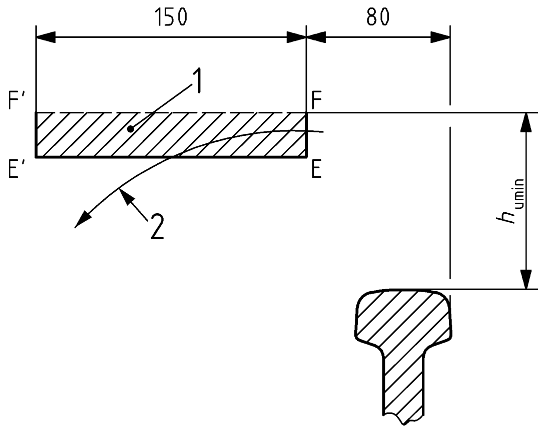
The height $h_{u\,\min}$ to be considered for the rail brakes in the activated position is 0,125 m and 0,080 m in the disengaged position.

The height reduction corresponding to

$$h_{\max} = h_{u\,\min} - \frac{h_{u\,\min} R_{v\,\min}}{R_v} - M_v \tag{125}$$

is not applied for the rail brakes.

No part of the infrastructure, other than retarders being retracted, shall penetrate into shaded zone no.1 (see Figure 43).



Key

1 retarder operation zone

2 arrow indicating the movement of the retarder when being retracted

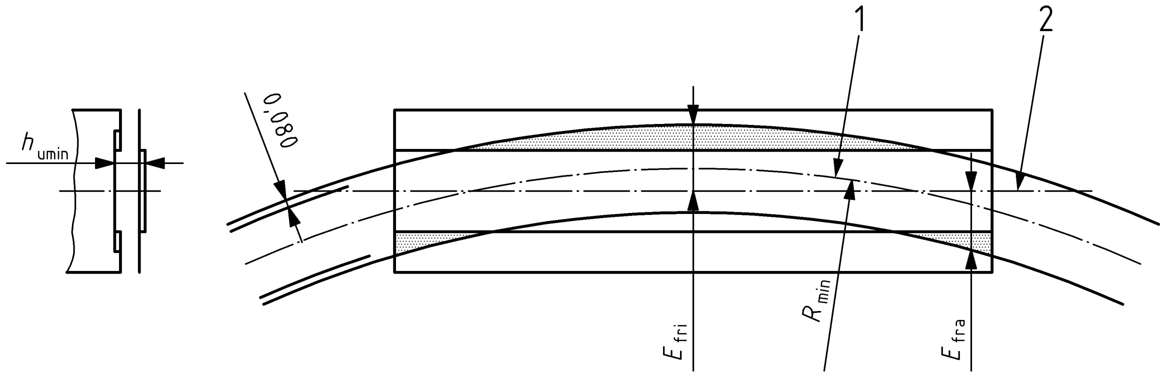
Figure 43 — Retarder operation zone

The infrastructure may install devices in a curve of radius $R \geq R_{\min}$ (150 m) whilst maintaining a constant distance relative to the inside edge of the rail (80 mm).

The rolling stock shall take into account the widening of the zone in order to clear the width E_{fri} or E_{fra} for the retraction of the retarders (see Figure 44). It should be noted that in the specific case of using shunting devices, the effect of the clearances $q+w$ may be regarded as being negligible.

$$E_{fri} = 0{,}080 + l_{\max} - \frac{d}{2} + \frac{an_i - n_i^{\,2} + \frac{p^2}{4}}{2R_{\min}} \quad (126)$$

$$E_{fra} = 0{,}080 + l_{\max} - \frac{d}{2} + \frac{an_a + n_a^{\,2} - \frac{p^2}{4}}{2R_{\min}} \quad (127)$$



Key

1 track centreline on a curve

2 centreline of the vehicle

Figure 44 — Widening of the retarder operation zone

8 Pantograph gauge

8.1 Pantograph kinematic gauge

8.1.1 General principle

8.1.1.1 General

The heads used for different electrification systems are in principle listed in EN 50367.

Other types of specific head can also be stipulated in the rolling stock construction contract on the basis of the lines to be operated.

NOTE Examples of other heads are given in file UIC 608.

The application of these rules therefore aims:

to allow the designer of the rolling stock to check that the space swept by the head fits the infrastructure gauge, and not to dimension the head width;

allow the infrastructure to clear the space necessary depending on the head chosen.

The rules given in this standard take account of the mechanical and electrical aspects.

8.1.1.2 Elements in the transverse direction

In the transverse direction, the displacement depends on the following elements:

the geometric overthrow in the curve dg_i or dg_a;

the transverse clearances $q + w_{(R)} + \frac{l_{réel} - d}{2}$;

the quasi-static roll $s\frac{I^{ou}D}{L}(h - h_c)$;

the transverse displacement "t" of the head raised to 6,5 m under the effect of a transverse force of 300 N;

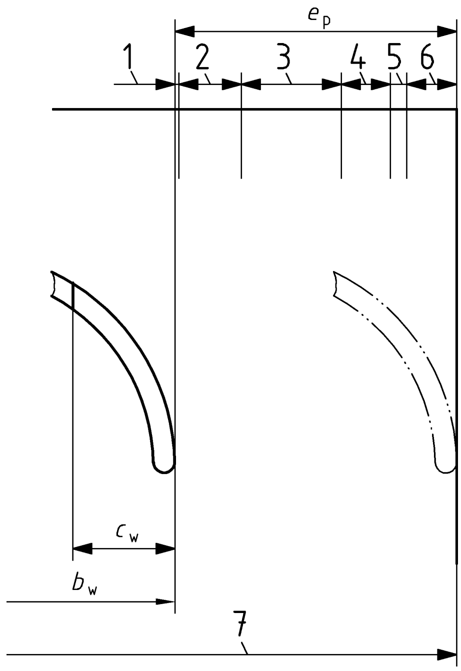
the pantograph installation and construction tolerance "τ" between the centreline of the vehicle body and the centre of the head raised to 6,5 m in the absence of any stress;

the angle "θ" created by the body suspension adjustment tolerances (angle expressed in radians);

the installation height "h_t" of the lower pantograph joint relative to the running surface.

The transverse displacement is shared between rolling stock and the infrastructure.

A kinematic reference profile of the pantograph of semi-width $b_w + e_p$ is thus established for the upper conventional height e_{po} and for the conventional height e_{pu} (see Figure 45).



Key

1 pantograph horn

2 transverse clearance of the reference vehicle $q_r + w_r$

3 quasi-static roll $s'_0 \frac{I'_0}{L}(h - h_{c0})$

4 transverse displacement "t_r" of the head under the effect of a 300 N force

5 pantograph installation and construction tolerance "τ_r"

6 suspension adjustment roll $\theta_r(h - h_{c0})$

7 semi-width of the reference profile

Figure 45 — Kinematic reference profile for pantograph in collection position

The rolling stock shall ensure that all the mechanical parts of the pantograph remain within this kinematic reference profile plus the additional overthrows.

In addition to the reference profile and the additional overthrow, the infrastructure shall clear an adequate space to take into account the extra quasi-static roll due to a cant or cant deficiency greater than the value I_0, add a possible electrical insulating allowance M_i where the head does not have any insulating horns and specify the allowances $M_{(1)}$, $M_{(2)}$ and $M_{(3)}$ defined with regard to the kinematic gauge. For insulating horns, the insulation allowance M_i includes the width c_w of the insulating horn.

8.1.1.3 Elements in the vertical direction

The height h_f to be considered to fit the gauge is that where the wire is the highest at rest during the year.

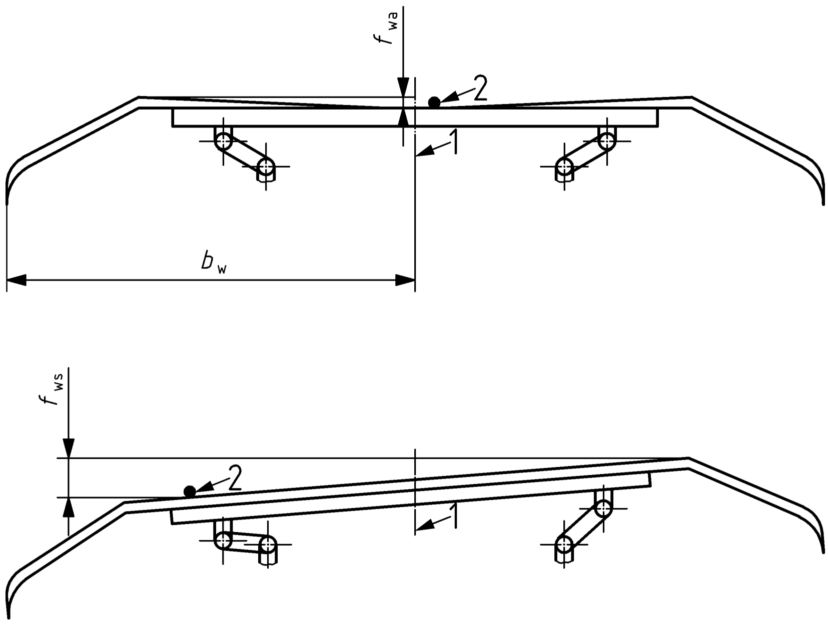
This height depends on the overhead contact line suspension system generally at the lowest winter temperature, estimated by the infrastructure.

In the raised position, the pantograph has a tendency to raise the contact wire by a value fs.

Starting from this effective height

$$h_{eff} = h_f + fs \tag{128}$$

allowance should be made for wear of the head f_{wa} and its behaviour on its suspension f_{ws} illustrated in Figure 46.



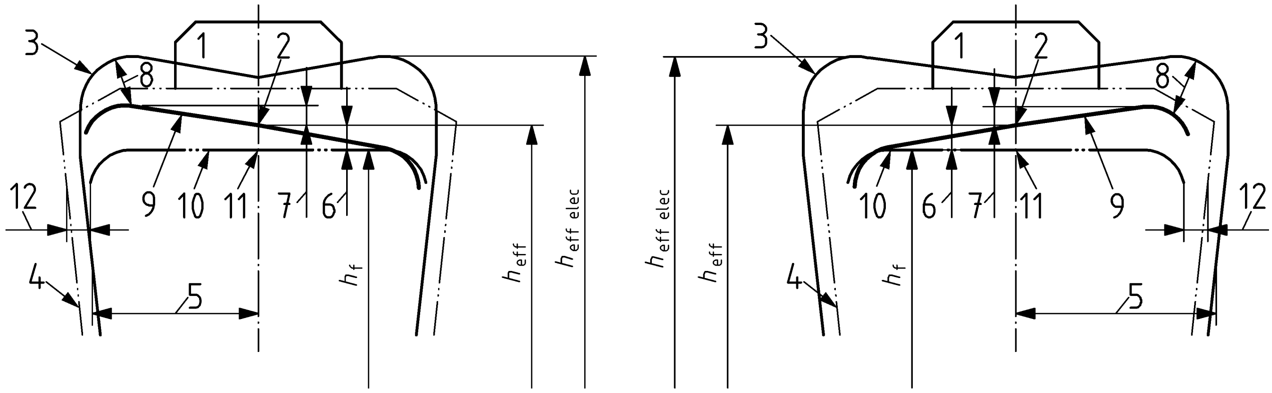
Key

b_w	semi-width of the head
f_{wa}	displacement caused by wear to the head
f_{ws}	displacement caused by the head roll
1	centreline of the vehicle
2	contact wire

Figure 46 — Encroachment of the head beyond the contact plane

8.1.1.4 General illustration

Figure 47 shows all the phenomena to be considered with regard to the pantograph gauge.



a) Pantograph fitted with insulating horns **b) Pantograph fitted with non-insulating horns**

Key

1 semi-width of the head

2 contact wire raised by the pantograph up to height"h_{eff}"

3 electric structure gauge up to height "$h_{eff,\ elec}$"

4 reference profile

5 space to be cleared for de-energized structures (*)

6 raising of the contact wire"f_s" and "f_{s0}"

7 roll and wear of the head "f_{wa}" and variable part of "f_{ws}" according to the transverse position of the contact wire

8 electrical insulating distance

9 pantograph head

10 nominal theoretical initial position of the head

11 unraised contact wire taking into account overhead contact line sag f_v and f_w

12 transverse displacement "e_p"

(*) the mechanical allowances $M_{(1)}$, $M_{(2)}$ and $M_{(3)}$ of the infrastructure not covered by the electricalinsulating allowance should be added.

Figure 47 — Pantograph gauges

8.1.2 Elements to be taken into account by the infrastructure

The infrastructure pantograph gauge depends directly on the type of head authorised to be used.

If the type of head used does not have insulating horns, an electrical insulating allowance M_i shall be added to the outside of the kinematic reference profile.

A distinction is made principally between:

— the space to be cleared for energized or electrically insulated structures.

The reference profile and its associated rules allow the definition of the space to be cleared for the passage of the pantograph in the raised position without an electrical insulating allowance.

Thus

$$b_{\inf} \geq CR_{cin} + S'_0 + s'_0 \frac{I^{ou}D - I'_0}{L}(h - h_{c0}) + M_{(1)d} + M_{(1)osc} + M_{(2)voie} + M_{(2)D} + M_{(3)} \quad (129)$$

$$h_{\inf} \geq hf + f_s + f_{wa} + f_{ws} + M_v \quad (130)$$

— the space to be cleared for de-energized structures.

The reference profile and its associated rules allow the definition of the space to be cleared taking into account the necessary electrical insulating allowance compared to the energized parts of the pantograph in the raised position.

Thus

$$b_{\inf} \geq CR_{cin} + S'_0 + s'_0 \frac{I^{ou}D - I'_0}{L}(h - h_{c0}) + M_i + M_{(1)d} + M_{(1)osc} + M_{(2)voie} + M_{(2)D} + M_{(3)} \quad (131)$$

$$h_{eff,elec} \geq hf + f_s + f_{wa} + f_{ws} + M_i + M_v \quad (132)$$

8.1.3 For the rolling stock

8.1.3.1 Gauge for pantographs in the raised position

8.1.3.1.1 General

The reference profile with its associated rules allows verification that the head with its displacements remains within the space allocated to it.

Transverse displacement values "e_{p}" contained in CR_{cin}:

It should be noted that in this context of dimensioning the reference profile, as the additional overthrow S'_0 is taken into account separately outside the profile, the geometric displacement dg_i or dg_a in a curve is not taken into consideration in value e_p.

The semi-width of the lower point of the reference profile of the pantographs located at height h'_u is established on the basis of the conventional value:

$$e_{p_{ur}} = q_r + w_{(R)} + s'_0 \frac{I'_0}{L}(h'_u - h_{co}) + \sqrt{\left(t_r \frac{h'_u - h_{tr}}{h'_o - h_{tr}}\right)^2 + \tau_r{}^2 + \left[\theta_r (h'_u - h_{co})\right]^2} - Abt_u \quad (133)$$

For heights greater than h_u, the semi-width of the reference profile is equal to

$$e_{p_{ur}} + K'(h - h'_u) \tag{134}$$

8.1.3.1.2 Values taken into account by the rolling stock

Taking into account the random character of certain phenomena and experience, the rolling stock takes into account a mean square for one part of the phenomena and applies a fixed reduction “ Abt ” based on experience.

Thus, checking that the parts fit the pantograph gauge is carried out on the basis of the following values:

the head fits the pantograph gauge if $e_{p_o} \leq e_{p_{or}}$ and if $e_{p_u} \leq e_{p_{ur}}$ with:

$$e_{p_o} = q + w_{(R)} + s\frac{I'_0}{L}(h'_o - h_c) + \sqrt{t^2 + \tau^2 + [\theta(h'_o - h_c)]^2} - Abt_o \tag{135}$$

$$e_{p_u} = q + w_{(R)} + s\frac{I'_0}{L}(h'_u - h_c) + \sqrt{\left(t\frac{h'_u - h_t}{h'_o - h_t}\right)^2 + \tau^2 + [\theta(h'_u - h_c)]^2} - Abt_u \tag{136}$$

8.1.3.1.3 Calculation formulae intended for verification of the rolling stock for classic vehicles not subjected to $I > I_c$

8.1.3.1.3.1 General

The pantograph fits the gauge if the value P_o at height h'_o or P_u at height h'_u is not positive, in the knowledge that a fixed value VF is allocated to the corresponding part of the dimensions of the reference vehicle.

$$VF = e_{p_r} + Abt - (q_r + w_r) \tag{137}$$

8.1.3.1.3.2 For vehicles in which $s \leq s'_0$

for pantographs located between the bogie centres:

$$P_{oi} = \frac{an_i - n_i^2 + \frac{p^2}{4} - \Delta_i}{2R} + j'_i + z' \tag{138}$$

$$P_{ui} = \frac{an_i - n_i^2 + \frac{p^2}{4} - \Delta_i}{2R} + j'_i + z'' \tag{139}$$

Where

$$\Delta_i = a_r n_r - n_r{}^2 + \frac{p_r{}^2}{4} = 2\left(S'_i - \frac{l_{\max} - l_{nom}}{2} \right) \tag{140}$$

$$j'i = q + w_{i(R)} - (q_r + w_r) \tag{141}$$

$$z' = s\frac{I'_0 (h'_o - h_c)}{L} + \sqrt{t^2 + \tau^2 + [\theta(h'_o - h_c)]^2} - VF_{o(I_0)} \tag{142}$$

$$z'' = s\frac{I'_0 (h'_u - h_c)}{L} + \sqrt{\left[t\frac{h'_u - h_t}{h'_o - h_t} \right]^2 + \tau^2 + [\theta(h'_u - h_c)]^2} - VF_{u(I_0)} \tag{143}$$

For the pantographs located beyond the bogie centres:

$$P_{o\,a} = \frac{an_a + n_a{}^2 - \frac{p^2}{4} - \Delta_a}{2R} + \frac{l_{\max} - d}{2} . \frac{2n_a}{a} + j'_a + z' \tag{144}$$

$$P_{u\,a} = \frac{an_a + n_a{}^2 - \frac{p^2}{4} - \Delta_a}{2R} + \frac{l_{\max} - d}{2} . \frac{2n_a}{a} + j'_a + z'' \tag{145}$$

Where

$$\Delta_a = a_r n_r + n_r{}^2 - \frac{p_r{}^2}{4} = 2\left(S'_a - \frac{l_{\max} - l_{nom}}{2} \right) \tag{146}$$

$$j'_a = q\frac{2n_a + a}{a} + w_{a(R)} \frac{n_a + a}{a} + w_{i(R)} \frac{n_a}{a} - (q_r + w_r) \tag{147}$$

$$z' = s\frac{I'_0 (h'_o - h_c)}{L} + \sqrt{t^2 + \tau^2 + [\theta(h'_o - h_c)]^2} - VF_{o(I_0)} \tag{148}$$

$$z'' = s\frac{I'_0 (h'_u - h_c)}{L} + \sqrt{\left[t\frac{h'_u - h_t}{h'_o - h_t} \right]^2 + \tau^2 + [\theta(h'_u - h_c)]^2} - VF_{u(I_0)} \tag{149}$$

8.1.3.1.3.3 For vehicles in which $s > s'_0$

The kinematic reference profile is established for a quasi-static roll based on a cant or a cant deficiency value I'_0 and a reference flexibility coefficient s'_0.

The infrastructure clears the space necessary for $I^{ou} D \phi\ I'_0$ but the value s'_0 remains constant.

In order to prevent a pantograph installed on a more flexible vehicle where $s \phi s'_0$ does not project beyond the space allocated to the rolling stock, the following additional conditions based on the maximum cant or cant deficiency value shall be met.

For pantographs located between the bogie centres:

$$P_{o\,i} = \frac{an_i - n_i{}^2 + \frac{p^2}{4} - \Delta_i}{2R} + j'_i + z' \qquad (150)$$

$$P_{u\,i} = \frac{an_i - n_i{}^2 + \frac{p^2}{4} - \Delta_i}{2R} + j'_i + z'' \qquad (151)$$

Where

$$\Delta_i = a_r n_r - n_r{}^2 + \frac{p_r{}^2}{4} = 2\left(S'_i - \frac{l_{\max} - l_{nom}}{2} \right) \qquad (152)$$

$$j'i = q + w_{i(R}) - (q_r + w_r) \qquad (153)$$

$$z' = s\frac{I_{\max}(h'_o - h_c)}{L} + \sqrt{t^2 + \tau^2 + \left[\theta\left(h'_o - h_c\right)\right]^2} - VF_{o(I_{\max})} \qquad (154)$$

$$z'' = s\frac{I_{\max}(h'_u - h_c)}{L} + \sqrt{\left[t\frac{h'_u - h_t}{h'_o - h_t}\right]^2 + \tau^2 + \left[\theta\left(h'_u - h_c\right)\right]^2} - VF_{u(I_{\max})} \qquad (155)$$

For the pantographs located beyond the bogie centres:

$$P_{oa} = \frac{an_a + n_a{}^2 + \frac{p^2}{4} - \Delta_a}{2R} + \frac{l_{\max} - d}{2} . \frac{2n_a}{a} + j'_a + z' \qquad (156)$$

$$P_{ua} = \frac{an_a + n_a{}^2 + \frac{p^2}{4} - \Delta_a}{2R} + \frac{l_{\max} - d}{2} . \frac{2n_a}{a} + j'_a + z'' \qquad (157)$$

Where

$$\Delta_a = a_r n_r + n_r{}^2 - \frac{p_r{}^2}{4} = 2\left(S'_a - \frac{l_{\max} - l_{nom}}{2}\right) \tag{158}$$

$$j'_a = q\frac{2n_a + a}{a} + w_{a(R)}\frac{n_a + a}{a} + w_{i(R)}\frac{n_a}{a} - \left(q_r + w_r\right) \tag{159}$$

$$z' = s\frac{I_{\max}(h'_o - h_c)}{L} + \sqrt{t^2 + \tau^2 + \left[\theta\left(h'_o - h_c\right)\right]^2} - VF_{o(I_{\max})} \tag{160}$$

$$z'' = s\frac{I_{\max}(h'_u - h_c)}{L} + \sqrt{\left[t\frac{h'_u - h_t}{h'_o - h_t}\right]^2 + \tau^2 + \left[\theta\left(h'_u - h_c\right)\right]^2} - VF_{u(I_{\max})} \tag{161}$$

8.1.3.1.3.4 Calculation formulae intended for the verification of the rolling stock for tilting vehicles or for vehicles subject to $I > I_c$

The spaces allocated to the pantographs installed on tilting vehicles are identical to those allocated to the pantographs installed on non-tilting vehicles.

The verification rules are contained in EN 15273-2 without any effect on the infrastructure except that the rules given in 7.3.1.14 are also applicable.

8.1.3.1.3.5 Values taken into account by the infrastructure

Starting from the pantograph kinematic reference profile, the infrastructure clears:

$$S'^{ou}_i\ S'_a + s'_0 * \frac{(D - D_0{}^{ou} I - I_0)_{>0}}{L}\left(h - h_{c0}\right) + \Sigma j + M_i \tag{162}$$

The values taken into account are given in EN 15273-3.

8.1.3.2 Gauge for non-insulated live parts on vehicle roof

The gauge for non-insulated live parts on the vehicle roof is defined in EN 15273-2.

8.2 Pantograph dynamic gauge

8.2.1 Values taken into account by the rolling stock

The displacement calculation shall be carried out on a straight track and in a curve.

Verification shall be carried out up to the maximum raised height.

On a straight track:

$$Dpl_{dyn} = \frac{l_{\max} - d}{2}(A) + q(A) + w_a(A) + s\cdot\frac{I_{\sup}}{L}\cdot\left|h - h_c\right|_{>0} + \left(t - 0{,}030\right) + \left(\tau - 0{,}010\right) \tag{163}$$

Towards the inside of the curve:

$$Dpl_{i\,dyn} = \frac{an_i - n_i^{\,2} + \frac{p^2}{4}(A)}{2R} + \frac{l_{\max} - d}{2}(A) + q(A) + w_{i(R)}(A) + z_{dyn} + (t - 0{,}030) + (\tau - 0{,}010) \quad (164)$$

Towards the outside of the curve:

$$Dpl_{a\,dyn} = \frac{an_a + n_a^{\,2} - \frac{p^2}{4}(A)}{2R} + \frac{l_{\max} - d}{2}(A) + q(A) + w_{i(R)}(A) + w_{a(R)}(A) + z_{dyn} + (t - 0{,}030) + (\tau - 0{,}010) \quad (165)$$

The coefficients (A) are identical to those used for sizing the body.

These displacements shall also be taken into account in the simulations for the pantograph in the raised position.

The pantograph is acceptable if $b_w + Dpl_{dyn}$ remains within the pantograph dynamic reference profile.

8.2.2 Values taken into account by the infrastructure

Starting from the pantograph dynamic reference profile, the infrastructure clears:

$$S'_i{}^{ou}\ S'_a + \Sigma j_{dyn} + M_i \quad (166)$$

The values taken into account are given in EN 15273-3.

Annex A
(normative)

Catalogue of gauges

The catalogue of gauges gives the reference profiles and the parameters of the rules associated with each part of the profile.

This list is not exhaustive.

A.1 Static gauges

Table A.1 — Static gauges

Static gauge	Generally used for	See
G1, G2, GI1 and GI2	Static gauge G1 is generally used for the upper parts of interoperable international wagons in Europe except for the United Kingdom. Static gauge G2 is generally used for the upper parts of interoperable wagons on certain networks in Central Europe. Static gauge GI1 is generally used for the lower parts of interoperable vehicles capable of being hump shunted. Static gauge GI2 is generally used for the lower parts of interoperable low-floor wagons not capable of being hump shunted. Rules relating to gradient transitions, ferries and marshalling humps.	B.1 Annex F
GA, GB and GC	Container transport Gauges GI1 and GI2 are applicable to the lower parts	B.2 B.1
GB1 and GB2	Container traffic between France and Italy Gauges GI1 and GI2 are applicable to the lower parts	B.3 B.1
OSJD	The countries of Eastern Europe concerned with traffic of vehicles from the ex-Soviet Union	B.4
FIN 1	Finland Rules relating to Finnish marshalling humps	B.5 Annex F
GHE16, GEA16, GEB16, GEC16, GEE10 and GED10	The general use railway network (REFIG) comprising the Spanish Iberian gauge railways and UIC managed by ADIF (Administrador de Infraestructuras Ferroviarias), and the metric gauge network managed by FEVE (Ferrocarriles de Vía Estrecha)	B.6

A.2 Kinematic gauges

Table A.2 — Kinematic gauges

Kinematic gauge	Generally used for	See
G1, G2, GI1 and GI2	Kinematic gauge G1 is generally used for the upper parts of interoperable international wagons in Europe except for the United Kingdom. Kinematic gauge G2 is generally used for the upper parts of interoperable wagons on certain networks in Central Europe. Kinematic gauge GI1 is generally used for the lower parts of interoperable vehicles capable of being hump shunted. Kinematic gauge GI2 is generally used for the lower parts of interoperable low-floor wagons not capable of being hump shunted. Kinematic gauge GI3 is generally used for the lower parts of low-floor special wagons intended for specific rolling road traffic. Rules relating to gradient transitions, ferries and marshalling humps.	C.1 Annex F
GA, GB and GC	International container and swap body traffic and for interconnections between the conventional network and the European high speed network. Gauges GI1, GI2 and GI3 are applicable for the lower parts	C.2 C.1
GB1 and GB2	Traffic between France and Italy Gauges GI1, GI2 and GI3 are applicable for the lower parts	C.3 C.1
GI3	Kinematic gauge GI3 is generally used for the lower parts of low-floor special wagons intended for specific rolling road traffic.	C.4
FR3.3	The French network Gauge G1 is applicable for the lower parts	C.5 C.1
BE1, BE2 and BE3	The Belgian network and its border interconnections Gauge GI2 relating to low-floor wagons is applicable to the lower parts of height less than 100 mm. If it is more favourable to the rolling stock, the additional space allocated in certain cases by gauge GI2 between 100 mm and 315 mm high, may be used to define the maximum construction gauge.	C.6 Figure C.4
NL1, NL2	The Netherlands network	C.7

Table A.2 *(continued)*

Kinematic gauge	Generally used for	See
PTb, PTb+, PTc	The Portuguese network	C.8
DE1	The German network	C.9
DE2	The German network and border networks	C.10
DE3	The German network and border networks	C.11
GHE16, GEA16, GEB16, GEC16, GEC14, GEE10 and GED10	The general use railway network (REFIG) comprising the Spanish Iberian gauge railways and UIC managed by ADIF (Administrador de Infraestructuras Ferroviarias), and the metric gauge network managed by FEVE (Ferrocarriles de Vía Estrecha)	C.12

A.3 Dynamic gauges

Table A.3 lists the dynamic gauges.

Table A.3 — Dynamic gauges

Dynamic gauge	Generally used for	See
SEa	The Swedish network	D.1.1
SEc	The Swedish network	D.1.2

A.4 Uniform gauges

Table A.4 lists the uniform gauges.

Table A.4 — Uniform gauges

Uniform gauge	Generally used for	See
GUC	The infrastructure of the European high speed network	E.1
GU1	The infrastructure of certain networks such as Greece	E.2
GU2	The Netherlands network and routes intended for the operation of vehicles constructed according to kinematic gauge G2	E.1
Z-GČD	The Czech network	E.3

Annex B
(normative)

Reference profiles and associated rules for static gauges

General comment as a practical measure to facilitate the reading of the standard:

— the dimensions of the reference profiles are given in mm;

— the values to be used in the formulae are given in m, unless otherwise indicated.

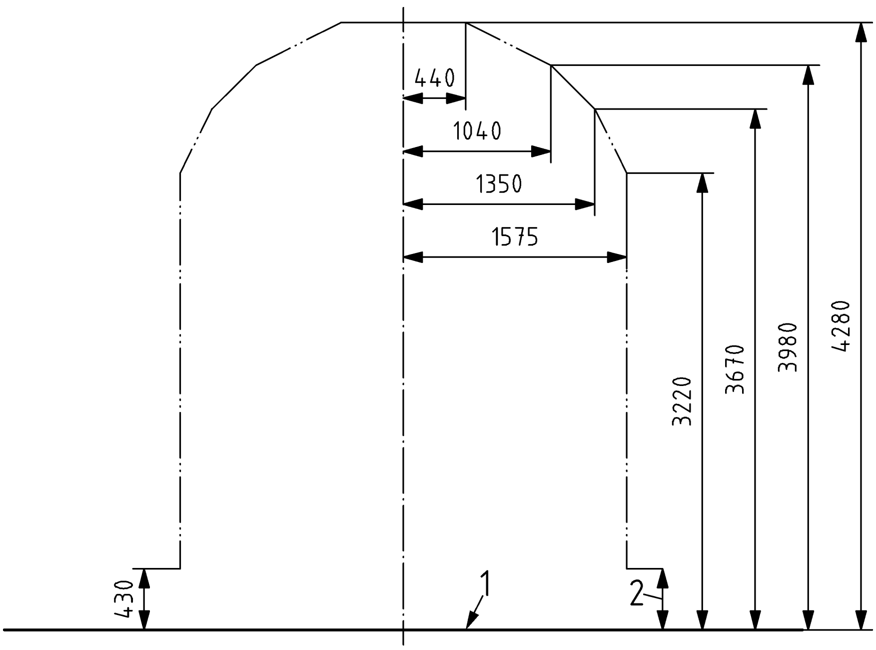
B.1 Static gauges G1 and G2

B.1.1 Upper parts of static gauges G1 and G2

B.1.1.1 Reference profiles for the lateral parts and upper parts

Figure B.1 shows the reference profile for static gauge G1.

Dimensions in millimetres



Key

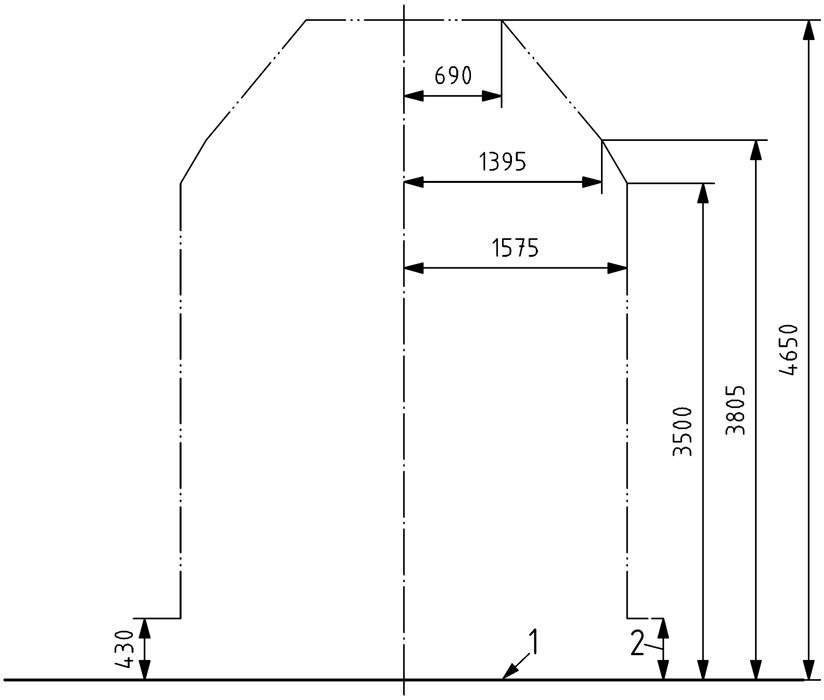
1 running surface

2 lower parts according to Figure B.3 or Figure B.4

Figure B.1 — Reference profile for static gauge G1

Figure B.2 shows the reference profile for static gauge G2.

Dimensions in millimetres



Key

1 running surface

2 lower parts according to Figure B.3 or Figure B.4

Figure B.2 — Reference profile for static gauge G2

B.1.1.2 Associated rules

B.1.1.2.1 Basic data

9 l_{nom} 1,435 m;

10 $l_{\max}$ 1,465 m;

11 L 1,5 m.

B.1.1.2.2 Additional overthrows

Table B.1 — Additional overthrows for static gauges G1 and G2

$\infty \geq R \geq 250$ (m)	$250 > R \geq 150$ (m)
$S_{ist} = S_{ast} = \frac{3{,}75}{R} + 0{,}045 + \frac{l - 1{,}435}{2}$ (B.1)	$S_{ist} = \frac{50}{R} - 0{,}140 + \frac{l - 1{,}435}{2}$ (B.2)
	$S_{ast} = \frac{60}{R} - 0{,}180 + \frac{l - 1{,}435}{2}$ (B.3)

NOTE The value F = 0,045 m is included in the additional overthrow on the outside of the static reference profile.

B.1.1.2.3 Taking the roll into account

For static gauges, the effects of roll are solely taken into consideration by the infrastructure. The values given in the following table determine the application limits for static gauges, i.e. the values from which kinematic gauging becomes mandatory.

Table B.2 — Values to be taken into account for the roll

Gauge	Height m	z_0 For D_0 or I_0 equal 0,050 m m	$s_{\lim}$
G1	0,430 to 1,169	0	-
	1,170 to 3,220	0,025	-
	3,220	0,025	0,27
	3,670	0,030	0,28
	3,980	0,035	0,3
	4,280	0,040	0,32
G2	0,430 to 1,169	0	-
	1,170 to 3,220	0,025	-
	3,500	0,025	0,25
	3,805	0,030	0,28
	4,650	0,050	0,36

For practical needs, although theoretically the flexibility limit is 0,25, the use of gauges G1 and G2 is limited to the vehicles and loadings where the flexibility coefficient remains less than $s_{\text{lim}} \leq 0{,}2$.

B.1.1.2.4 Vertical geometric overthrow upwards and vertical allowance of the infrastructure

The infrastructure shall add 0,030 m to the height of the upper part of the static reference profile to take account of the dynamic uplift of the vehicle suspension in operation.

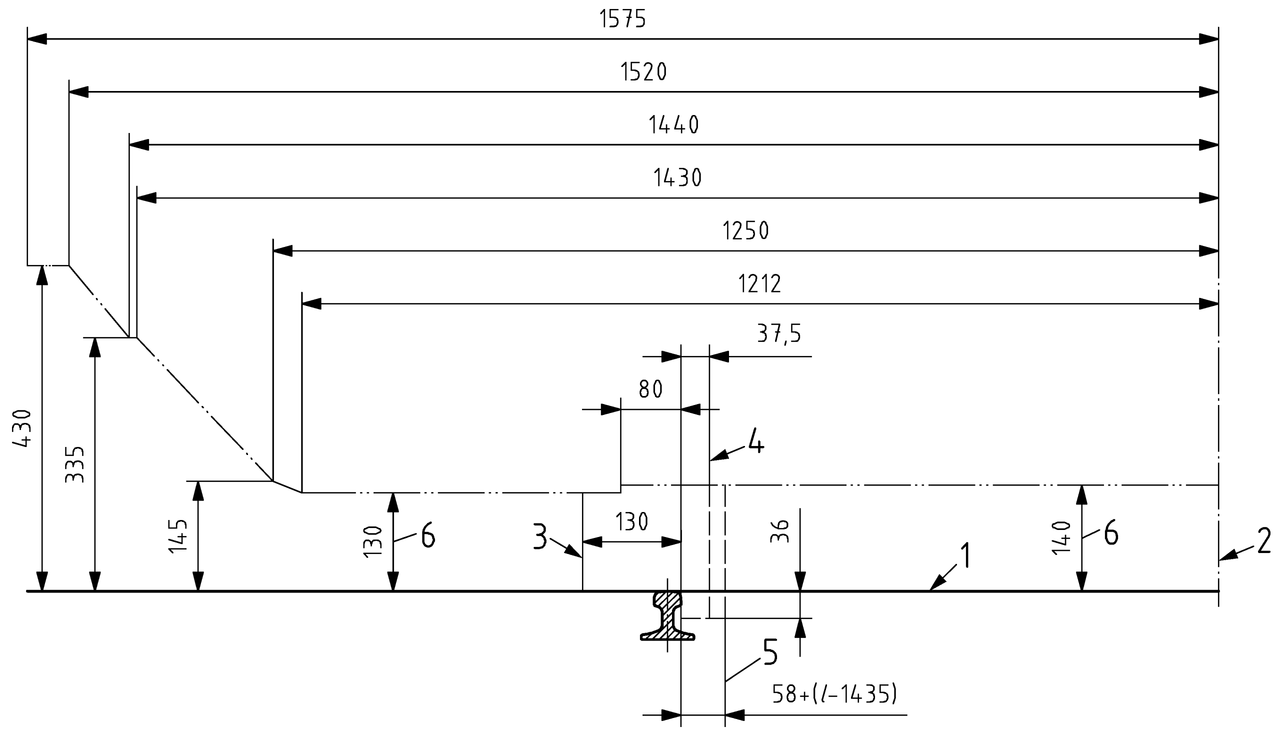
The conventional values to be considered with regard to the vertical geometric overthrow are given in Annex F.

B.1.2 Lower parts of static gauges GI1 and GI2

B.1.2.1 Static reference profile for the lower parts giving the lower limit of vehicles passing over marshalling humps and rail brakes and other shunting and stopping devices

Figure B.3 shows reference profile GI1 of the lower parts of static gauge G1.

Dimensions in millimetres



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 insidesurface of the tyre when the opposite wheel is in flange contact

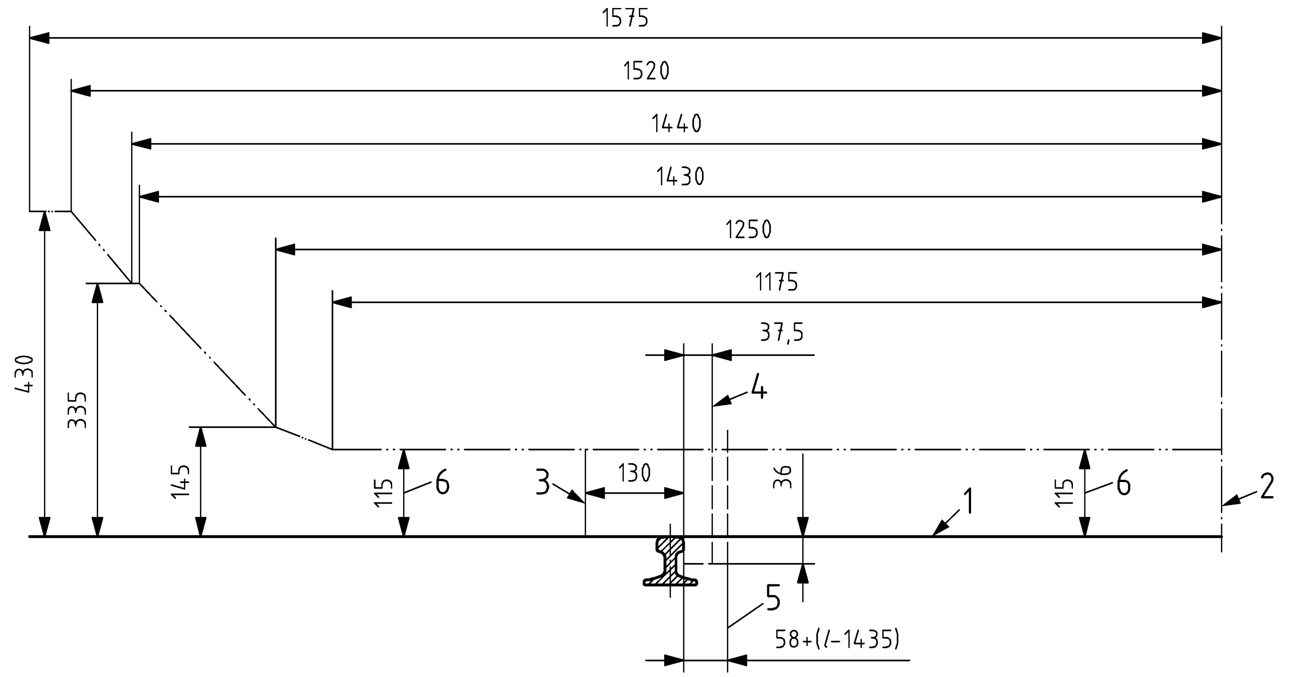
6 heights may be reduced by 15 mm for non-suspended parts (see B.2.2.3.3)

Figure B.3 — Reference profile GI1 for the lower parts of static gauge G1

B.1.2.2 Static reference profile for the lower parts corresponding to the lower limit of vehicles not passing over either marshalling humps or rail brakes in an active position

Figure B.4 shows the GI2 reference profile for the lower parts of static gauge G1 for vehicles not passing over either marshalling humps or rail brakes in an active position.

Dimensions in millimetres



Key

1 running surface

2 centreline of the reference profile

3 limit position of the outersurface 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 heights may be reduced by 15 mm for non-suspended parts (see B.2.2.3.3)

Figure B.4 — GI2 reference profile for the lower parts of static gauge G1 for vehicles not passing over either marshalling humps or rail brakes in an active position

B.1.2.3 Associated rules

B.1.2.3.1 Basic data

12 l_{nom} 1,435 m;

13 l_{max} 1,465 m;

14 L 1,5 m.

Table B.3 — Additional overthrows for static gauges GI1 and GI2

$\infty \geq R \geq 250$ m	$250 > R \geq 150$ m	
$S_{i_{st}} = S_{a_{st}} = \frac{2,5}{R} + \frac{l - 1,435}{2}$ (B.4)	$S_{i_{st}} = \frac{50}{R} - 0,190 + \frac{l - 1,435}{2}$	(B.5)
	$S_{a_{st}} = \frac{60}{R} - 0,230 + \frac{l - 1,435}{2}$	(B.6)

NOTE The value F = 0 m for the lower parts of the static reference profile.

B.1.2.3.2 Vertical geometric overthrow downwards and vertical allowance of the infrastructure

It is allowed for the axle boxes and other unsprung parts not subjected to oscillations to project 0,015 m lower than the reference profile of the lower parts.

The conventional values to be considered with regard to the vertical geometric overthrow are given in Annex F.

B.1.2.3.3 Taking the roll into account

The effects of the roll are included in the infrastructure allowances.

B.2 Static gauges GA, GB and GC

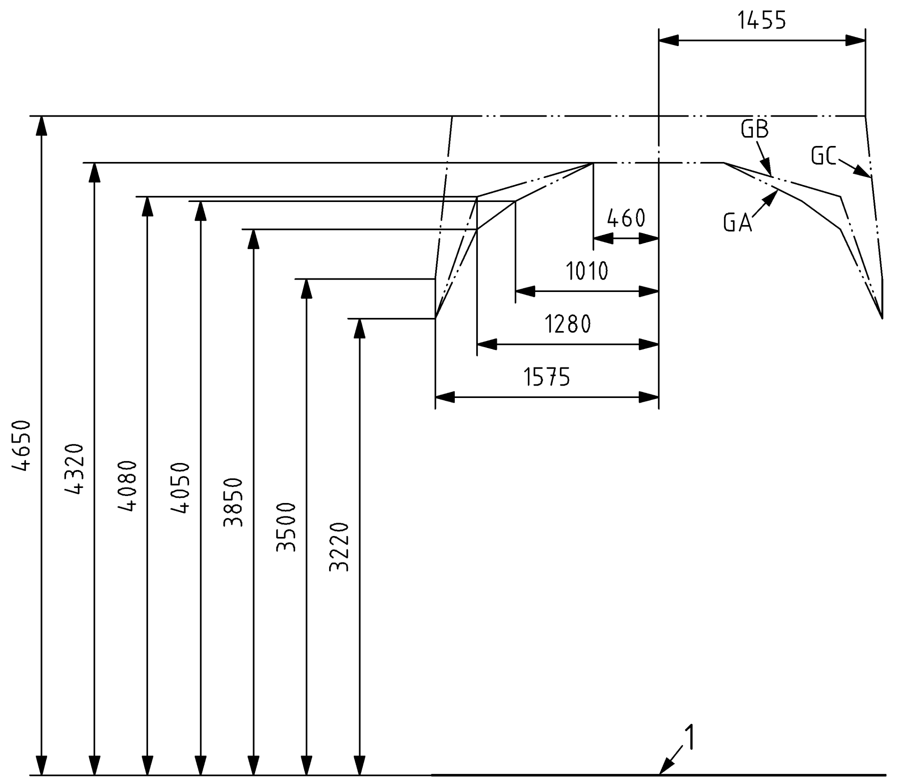
B.2.1 Lateral part

The reference profile and the rules for static gauge G1 are applicable below 3,220 m.

B.2.2 Static reference profiles for the upper parts

Figure B.5 shows the reference profiles for static gauges GA, GB and GC.

Dimensions in millimetres



Key

1 running surface

NOTE Lower parts according to Figure B.3 or Figure B.4.

Figure B.5 — Reference profiles for static gauges GA, GB and GC

B.2.3 Associated rules

B.2.3.1 Basic data

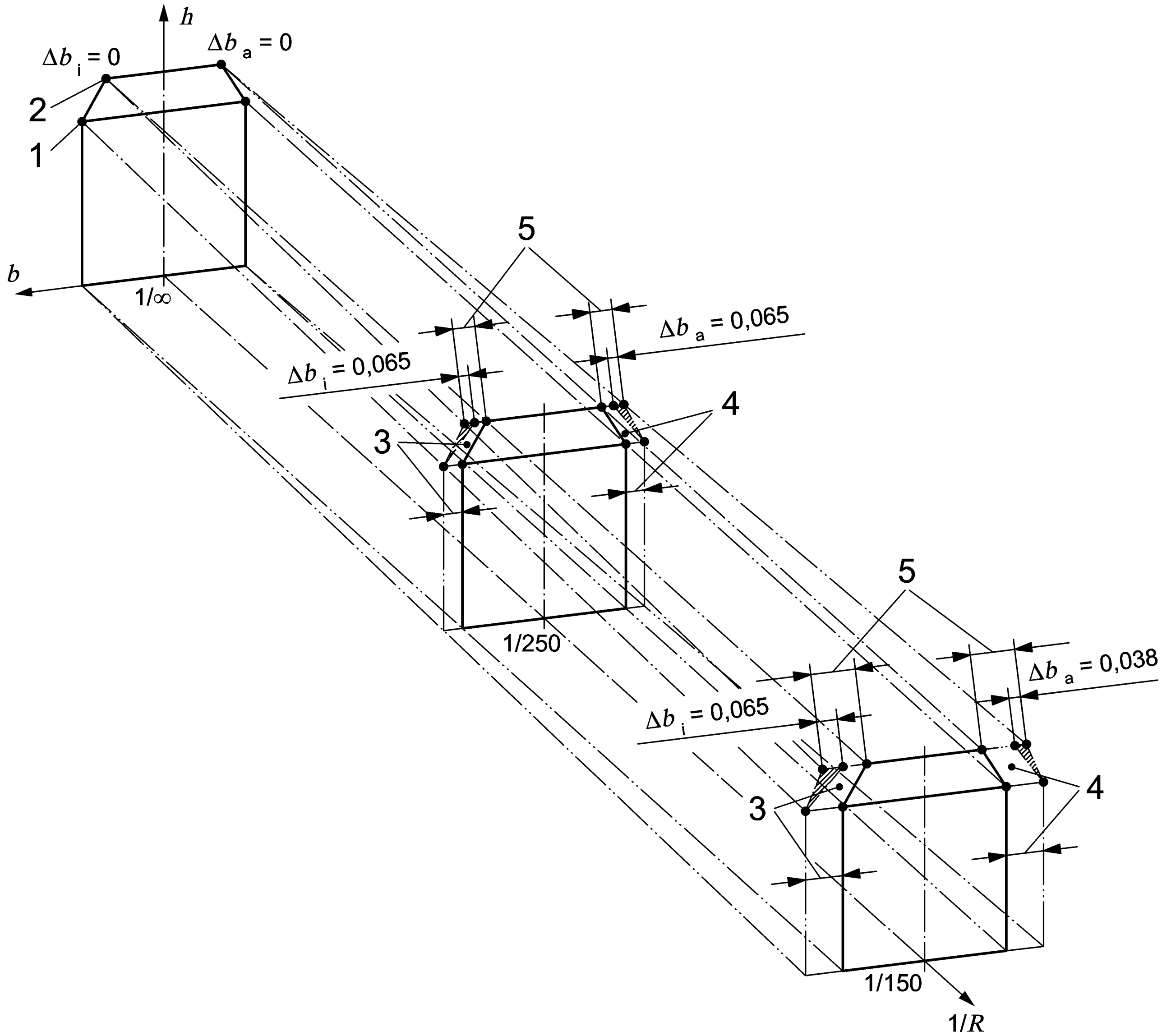
15 l_{nom} 1,435 m;

16 $l_{\max}$ 1,465 m;

17 L 1,5 m.

B.2.3.2Additional overthrows for gauges GA and GB

The additional overthrows for static gauges GA and GB are given in Table B.4. Figure B.6 illustrates the linear extrapolation of static gauges GA and GB compared to the additional overthrows of static gauge G1 for $h \geq 3{,}22$ m.



Key

1	peak of the vertical part of the reference profile of gauge G1
2	peak of the upper part of the reference profile of gauge GA or GB
3	additional overthrow S_i for gauge G1
4	additional overthrow S_a for gauge G1
5	additional overthrow S_i or S_a for gauge GA and GB
Δb_i	width supplement corresponding to the difference between the additional overthrows S_i of gauges G1 and GA or GB with the semi-width of the inside of the curve
Δb_a	width supplement corresponding to the difference between the additional overthrows S_a of gauges G1 and GA or GB with the semi-width of the outside of the curve

Figure B.6 — Reference profiles for static gauges GA, GB and GC

Table B.4 — Additional overthrows for h ≥ 3,220 m

Gauge	$\infty \geq R \geq 250$ **m**	$250 > R \geq 150$ **m**
GA $3{,}22 \leq h \leq 3{,}85$ and GB $3{,}22 \leq h \leq 4{,}08$	$S_{i_{st}} = S_{a_{st}} = \frac{3{,}75}{R} + 0{,}045 + \frac{l-1{,}435}{2} + k\Delta b_{(i/a)}$ (B.7)	$S_{i_{st}} = \frac{50}{R} - 0{,}140 + \frac{l-1{,}435}{2} + k\Delta b_i$ (B.8) $S_{a_{st}} = \frac{60}{R} - 0{,}180 + \frac{l-1{,}435}{2} + k\Delta b_a$ (B.9)
GA $h = 3{,}85$ GB $h = 4{,}08$	$S_{i_{st}} = S_{a_{st}} = \frac{20}{R} + 0{,}045 + \frac{l-1{,}435}{2}$ (B.10)	$S_{i_{st}} = S_{a_{st}} = \frac{50}{R} - 0{,}075 + \frac{l-1{,}435}{2}$ (B.11)
GC	$S_{i_{st}} = S_{a_{st}} = \frac{3{,}75}{R} + 0{,}045 + \frac{l-1{,}435}{2}$ (B.12)	$S_{i_{st}} = \frac{50}{R} - 0{,}140 + \frac{l-1{,}435}{2}$ (B.13) $S_{a_{st}} = \frac{60}{R} - 0{,}180 + \frac{l-1{,}435}{2}$ (B.14)

NOTE The value F = 0,045 m is included in the additional overthrow on the outside of the static reference profile.

With the following values:

Table B.5 — Coefficient to be applied relative to height

	Gauge GA		**Gauge GB**	
Height m	$3{,}22 < h < 3{,}85$	$h \geq 3{,}85$	$3{,}22 < h < 4{,}08$	$h \geq 4{,}08$
k	$k = \frac{h-3{,}22}{0{,}63}$ (B.15)	$k = 1$	$k = \frac{h-3{,}22}{0{,}86}$ (B.16)	$k = 1$

B.2.3.3 Taking the roll into account

For static gauges, the effects of roll are solely taken into consideration by the infrastructure. The values given in the following table determine the application limits for static gauges, i.e. the values from which kinematic gauging becomes mandatory.

Table B.6 — Values to be taken into account for the roll

Gauge	z_0 For D_0 or I_0 equal 0,050 m m	h m	s_{lim}
GA	0,025	3,220	0,2
	0,035	3,850	0,3
	0,035	4,050	
	0,040	4,320	
GB	0,025	3,220	0,2
	0,035	4,080	0,3
	0,040	4,320	
GC	0,025	3,220	0,2
	0,040	4,650	0,3

B.2.3.4 Vertical geometric overthrow upwards and vertical allowance of the infrastructure

— For gauges GA and GB, 0,030 m shall be added to the height of the upper part of the reference profile to take into account the dynamic uplift of the suspension and the vertical oscillations of the vehicles during operation.

— For gauges GC, 0,050 m shall be added to the height of the upper part to take into account the dynamic uplift of the suspension and the vertical oscillations of the vehicles during operation. The infrastructure shall also add the vertical dimensions of the upper part of the reference profile of $\frac{50}{R}$ in the gradient transitions and the values defined in 7.3.2.

— The conventional values to be considered with regard to the vertical geometric overthrow are given in Annex F.

B.3 Static gauge GB1 and GB2

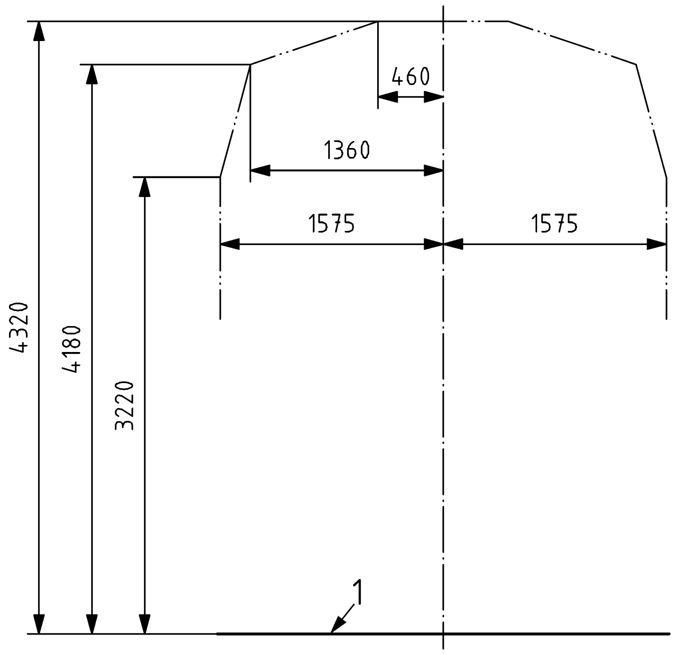
B.3.1 Lateral part

The reference profile and the rules for static gauge G1 are applicable below 3,220 m.

B.3.2 Static reference profiles for the upper parts

Figure B.7 shows the static reference profile GB1.

Dimensions in millimetres



Key

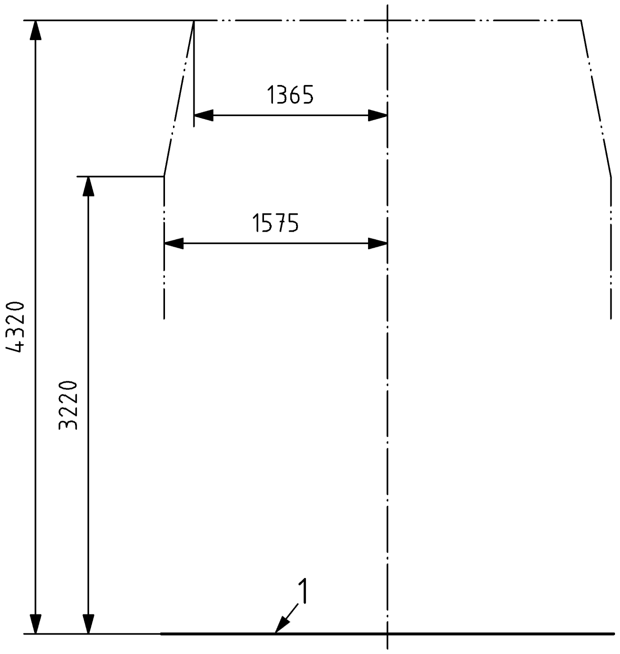
1 running surface

NOTE Lower parts according to Figure B.3 or Figure B.4.

Figure B.7 — Static reference profile GB1

Figure B.8 shows static reference profile GB2.

Dimensions in millimetres



Key

1 running surface

NOTE Lower parts according to Figure B.3 or Figure B.4.

Figure B.8 — Static reference profile GB2

B.3.3 Associated rules

B.3.3.1 Basic data

18 l_{nom} 1,435 m;

19 $l_{\max}$ 1,465 m;

20 L 1,5 m.

B.3.3.2 Additional overthrows for $h \geq 3{,}220$ m

Table B.7 — Additional overthrows for h ≥ 3,220 m

Gauge	$\infty \geq R \geq 250$ m	$250 > R \geq 150$ m
GB1 $3{,}22 \leq h \leq 4{,}180$ and GB2 $3{,}22 \leq h \leq 4{,}320$	$S_{i_{st}} = S_{a_{st}} = \frac{3{,}75}{R} + 0{,}045 + \frac{l - 1{,}435}{2} + k\Delta b_{(i/a)}$ (B.17)	$S_{i_{st}} = \frac{50}{R} - 0{,}140 + \frac{l - 1{,}435}{2} + k\Delta b_{(i/a)}$ (B.18)
GB1 $h \geq 4{,}180$	$S_{ist} = S_{ast} = \frac{20}{R} + 0{,}045 + \frac{l - 1{,}435}{2}$ (B.19)	$S_{ist} = S_{ast} = \frac{50}{R} - 0{,}075 + \frac{l - 1{,}435}{2}$ (B.20)

With the following indicated values for coefficient k:

Table B.8 — Coefficient k to be applied relative to height

GB1		GB2
$3{,}22 < h < 4{,}18$	$h \geq 4{,}18$	$3{,}22 < h \leq 4{,}32$
$k = \frac{h - 3{,}22}{0{,}96}$ (B.21)	$k = 1$	$k = \frac{h - 3{,}22}{1{,}1}$ (B.22)

NOTE The value F = 0,045 m is included in the additional overthrow on the outside of the static reference profile.

B.3.3.3 Taking the roll into account

For static gauges, the effects of roll are solely taken into consideration by the infrastructure. The values given in the following table determine the application limits for static gauges, i.e. the values from which kinematic gauging becomes mandatory.

Table B.9 — Values to be taken into account for the roll

Gauge	z_0 m	h m	$s_{\lim}$
GB1	0,025	3,220	0,2
	0,035	4,180	0,28
	0,040	4,320	0,32
GB2	0,025	3,220	0,2
	0,040	4,320	0,32

B.3.3.4 Vertical geometric overthrow upwards and vertical allowance of the infrastructure

— For static gauges GB1 and GB2, 0,030 m shall be added to the height of the upper part of the reference profile to take into account the dynamic uplift of the suspension of the vehicles during operation.

— The conventional values to be considered with regard to the vertical geometric overthrow are given in Annex F.

B.4 Static gauges OSJD

B.4.1 General comment

These static reference profiles apply to the rolling stock.

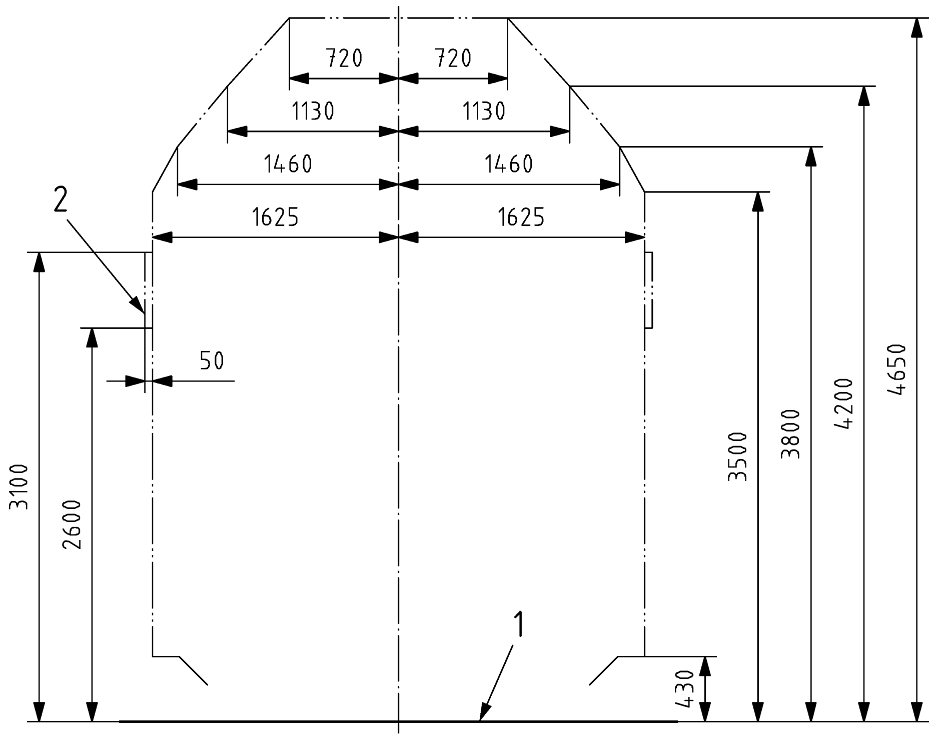
Profiles 0-WM, 1-WM, 02-WM, 03-WM apply particularly to coaches and wagons.

The OSJD applies fixed allowances for the infrastructure.

B.4.2 Static reference profiles for the upper parts

Figure B.9 shows the static reference profile for gauge 0-WM.

Dimensions in millimetres



Key

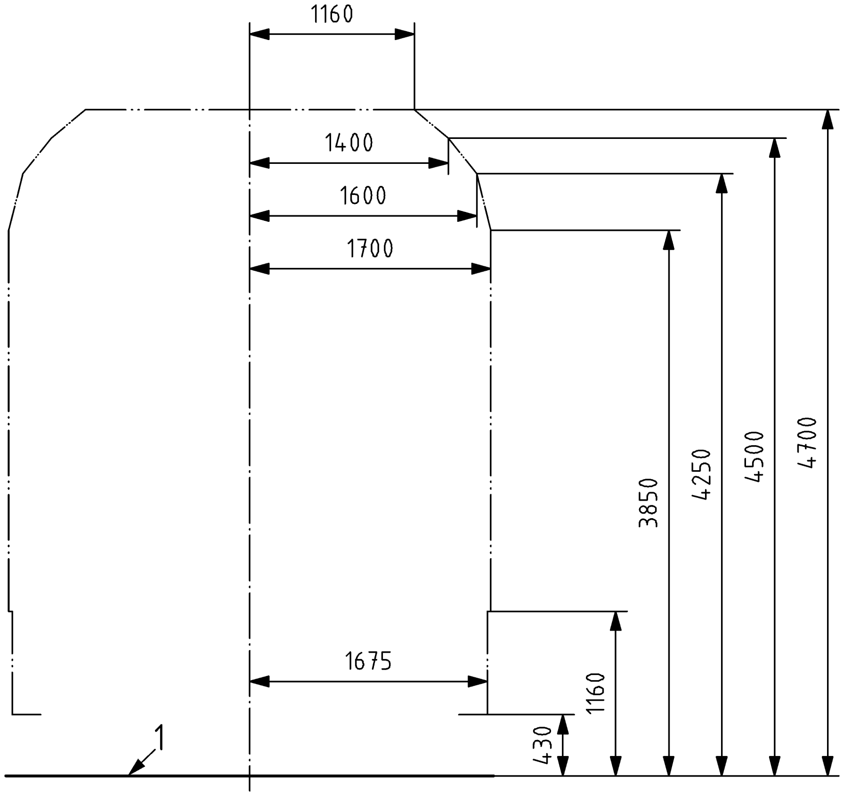
1 running surface

2 only for signals installed on the vehicles

Figure B.9 — Static reference profile for gauge 0-WM

Figure B.10 shows the static reference profile for gauge 1-WM.

Dimensions in millimetres



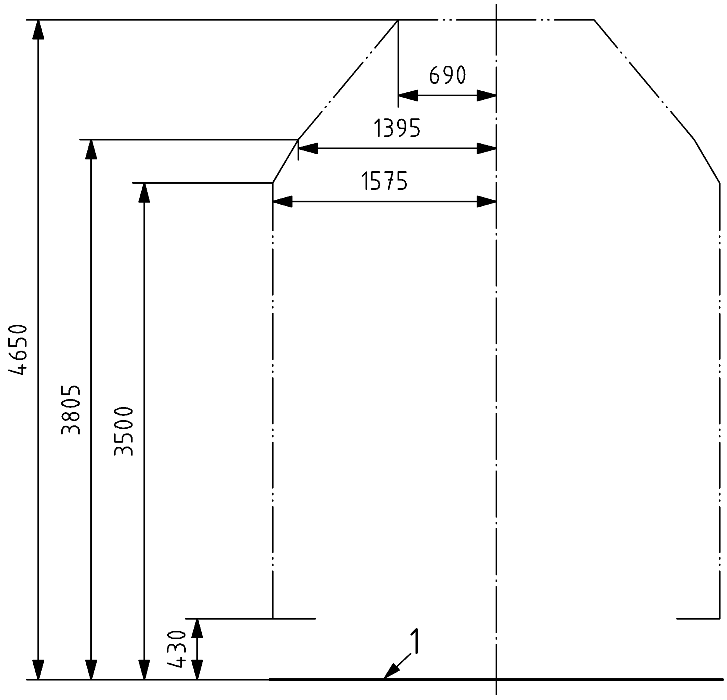
Key

1 running surface

Figure B.10 — Static reference profile for gauge 1-WM

Figure B.11 shows the reference profile for static gauge 02-WM.

Dimensions in millimetres



Key

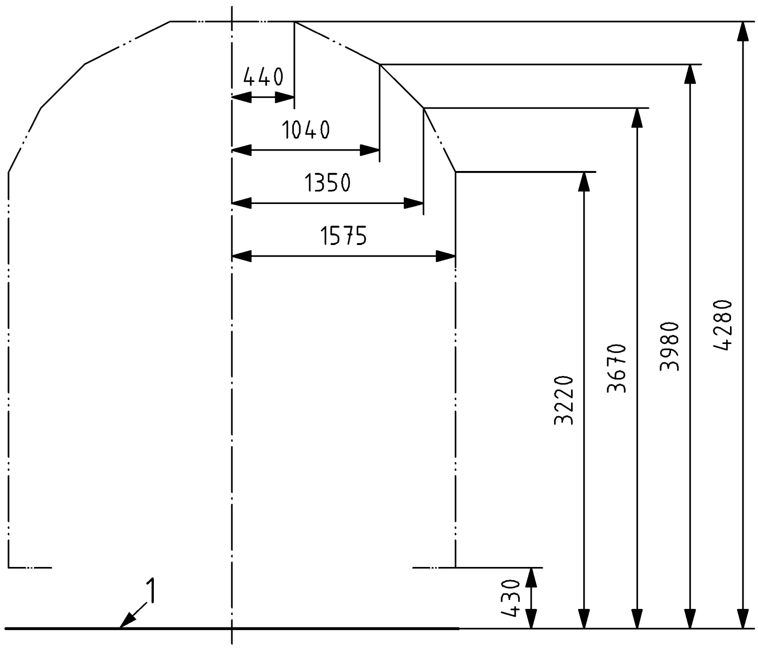
1 running surface

NOTE Gauge 02-WM of the OSJD corresponds to static gauge G2 used in Europe.

Figure B.11 — Reference profile for static gauge 02-WM

Figure B.12 shows the reference profile for static gauge 03-WM.

Dimensions in millimetres



Key

1 running surface

NOTE Gauge 03-WM of the OSJD corresponds to static gauge G1 used in Europe.

Figure B.12 — Reference profile for static gauge 03-WM

B.4.3 Associated rules

B.4.3.1 Basic data

21 l_{nom} 1,520 m;

22 l_{max} 1,546 m;

23 L 1,585 m.

B.4.3.2 Additional overthrows

Table B.10 — Additional overthrows for static gauges WM

$\infty \geq R \geq 100$	03-WM, 02-WM and 0-WM		1-WM	
	For heights ≥ 0,430 m	For heights < 0,430 m	For heights ≥ 0,430 m	For heights < 0,430 m
S_{st}	0,075	0,025	0	0,025
$\frac{1{,}546 - d}{2}$	0,030	0,030	0,030	0,030

The vertical dimensions of the wagons are determined taking into account the marshalling humps of which the convex vertical radius is 250 m.

NOTE The value F = 0,045 m is included in the additional overthrow on the outside of the static reference profile for $h \geq 0{,}430$ m.

B.4.3.3 Taking the roll into account

Reserved.

B.4.3.4 Vertical geometric overthrow upwards and vertical allowance of the infrastructure

Reserved.

B.4.4 Static reference profiles for the lower parts

B.4.4.1 Profiles

Figure B.13 shows the static reference profile for the lower parts of gauges 0-WM, 1-WM and 02-WM.

Dimensions in millimetres

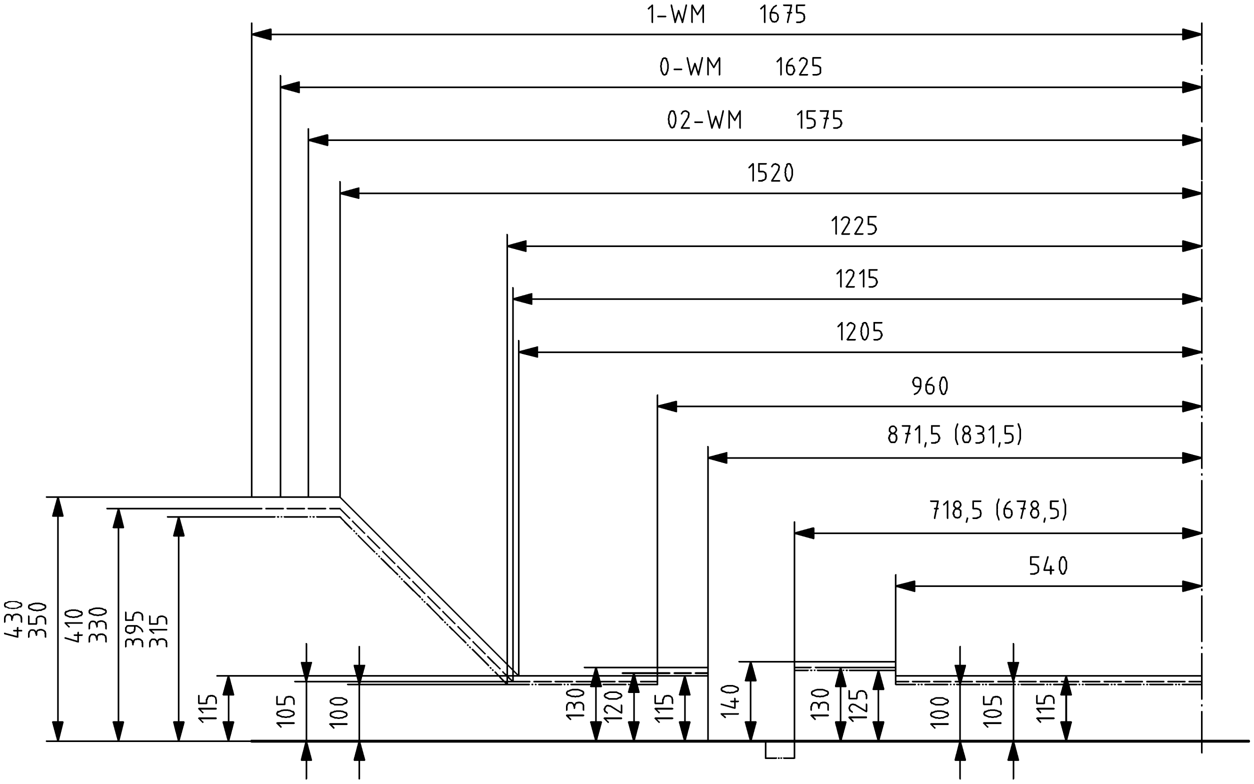
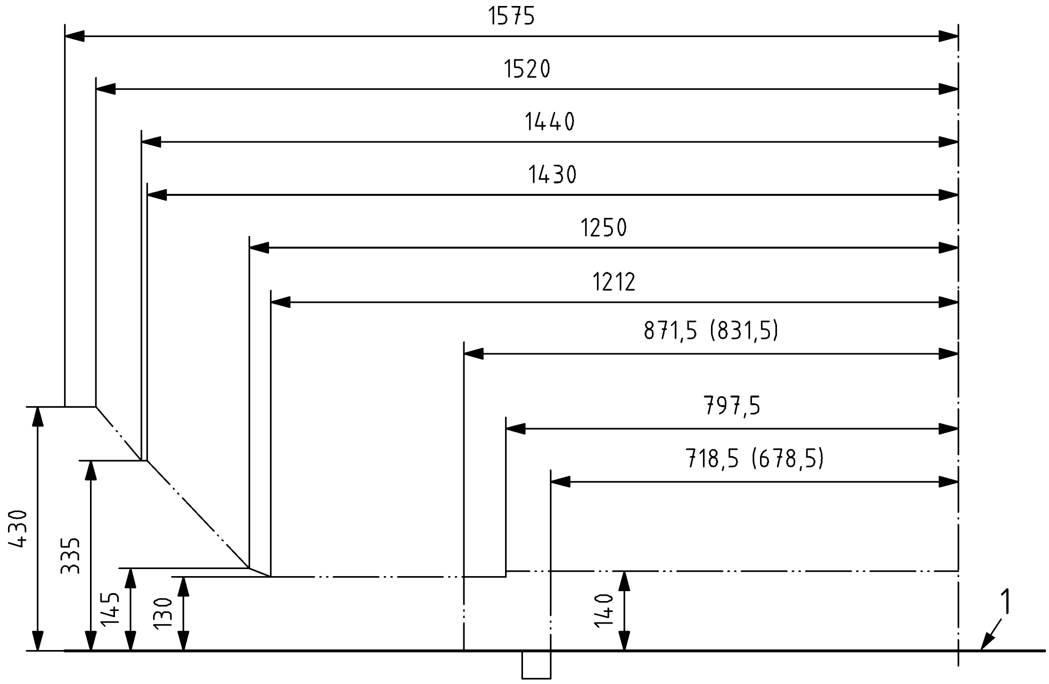


Figure B.13 — Static reference profile of the lower parts of gauges 0-WM, 1-WM and 02-WM

Figure B.14 shows the static reference profile for the lower parts of gauge 03-WM.

Dimensions in millimetres



Key

1 running surface

Figure B.14 — Static reference profile for the lower parts of gauge 03-WM

The heights shall be reduced by 0,015 m for unsprung parts.

B.4.4.2 Vertical geometric overthrow downwards and vertical allowance of the infrastructure

Reserved.

B.5 Static gauge FIN 1

B.5.1 General comment

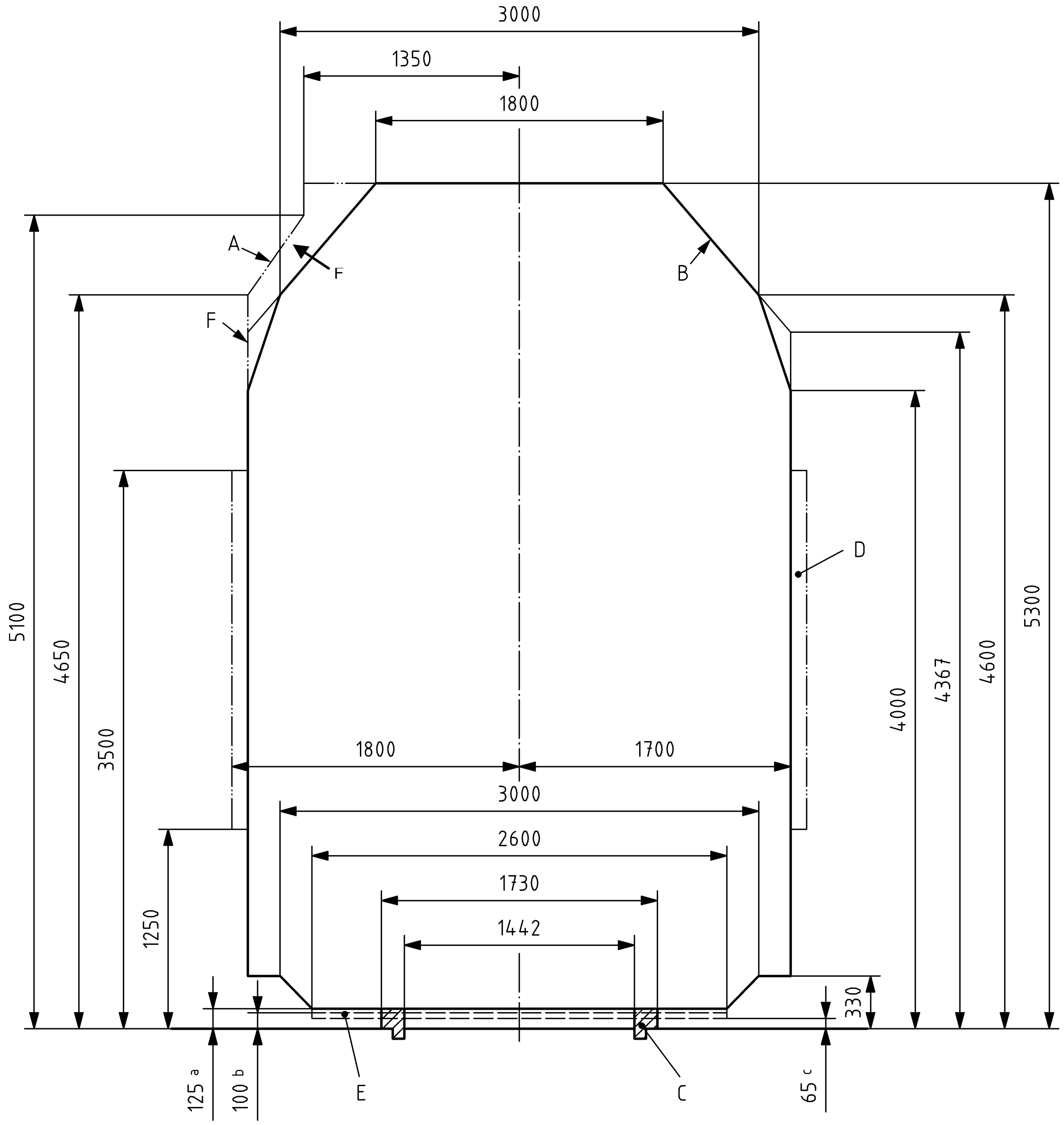
These static reference profiles apply to the rolling stock.

As Finland applies fixed allowances for the infrastructure, the corresponding structure installation gauges are given in EN 15273-3.

B.5.2 Static reference profile for the upper parts

Figure B.15 shows the reference profile of static gauge FIN 1.

Dimensions in millimetres



Key

A gauge of rolling stock suitable for running on the routes listed in the list of line descriptions published by the Transport Agency of Finland (technical specifications relating to railway safety standards), where the structure gauge has been established

B rolling stock gauge

C space for the wheels to pass

D lights and rear-view mirrors in the Figure

E widening of the lower part of the gauge for the application of a national regulation to be specified

F widening of the upper part of the gauge for the application of a national regulation to be specified

a lower part ($h \leq 0,125$ m) of the rolling stock suitable for running over marshalling humps and rail brakes

b lower part ($h \leq 0,100$ m) of the rolling stock unsuitable for running over marshalling humps and rail brakes, except for bogies of traction units

c lower part ($h \leq 0,065$ m) of the bogies of the traction unit unsuitable for running over marshalling humps and rail brakes

Figure B.15 — Reference profile for static gauge FIN 1

B.5.3 Associated rules

B.5.3.1 Basic data

24 l_{nom} 1,524 m;

25 $l_{\max}$ 1,544 m;

26 L 1,600 m.

B.5.3.2 Additional overthrows

Table B.11 — Additional overthrows for gauge FIN 1

Height m	$k = F + \frac{l - l_{nom}}{2}$ m	$\infty \geq R \geq 150$ m
$h \geq 0{,}600$	0,075	$S_{i\,st} = S_{a\,st} = \frac{36}{R} + k$ (B.23)
$h < 0{,}600$	0,060	
$h < 0{,}330$ for vehicles suitable for running over rail brakes	0	

NOTE The value F is included in the additional overthrow on the outside of the static reference profile.

B.5.3.3 Taking the roll into account

All the roll is taken into account by the infrastructure on the outside of the reference profile.

B.5.3.4 Vertical geometric overthrow upwards and vertical allowance of the infrastructure

The fixed vertical allowances are applied by the infrastructure. See Annex F and the structure gauge in EN 15273-3.

B.5.4 Position of the platforms

$$b_{\inf} = AT + \frac{36}{R} - T_{voie} \qquad \text{(B.42)}$$

Table B.12 lists the position of the platforms.

Table B.12 — Position of the platforms

Height m	AT m	T_{track} m
$h > 1{,}300$	2,000	0,020
$0{,}600 < h \leq 1{,}300$	1,920	0,020
$h \leq 0{,}600$	1,800	0,020

B.6 Spanish static gauges GHE16, GEA16, GEB16, GEC16, GEE10 and GED10

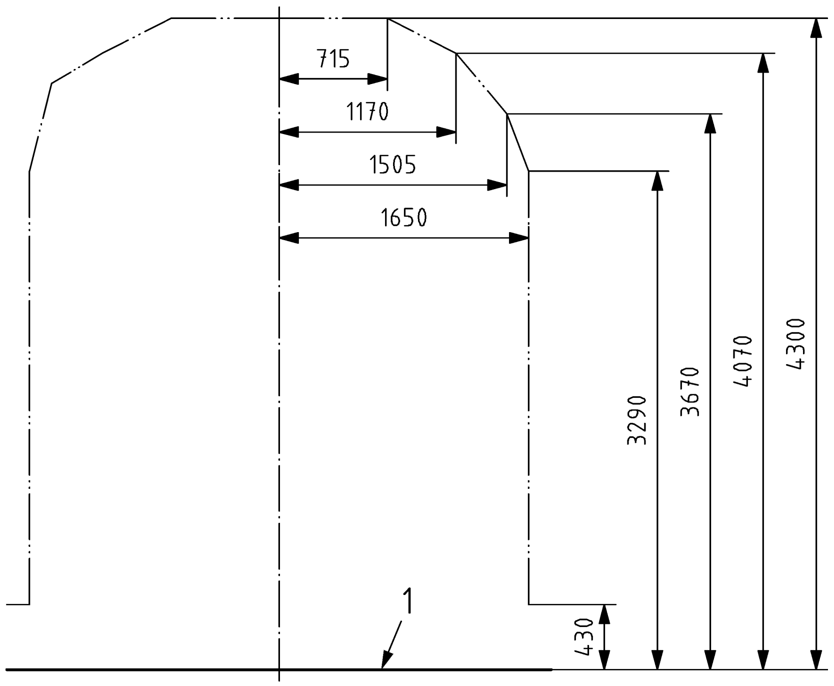
B.6.1 Reference profiles for static gauges

B.6.1.1 Static gauge GHE16

B.6.1.1.1 Static reference profile for the lateral parts and upper parts

Figure B.16 shows the reference profile for static gauge GHE16.

Dimensions in millimetres



Key

1 running surface

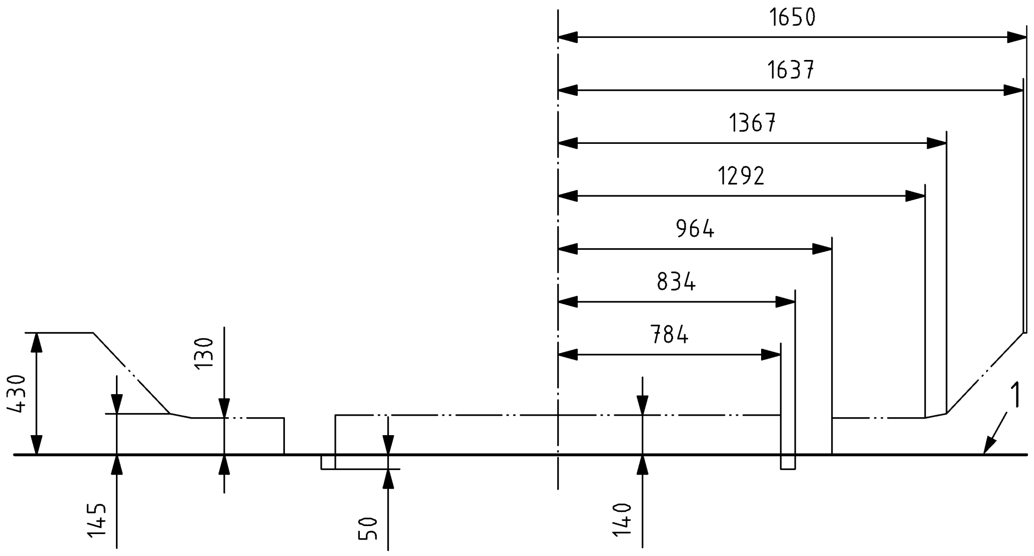
NOTE Lower parts as per Figure B.17.

Figure B.16 — Reference profile for static gauge GHE16

B.6.1.1.2 Static reference profile for the lower parts

Figure B.17 shows the reference profile for static gauge GHE16.

Dimensions in millimetres



Key

1 running surface

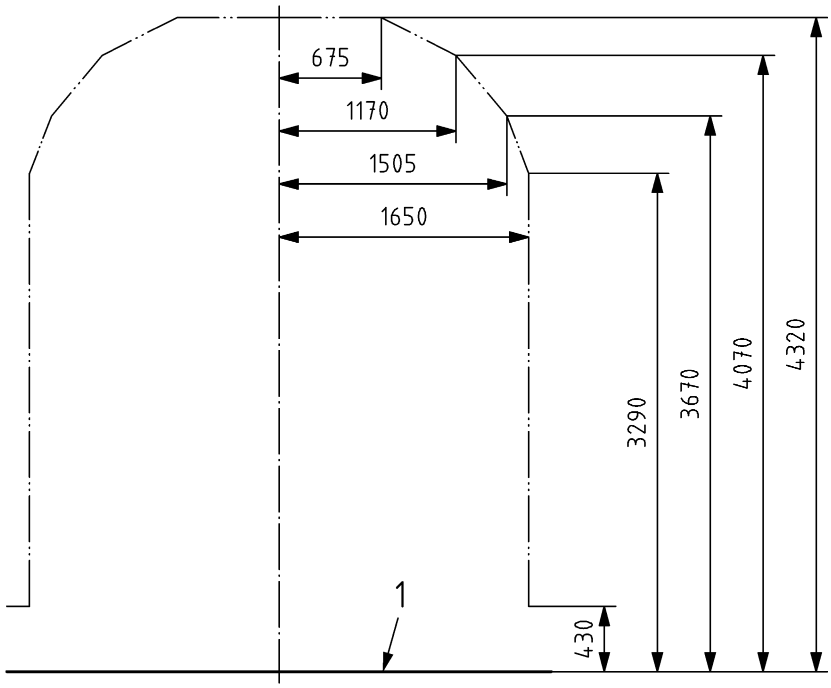
Figure B.17 — Reference profile for the lower parts of static gauge GHE16

B.6.1.2 Static gauge GEA16

The reference profile for the lower parts of static gauge GEA16 is the same as that shown for gauge GHE16.

Figure B.18 shows the reference profile for the upper parts of static gauge GEA16.

Dimensions in millimetres



Key

1 running surface

NOTE Lower parts as per Figure B.17.

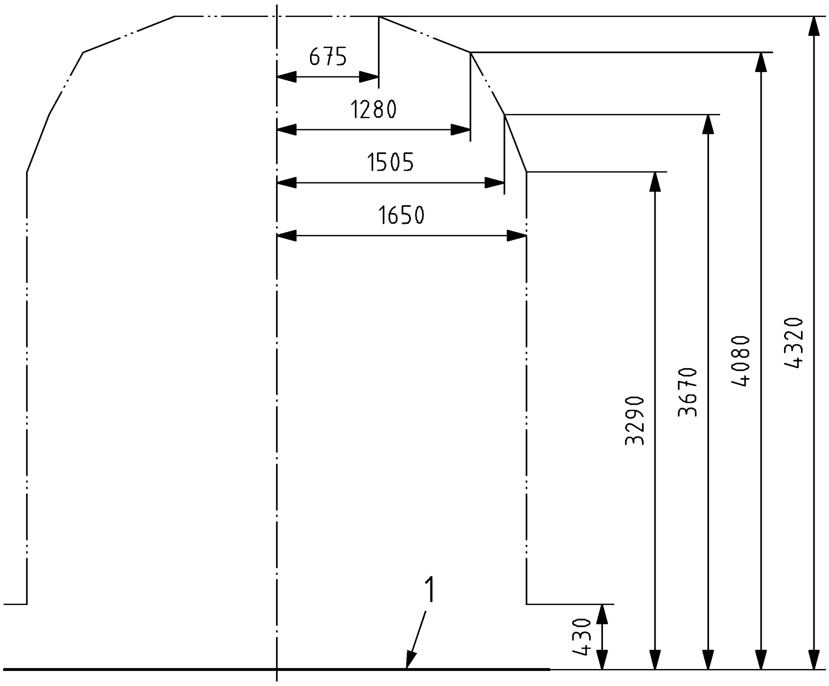
Figure B.18 — Reference profile of the upper parts of static gauge GEA16

B.6.1.3 Static gauge GEB16

The reference profile for the lower parts of static gauge GEB16 is the same as that shown for gauge GHE16.

Figure B.19 shows the reference profile for the upper parts of static gauge GEB16

Dimensions in millimetres



Key

1 running surface

NOTE Lower parts as per Figure B.17.

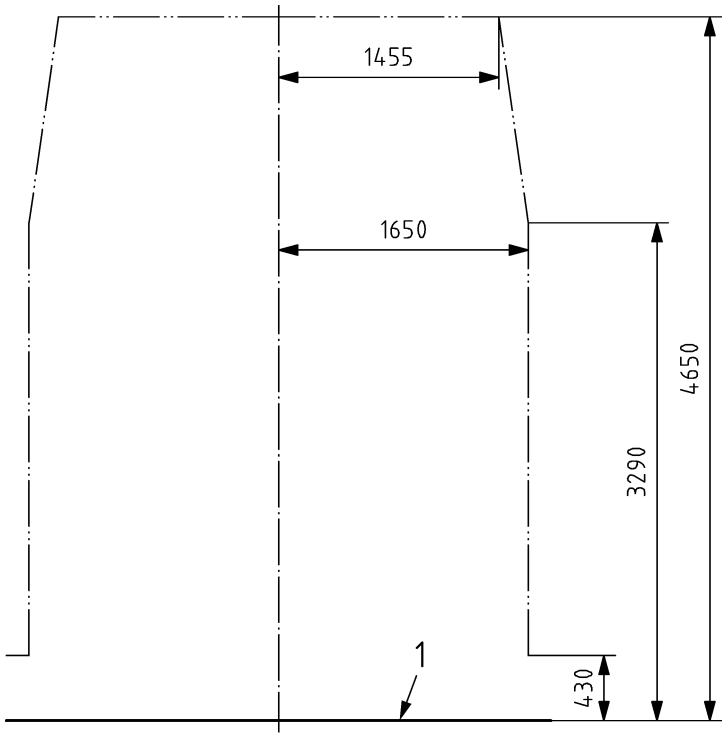
Figure B.19 — Reference profile of the upper parts of static gauge GEB16

B.6.1.4 Static gauge GEC16

The reference profile for the lower parts of static gauge GEC16 is the same as that shown for gauge GHE16.

Figure B.20 shows the reference profile for the upper parts of static gauge GEC16.

Dimensions in millimetres



Key

1 running surface

NOTE Lower parts as per Figure B.17.

Figure B.20 — Reference profile of the upper parts of static gauge GEC16

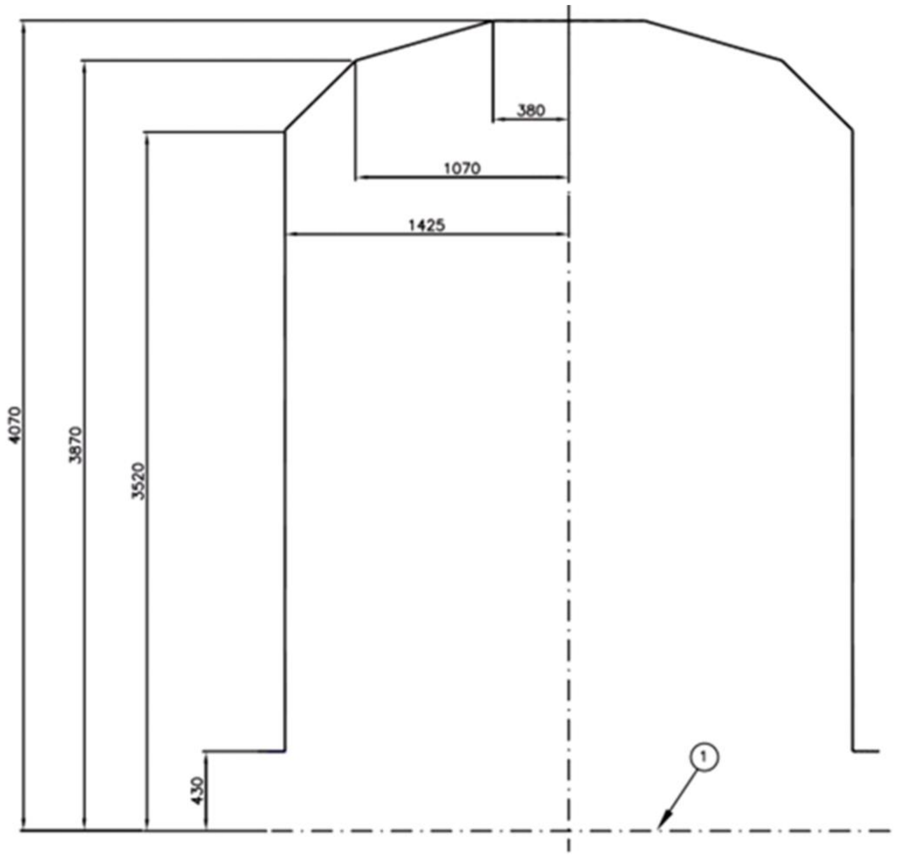
B.6.1.5 Static gauge GEE10

B.6.1.5.1 Static reference profile for the lateral parts and upper parts

Figure B.21 shows the reference profile for static gauge GEE10.

Dimensions in millimetres

A1⟩



⟨A1

Key

1 running surface

NOTE Lower parts as per Figure B.22.

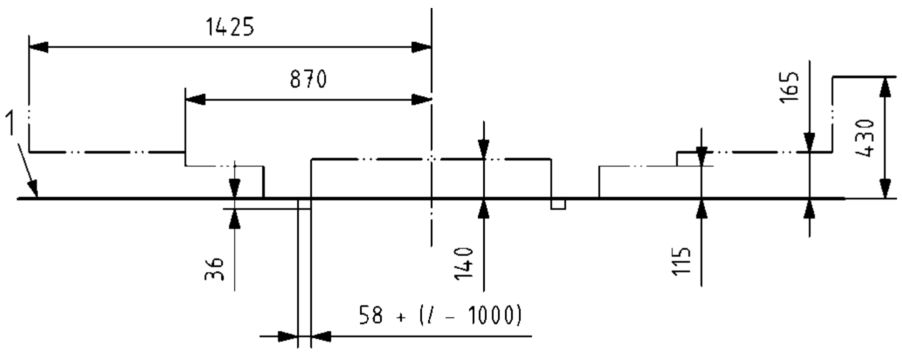
Figure B.21 — Reference profile for static gauge GEE10

B.6.1.5.2 Static reference profile for the lower parts

Figure B.22 shows the reference profile for static gauge GEE10.

Dimensions in millimetres

!A1►



◄A1

Key

1 running surface

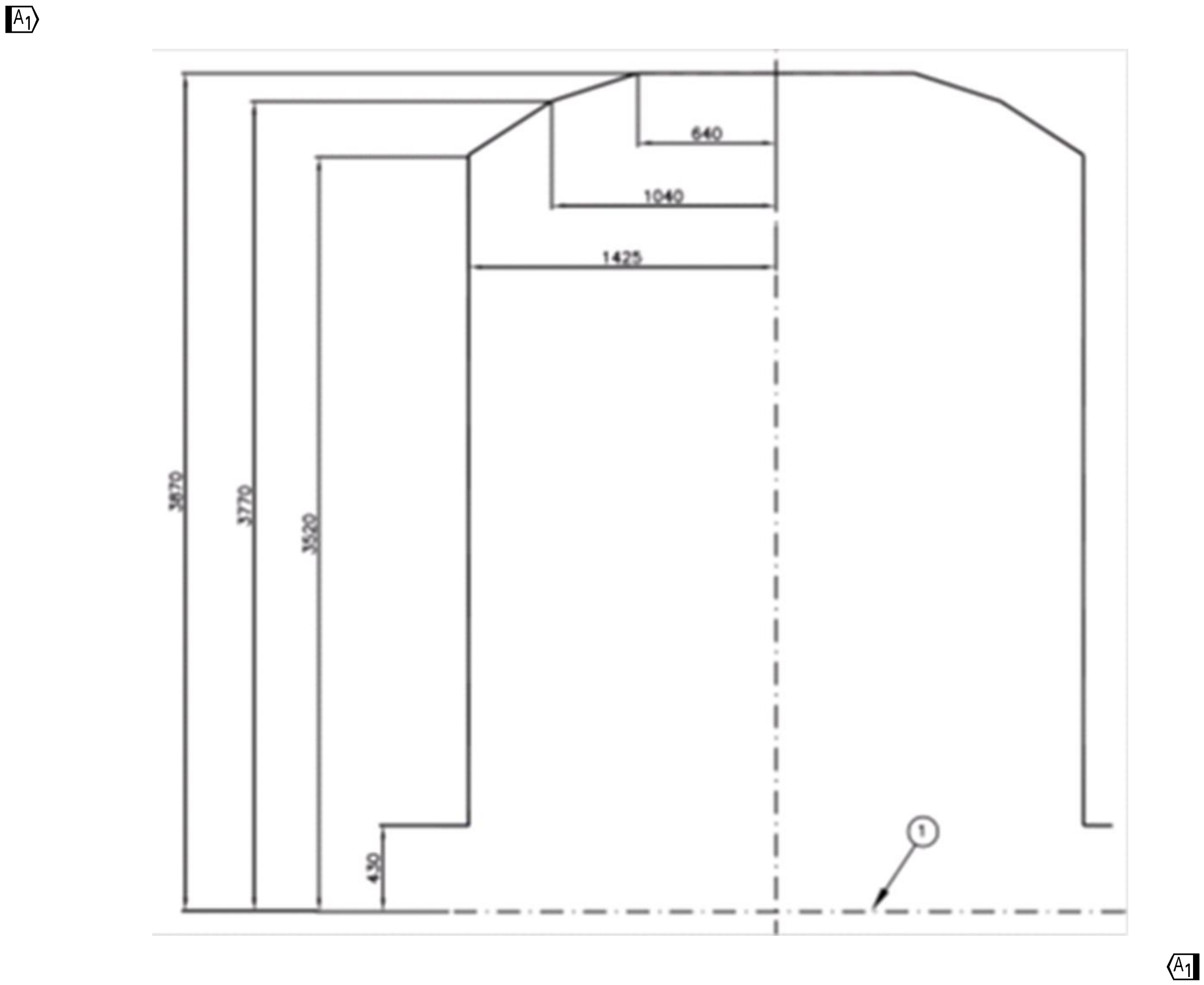
Figure B.22 — Reference profile for the lower parts of static gauge GEE10

B.6.1.6 Static gauge GED10

The reference profile for the lower parts of static gauge GED10 is the same as that shown for gauge GEE10.

Figure B.23 shows the reference profile for the upper parts of static gauge GED10.

Dimensions in millimetres



Key

1 running surface

NOTE Lower parts as per Figure B.22.

Figure B.23 — Reference profile of the upper parts of static gauge GED10

B.6.2 Basic rules

B.6.2.1 Basic data

Table B.13 — Basic data

Gauges	l_{nom} **m**	$l_{\max}$ **m**	L **m**
GHE16, GEA16, GEB16 and GEC16	1,668	1,698	1,733
GEE10 and GED10	1,000	1,030	1,055

B.6.2.2 Additional overthrows

Table B.14 — Additional overthrows

Additional overthrows for track gauge "l" and height "h" compared to the running surface				
Gauges	*Radii*	*h ≤0,43 m*	*h > 0,43 m*	
			0,43 m < h ≤ 3,29 m	*h > 3,29 m*
GHE16 and GEC16	*250 ≤ R < ∞*	$S_{i_{st}} = S_{ast} = \frac{2,5}{R} + \frac{l-1,668}{2}$	$S_{i_{st}} = S_{a_{st}} = \frac{3,75}{R} + \frac{l-1,668}{2} + 0,045$	
	150 ≤ R < 250	$S_{i_{st}} = \frac{50}{R} - 0,19 + \frac{l-1,668}{2}$ $S_{a_{st}} = \frac{60}{R} - 0,23 + \frac{l-1,668}{2}$	$S_{i_{st}} = \frac{50}{R} - 0,140 + \frac{l-1,668}{2}$ $S_{a_{st}} = \frac{60}{R} - 0,180 + \frac{l-1,668}{2}$	
GEA16 and GEB16	*250 ≤ R < ∞*	$S_{i_{st}} = S_{a_{st}} = \frac{2,5}{R} + \frac{l-1,668}{2}$	$S_{i_{st}} = S_{a_{st}} = \frac{3,75}{R} + \frac{l-1,668}{2} + 0,045$	$S_{i_{st}} = S_{a_{st}} = \frac{3,75}{R} + \frac{16,25 \cdot k}{R} + \frac{l-1,668}{2} + 0,045$

Table B.14 *(continued)*

Additional overthrows for track gauge "l" and height "h" compared to the running surface				
Gauges	*Radii*	*h ≤ 0,43 m*	*h > 0,43 m*	
			0,43 m < h ≤ 3,29 m	*h > 3,29 m*
	150 ≤ R < 250	$S_{i_{st}} = \frac{50}{R} - 0{,}19 + \frac{l-1{,}668}{2}$ $S_{a_{st}} = \frac{60}{R} - 0{,}23 + \frac{l-1{,}668}{2}$	$S_{i_{st}} = \frac{50}{R} - 0{,}140 + \frac{l-1{,}668}{2}$ $S_{a_{st}} = \frac{60}{R} - 0{,}180 + \frac{l-1{,}668}{2}$	$S_{i_{st}} = \frac{50}{R} - 0{,}140 + 0{,}065k + \frac{l-1{,}668}{2}$ $S_{a_{st}} = \frac{60}{R} - 0{,}180 + k\left(0{,}105 - \frac{10}{R}\right) + \frac{l-1{,}668}{2}$
GEE10 and GED10	*100 ≤ R < ∞*	$S_{i_{st}} = S_{a_{st}} = \frac{1}{R} + \frac{l-1}{2}$	$S_{i_{st}} = S_{a_{st}} = \frac{1{,}5}{R} + \frac{l-1}{2} + 0{,}045$	
	80 ≤ R < 100	$S_{i_{st}} = \frac{20}{R} - 0{,}19 + \frac{l-1}{2}$ $S_{a_{st}} = \frac{24}{R} - 0{,}23 + \frac{l-1}{2}$	$S_{i_{st}} = \frac{20}{R} - 0{,}140 + \frac{l-1}{2}$ $S_{a_{st}} = \frac{24}{R} - 0{,}180 + \frac{l-1}{2}$	

With the values for k defined in Table B.15:

Table B.15 — Values for k for calculations

Gauges	Height m	*k*
GHE16 and GEC16	For all heights	0
GEA16	$h \leq 3{,}29$	0
	$3{,}29 < h < 3{,}67$	$\frac{h - 3{,}29}{0{,}38}$
	$h \geq 3{,}67$	1
GEB16	$h \leq 3{,}29$	0
	$3{,}29 < h < 4{,}08$	$\frac{h - 3{,}29}{0{,}79}$
	$h \geq 4{,}08$	1
GEE10 and GED10	For all heights	0

NOTE The value $F = 0{,}045$ m is included in the additional overthrow on the outside of the static reference profile for $h \geq 0{,}43$ m.

B.6.2.3 Taking the roll into account

For static gauges, the effects of roll are solely taken into consideration by the infrastructure. The values given in the following table determine the application limits for static gauges, i.e. the values from which kinematic gauging becomes mandatory.

Table B.16 — Values to be considered for static gauges GHE16, GEA16, GEB16 and GEC16, taking into consideration roll

Gauges	z_0 For D_0 or I_0 equal to 0,050 m	Height m	s_{lim}
GHE16	0,025	3,290	0,3
	0,030	3,670	
	0,035	4,070	
	0,040	4,300	
GEA16	0,025	3,290	0,3
	0,030	3,670	
	0,035	4,070	
	0,041	4,320	
GEB16	0,025	3,290	0,3
	0,030	3,670	
	0,035	4,080	
	0,041	4,320	
GEC16	0,025	3,290	0,3
	0,040	4,650	

Table B.17 — Values to be considered for static gauges GEE10 and GED10, taking into consideration roll

Gauge	z_0 For D_0 or I_0 equal to 0,070 m	Height m	s_{lim}
GEE10	0,053	3,170	0,3
	0,065	3,770	
	0,071	4,070	
GED10	0,053	3,170	0,3
	0,061	3,570	
	0,067	3,870	

B.6.2.4 Vertical geometric overthrow upwards and vertical allowance of the infrastructure

For gauges GHE16, GEA16, GEB16, GEE10 and GED10, 0,030 m shall be added to the height of the upper part of the reference profile to take into account the dynamic uplift of the suspension and the vertical oscillations of the vehicles during operation.

For gauges GEC16, 0,050 m shall be added to the height of the upper part to take into account the dynamic uplift of the suspension and the vertical oscillations of the vehicles during operation.

The conventional values to be considered with regard to the vertical geometric overthrow are given in Annex F.

Annex C
(normative)

Reference profiles and associated rules for kinematic gauges

General comment as a practical measure to facilitate the reading of the standard

— the dimensions of the reference profiles are given in mm;

— the values to be used in the formulae are given in m, unless otherwise indicated.

C.1 Kinematic gauges G1 and G2

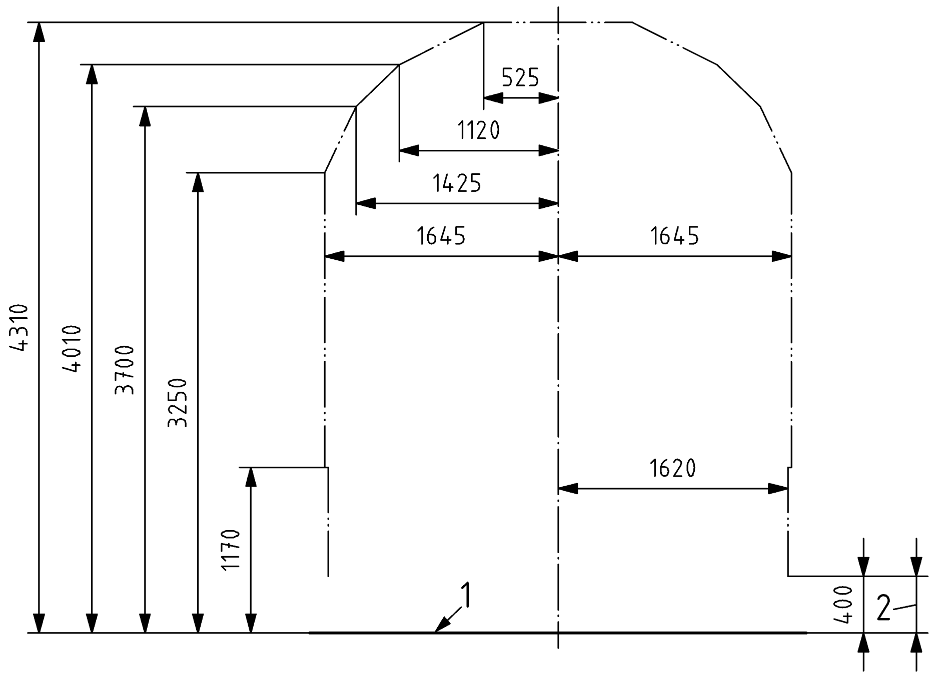
C.1.1 Upper part of gauges G1 and G2

The reference profiles and rules for kinematic gauges G1, G2 are applicable above 0,4 m.

C.1.1.1 Kinematic reference profiles

Figure C.1 shows the reference profile of kinematic gauge G1.

Dimensions in millimetres



Key

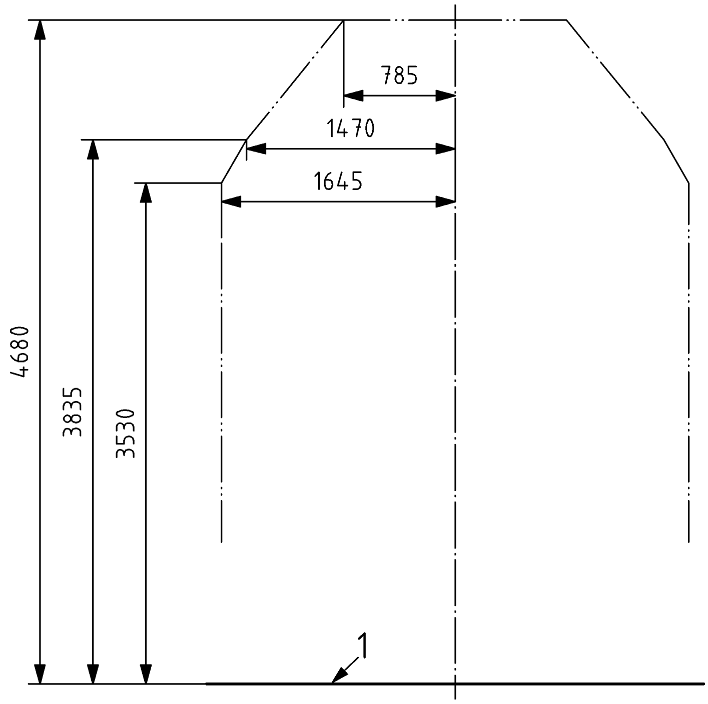
1 running surface

2 lower parts according to Figure C.3, Figure C.4 or Figure C .8

Figure C.1 — Reference profile of kinematic gauge G1

Figure C.2 shows the reference profile of kinematic gauge G2.

Dimensions in millimetres



Key

1 running surface

NOTE Lower parts according to Figure C.3, Figure C.4 or Figure C.8.

Figure C.2 — Reference profile of kinematic gauge G2

C.1.1.2 Associated rules

C.1.1.2.1 Basic data

— l_{nom} 1,435 m;

— $l_{\max}$ 1,465 m;

— L 1,5 m.

C.1.1.2.2 Additional overthrows

Table C.1 — Additional overthrows for gauges G1 and G2

Radius R	Inside curve	Outside curve
$\infty \geq R \geq 250$	$S_{i_{cin}} = S_{a_{cin}} = \frac{3,75}{R} + \frac{\lambda - 1,435}{2}$ (C.1)	
$250 > R \geq 150$	$S_{i_{cin}} = \frac{50}{R} - 0,185 + \frac{\lambda - 1,435}{2}$ (C.2)	$S_{a_{cin}} = \frac{60}{R} - 0,225 + \frac{\lambda - 1,435}{2}$ (C.3)

NOTE The value [A1⟩ F ⟨A1] is included in the semi-width of the kinematic reference profile.

C.1.1.3 Vertical geometric overthrow upwards and vertical allowance of the infrastructure

The conventional values to be considered with regard to the vertical geometric overthrow are given in Annex F.

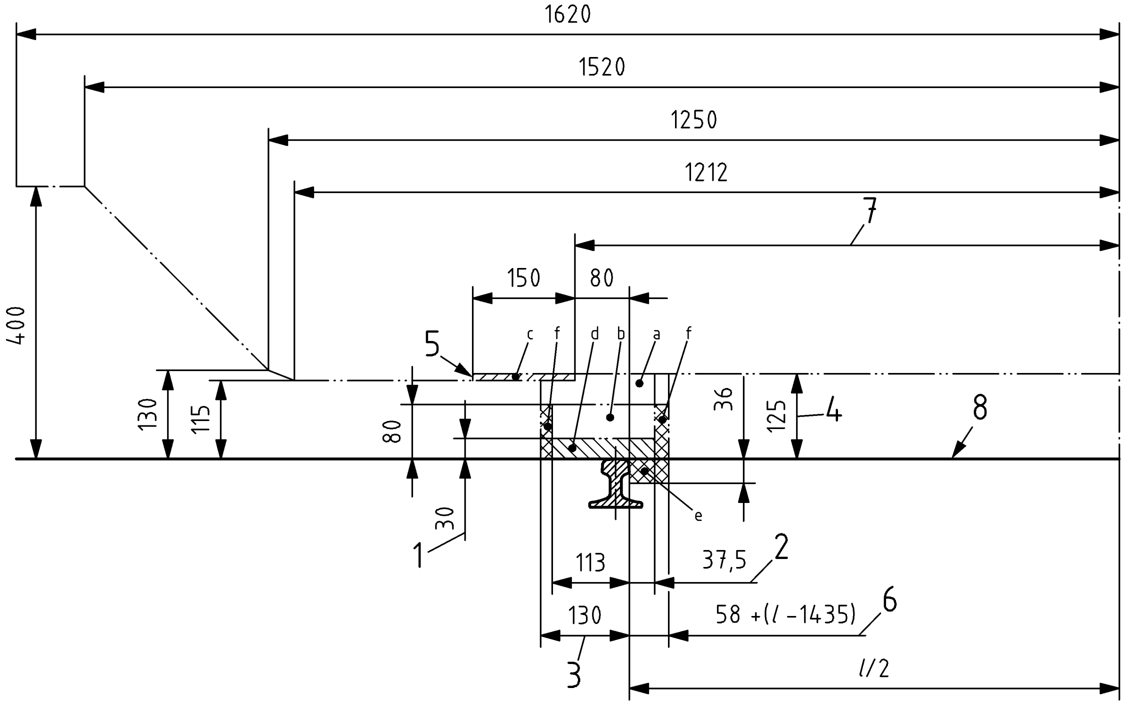
C.1.2 Gauges of the lower parts of GI1, GI2

C.1.2.1 Kinematic reference profiles

C.1.2.1.1 Kinematic reference profile for the lower parts corresponding to the lower limit of the vehicles passing over marshalling humps and rail brakes and other shunting or stopping devices

Figure C.3 shows the reference profile for the lower parts of kinematic gauge GI1.

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, not to be exceeded, of the parts located outside the end wheelsets (guard-irons, sanders, etc.) for passing over detonators

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 a 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 projection of standardized retarders

8 running surface

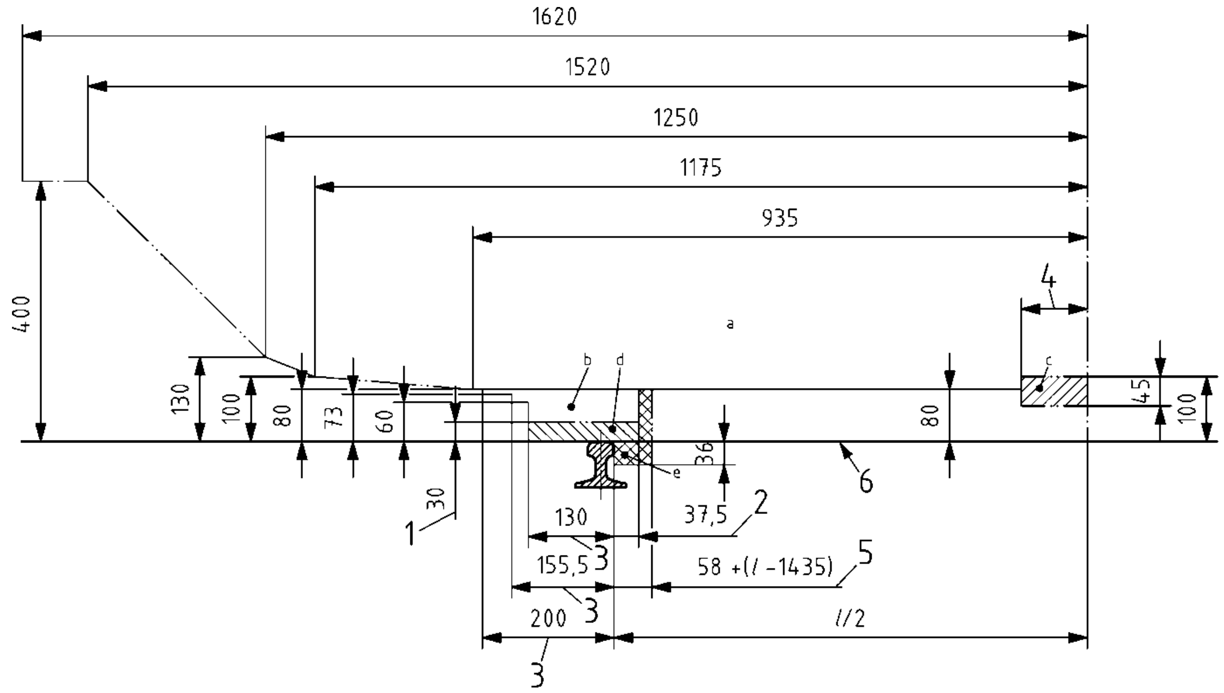
Figure C.3 — Reference profile for the lower parts of kinematic gauge GI1

C.1.2.1.2 Kinematic reference profile for the lower parts corresponding to the lower limit of vehicles not passing over either marshalling humps or rail brakes in an active position

Figure C.4 shows the reference profile for the lower parts of kinematic gauge GI2.

Dimensions in millimetres

A1



26.2

A1

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 not to be exceeded, of parts located outside the end wheelsets (guard-irons, sanders etc.) for passing over detonators. However, this limit need not be adhered to by parts located between the wheels as long as these latter remain within the path of the wheel

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 m, no part of the vehicle likely to descend to less than 0,100 m from the running surface, except for the contact brush, shall be less than 0,125 m from the track centre line (see 7.3.3.3 - Figure 39). For bodies mounted between 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 C.4 — Reference profile for the lower parts of kinematic gauge GI2

C.1.2.2 Associated rules

C.1.2.2.1 Basic data

— l_{nom} 1,435 m;

— $l_{\max}$ 1,465 m;

— L 1,5 m.

C.1.2.2.2 Additional overthrows

Table C.2 — Additional overthrows for gauges GI1 and GI2

Radius R	S_i (inside of the curve)	S_a (outside of the curve)
$\infty \geq R \geq 250$	$S_{i\,cin} = \frac{2,5}{R} + \frac{\lambda - 1,435}{2}$ (C.4)	$S_{a\,cin} = \frac{2,5}{R} + \frac{\lambda - 1,435}{2}$ (C.6)
$250 > R \geq 150$	$S_{i\,cin} = \frac{50}{R} - 0,190 + \frac{\lambda - 1,435}{2}$ (C.5)	$S_{a\,cin} = \frac{60}{R} - 0,230 + \frac{\lambda - 1,435}{2}$ (C.7)

NOTE The value F = 0 m for the lower parts of the kinematic reference profile.

A1⟩

C.1.3 ⟨A1 Taking the roll into account

Table C.3 lists the values that take the roll into account.

Table C.3 — Values to be taken into account for the roll

L m	D_0 m	I_0 m	h_{c0} m	s_0	η_{0r}	$D_{\max}$ m	$I_{\max}$ m	I_c m
1,5	0,050	0,050	0,5	0,4	1°	0,200	0,200	0,180

A1⟩

C.1.4 ⟨A1 Vertical geometric overthrow downwards and vertical allowance of the infrastructure

The conventional values to be considered with regard to the vertical geometric overthrow are given in Annex F.

C.2 Kinematic gauges GA, GB, and GC

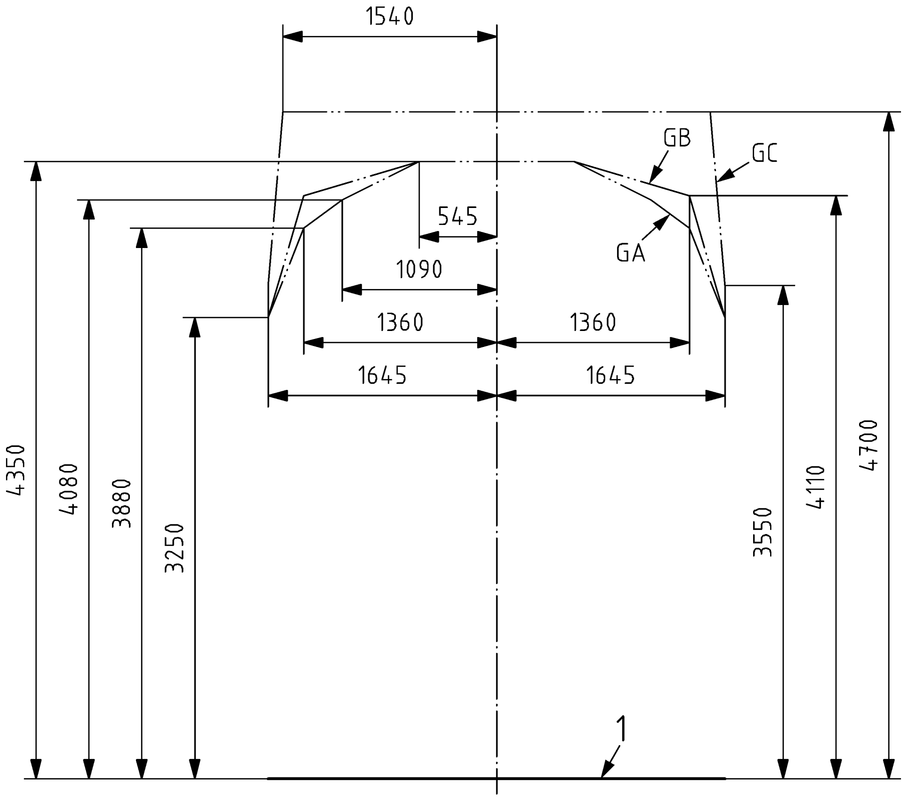
C.2.1 Lateral part

The reference profile and the rules for kinematic gauge G1 are applicable below 3,250 m.

C.2.2 Kinematic reference profiles for the upper parts

Figure C.5 shows the reference profiles for kinematic gauges GA, GB and GC.

Dimensions in millimetres



Key

1 running surface

NOTE Lower parts according to Figure C.3, Figure C.4 or Figure C.8.

Figure C.5 — Reference profile for kinematic gauges GA, GB and GC

C.2.3 Associated rules

C.2.3.1 Basic data

27 l_{nom} 1,435 m;

28 $l_{\max}$ 1,465 m;

29 L 1,5 m.

C.2.3.2 Additional overthrows

The additional overthrows for kinematic gauges GA, GB and GC are given in Table C.4. An illustration of the linear extrapolation of the latter compared to the additional overthrows for kinematic gauge G1 for $h \geq 3{,}22$ m is shown in the image in Figure B.6 (Annex B).

Table C.4 — Additional overthrows for gauges GA, GB, and GC

Gauge	$\infty \geq R \geq 250$ m	$250 > R \geq 150$ m
GA $3{,}25 \leq h \leq 3{,}88$ *and GB* $3{,}25 \leq h \leq 4{,}11$	$S_{i_{cin}} = S_{a_{cin}} = \frac{3{,}75}{R} + \frac{l - 1{,}435}{2} + k\Delta b_{(i/a)}$ (C.8)	$S_{i_{cin}} = \frac{50}{R} - 0{,}185 + \frac{l - 1{,}435}{2} + k\Delta b_i$ (C.9) $S_{a_{cin}} = \frac{60}{R} - 0{,}225 + \frac{l - 1{,}435}{2} + k\Delta b_a$ (C.10)
GA $h \geq 3{,}88$ *and GB* $h \geq 4{,}11$	$S_{i_{cin}} = S_{a_{cin}} = \frac{20}{R} + \frac{l - 1{,}435}{2}$ (C.11)	$S_{i_{cin}} = S_{a_{cin}} = \frac{50}{R} - 0{,}120 + \frac{l - 1{,}435}{2}$ (C.12)
GC	$S_{i_{cin}} = S_{a_{cin}} = \frac{3{,}75}{R} + \frac{l - 1{,}435}{2}$ (C.13)	$S_{i_{cin}} = \frac{50}{R} - 0{,}185 + \frac{l - 1{,}435}{2}$ (C.14) $S_{a_{cin}} = \frac{60}{R} - 0{,}225 + \frac{l - 1{,}435}{2}$ (C.15)

With the following values:

Table C.5 — Coefficient *k* relative to height

	Gauge GA		Gauge GB	
Height m	$3{,}25 < h < 3{,}88$	$h \geq 3{,}88$	$3{,}25 < h < 4{,}11$	$h \geq 4{,}11$
k	$k = \frac{h - 3{,}25}{0{,}63}$ (C.16)	$k = 1$	$k = \frac{h - 3{,}25}{0{,}86}$ (C.17)	$k = 1$

NOTE The value [A1⟩ F ⟨A1] is included in the semi-width of the kinematic reference profile.

C.2.3.3 Taking the roll into account

Table C.6 — Values to be taken into account for the roll

	Height m	L m	D_0 m	I_0 m	h_{c0} m	s_0	η_{0r}	D_{max} m	I_{max} m
GA	$h \leq 3{,}25$	1,5	0,050	0,050	0,5	0,4	1°	0,200	0,200
	$3{,}25 < h < 3{,}88$	1,5	0,050	0,050	0,5	0,4 - 0,1 k	1°	0,200	0,200
	$h \geq 3{,}88$	1,5	0,050	0,050	0,5	0,3	1°	0,200	0,200
GB	$h \leq 3{,}25$	1,5	0,050	0,050	0,5	0,4	1°	0,200	0,200
	$3{,}25 < h < 4{,}11$	1,5	0,050	0,050	0,5	0,4 - 0,1 k	1°	0,200	0,200
	$h \geq 4{,}11$	1,5	0,050	0,050	0,5	0,3	1°	0,200	0,200
GC		1,5	0,050	0,050	0,5	0,4	1°	0,200	0,200

C.2.3.4 Vertical geometric overthrow upwards and vertical allowance of the infrastructure

The conventional values to be considered with regard to the vertical geometric overthrow are given in Annex F.

[A1) For the upper part of the gauge GC (or analogues BE4, GB2, etc.) the vertical component of the quasi-static displacement shall be taken into consideration by the rolling stock. (A1]

C.3 Kinematic gauges GB1 and GB2

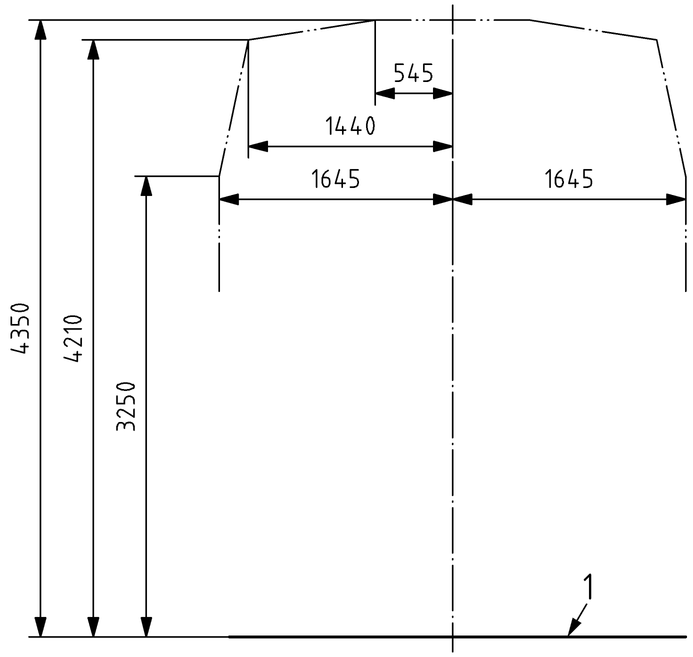
C.3.1 Lateral part

The reference profile and the rules for kinematic gauge G1 are applicable below 3,250 m.

C.3.2 Kinematic reference profiles for the upper parts

Figure C.6 shows the reference profile of kinematic gauge GB1.

Dimensions in millimetres



Key

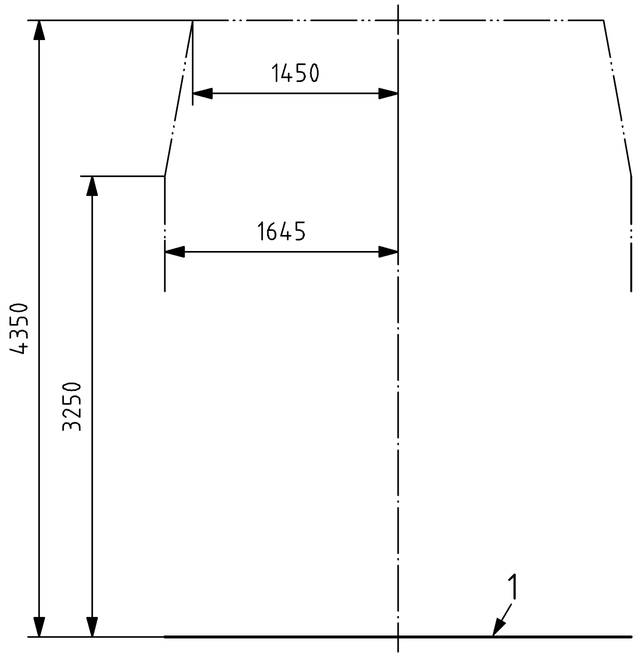
1 running surface

NOTE Lower parts according to Figure C.3, Figure C.4 or Figure C.8.

Figure C.6 — Reference profile of kinematic gauge GB1

Figure C.7 shows the reference profile of kinematic gauge GB2.

Dimensions in millimetres



Key

1 running surface

NOTE Lower parts according to Figure C.3, Figure C.4 or Figure C.8.

Figure C.7 — Reference profile of kinematic gauge GB2

C.3.3 Associated rules

C.3.3.1 Basic data

—	l_{nom}	1,435 m ;
—	$l_{\max}$	1,465 m ;
—	L	1,5 m.

C.3.3.2 Additional overthrows

Table C.7 — Additional overthrows for gauges GB1 and GB2

	$\infty \geq R \geq 250$ m	$250 > R \geq 150$ m
GB1 $3{,}25 \leq h \leq 4{,}21$ and GB2 $3{,}25 \leq h \leq 4{,}35$	$S_{i_{cin}} = S_{a_{cin}} = \frac{3{,}75}{R} + \frac{l - 1{,}435}{2} + k\Delta b_{(i/a)}$ (C.18)	$S_{i_{cin}} = \frac{50}{R} - 0{,}185 + \frac{l - 1{,}435}{2} + k\Delta b_i$ (C.19)
GB1 $h \geq 4{,}21$	$S_{i_{st}} = S_{a_{st}} = \frac{20}{R} + \frac{l - 1{,}435}{2}$ (C.20)	$S_{i_{st}} = S_{a_{st}} = \frac{50}{R} - 0{,}120 + \frac{l - 1{,}435}{2}$ (C.21)

With the following values:

Table C.8 — Coefficient *k* relative to height

GB1		GB2
$3{,}25 < h < 4{,}21$	$h \geq 4{,}21$	$3{,}25 < h < 4{,}35$
$k = \frac{h - 3{,}25}{0{,}96}$ (C.22)	$k = 1$	$k = \frac{h - 3{,}25}{1{,}1}$ (C.23)

NOTE The value [A1⟩ F ⟨A1] is included in the semi-width of the kinematic reference profile.

C.3.3.3 Taking the roll into account

Table C.9 — Values to be taken into account for the roll

	Height	L m	D_0 m	I_0 m	h_{c0} m	s_0	η_{0r}	I_{max} m
GB1	$h \leq 3{,}25$	1,5	0,050	0,050	0,5	0,4	1°	0,200
	$3{,}25 < h < 4{,}21$	1,5	0,050	0,050	0,5	0,4 - 0,1 k	1°	0,200
	$h \geq 4{,}21$	1,5	0,050	0,050	0,5	0,3	1°	0,200
GB2	$h \leq 3{,}25$	1,5	0,050	0,050	0,5	0,4	1°	0,200
	$3{,}25 < h < 4{,}32$	1,5	0,050	0,050	0,5	0,4 - 0,1 k	1°	0,200

C.3.3.4 Vertical geometric overthrow upwards and vertical allowance of the infrastructure

The conventional values to be considered with regard to the vertical geometric overthrow are given in Annex F.

C.4 Kinematic gauge GI3

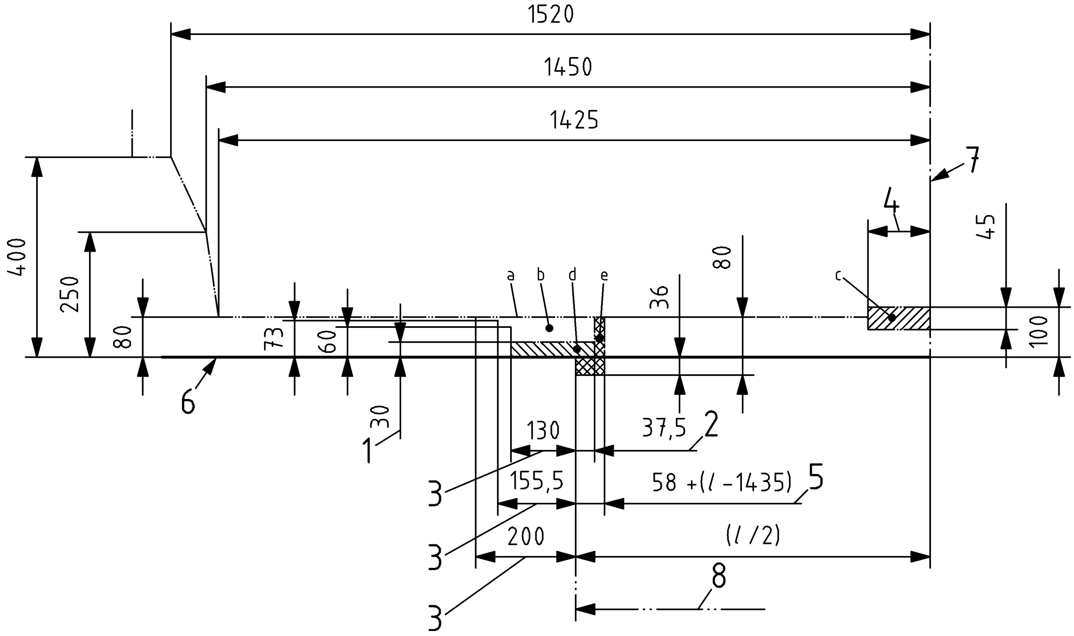
C.4.1 Upper parts

Kinematic gauges G1, G2, GA, GB, GC, GB1 and GB2 are applicable above 0,4 m.

C.4.2 Reference profile for the lower parts

Figure C.8 shows the reference profile for the lower parts of kinematic gauge GI3.

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 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, not to be exceeded, of parts located outside the end wheelsets (guard-irons, sanders, etc.) for passing over detonators. However, this limit need not be adhered to by parts located between the wheels as long as these latter remain within the path of the wheels

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 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 m, 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 in 7.3.3.3 - Figure 39). For bodies mounted between 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

7 centreline of the reference profile

8 internal rail surface

Figure C.8 — Reference profile for the lower parts of kinematic gauge GI3

C.4.3 Associated rules

C.4.3.1 Basic data

30 l_{nom} 1,435 m;

31 $l_{\max}$ 1,465 m;

32 L 1,5 m.

C.4.3.2 Additional overthrows

Table C.10 — Additional overthrows for kinematic gauge GI3

Height	$\infty \geq R \geq 250$ m	$250 > R \geq 150$ m
h = 0,400 m	$S_{i_{cin}} = S_{a_{cin}} = \frac{2,5}{R} + \frac{l - 1,435}{2}$ (C.24)	$S_{i_{cin}} = \frac{50}{R} - 0,190 + \frac{l - 1,435}{2}$ (C.25)
		$S_{a_{cin}} = \frac{60}{R} - 0,230 + \frac{l - 1,435}{2}$ (C.26)
0,400 < h < 0,250	Point h = 0,400 and point h = 0,250 are connected by a straight line	
$h \leq$ 0,250 m	$S_{i_{cin}} = \frac{2,5}{R} + \frac{l - 1,435}{2}$ (C.27)	$S_{i_{cin}} = \frac{37,5}{R} - 0,140 + \frac{l - 1,435}{2}$ (C.28)
	$S_{a_{cin}} = \frac{l - 1,435}{2}$ (C.29)	$S_{a_{cin}} = \frac{40}{R} - 0,160 + \frac{l - 1,435}{2}$ (C.30)

NOTE The value F = 0 m for the lower parts of the kinematic reference profile.

C.4.3.3 Vertical geometric overthrow downwards and vertical allowance of the infrastructure

The conventional values to be considered with regard to the vertical geometric overthrow are given in Annex F.

C.5 Kinematic gauge FR3.3

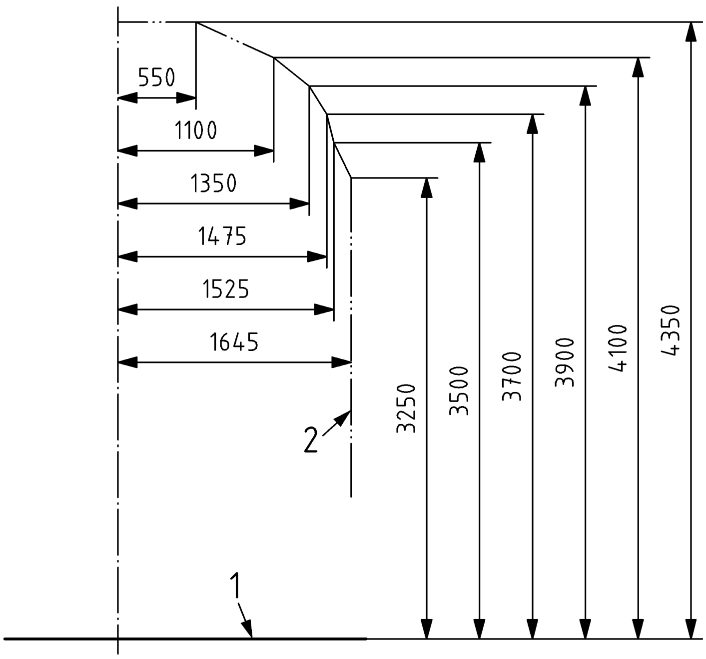
C.5.1 Lateral part

The reference profile and the rules for kinematic gauge G1 are applicable below 3,250 m.

C.5.2 Kinematic reference profile for upper parts

Figure C.9 shows the reference profile of kinematic gauge FR3.3.

Dimensions in millimetres



Key

1 running surface

2 reference profile

NOTE Lower parts according to Figure C.3, Figure C.4 or Figure C.8.

Figure C.9 — Reference profile of kinematic gauge FR3.3

C.5.3 Associated rules

C.5.3.1 Basic data

— l_{nom} 1,435 m ;

— $l_{\max}$ 1,465 m ;

— L 1,5 m.

C.5.3.2 Additional overthrows

Table C.11 — Additional overthrows of kinematic gauge FR3.3

Height	$\infty \geq R \geq 250$ m	$250 > R \geq 150$ m
$h > 3{,}5$	$S_{i_{cin}} = S_{a_{cin}} = \frac{37{,}5}{R} + \frac{l - 1{,}435}{2}$ (C.31)	$S_{i_{cin}} = S_{a_{cin}} = \frac{37{,}5}{R} + \frac{l - 1{,}435}{2}$ (C.32)
$3{,}25 \leq h \leq 3{,}5$	Linear connection between h = 3,25 and h = 3,5 m	Linear connection between h = 3,25 and h = 3,5 m
$h < 3{,}25$	$S_{i_{cin}} = S_{a_{cin}} = \frac{3{,}75}{R} + \frac{l - 1{,}435}{2}$ (C.33)	$S_{i_{cin}} = \frac{50}{R} - 0{,}185 + \frac{l - 1{,}435}{2}$ (C.34) $S_{a_{cin}} = \frac{60}{R} - 0{,}225 + \frac{l - 1{,}435}{2}$ (C.35)

NOTE The value [A1⟩ F ⟨A1] is included in the semi-width of the kinematic reference profile.

C.5.3.3 Taking the roll into account

Table C.12 — Values to be taken into account for the roll

Height	L m	D_0 m	I_0 m	h_{c0} m	s_0	η_{0r}	D_{max} m	I_{max} m
$h \leq 3{,}25$	1,5	0,050	0,050	0,5	0,4	1°	0,200	0,200
3,25 < h < 3,5	1,5	0,050	0,050	0,5	Linear connection	1°	0,200	0,200
$h \geq 3{,}5$	1,5	0,050	0,050	0,5	0,3	1°	0,200	0,200

C.5.3.4 Vertical geometric overthrow upwards and vertical allowance of the infrastructure

The conventional values to be considered with regard to the vertical geometric overthrow are given in Annex F.

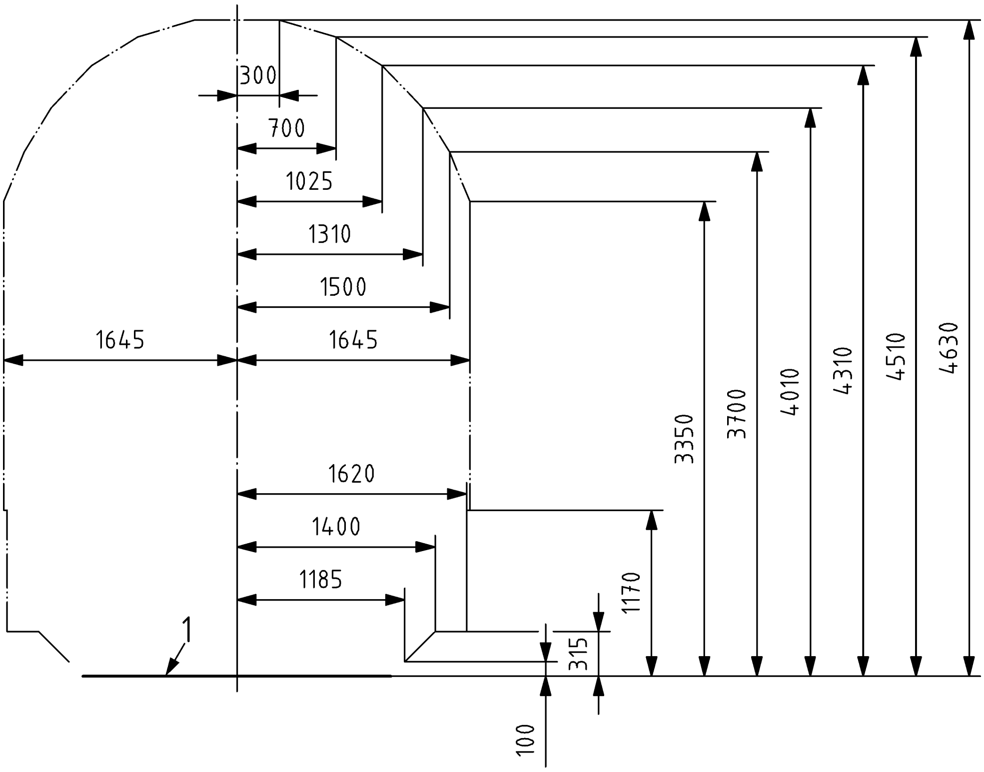
C.6 Kinematic gauges BE1, BE2 and BE3

C.6.1 Lateral part

C.6.2 Kinematic reference profiles for the upper parts

Figure C.10 shows the reference profile for gauge BE1.

Dimensions in millimetres



Key

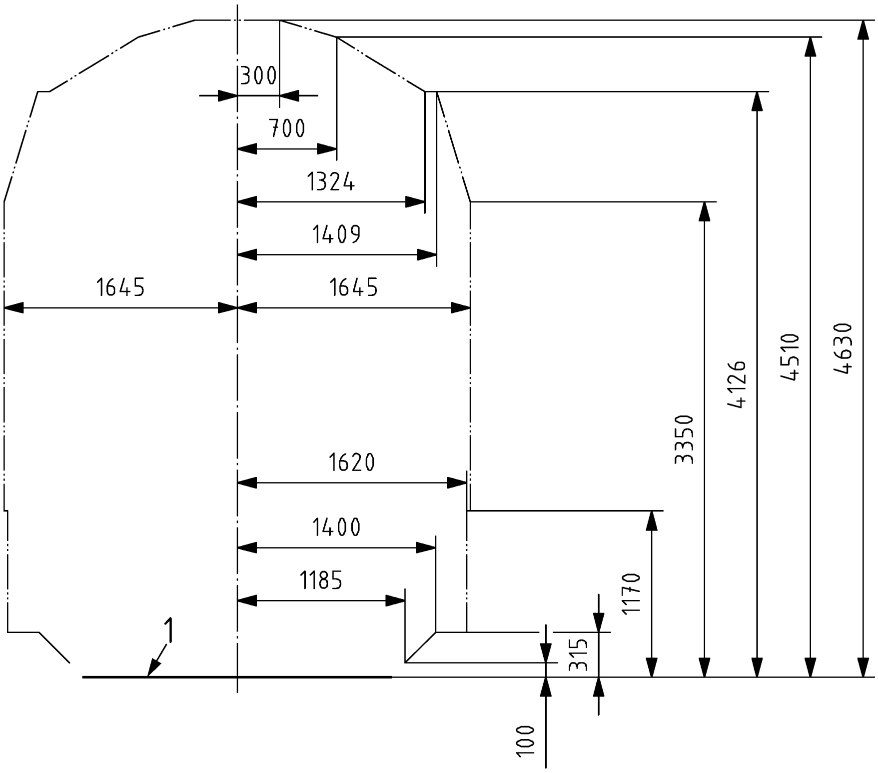
1 running surface

NOTE For the lower parts, the lower horizontal of the profile is extended as shown in Figure C.4.

Figure C.10 — Reference profile of gauge BE1

Figure C.11 shows the reference profile of gauge BE2.

Dimensions in millimetres



Key

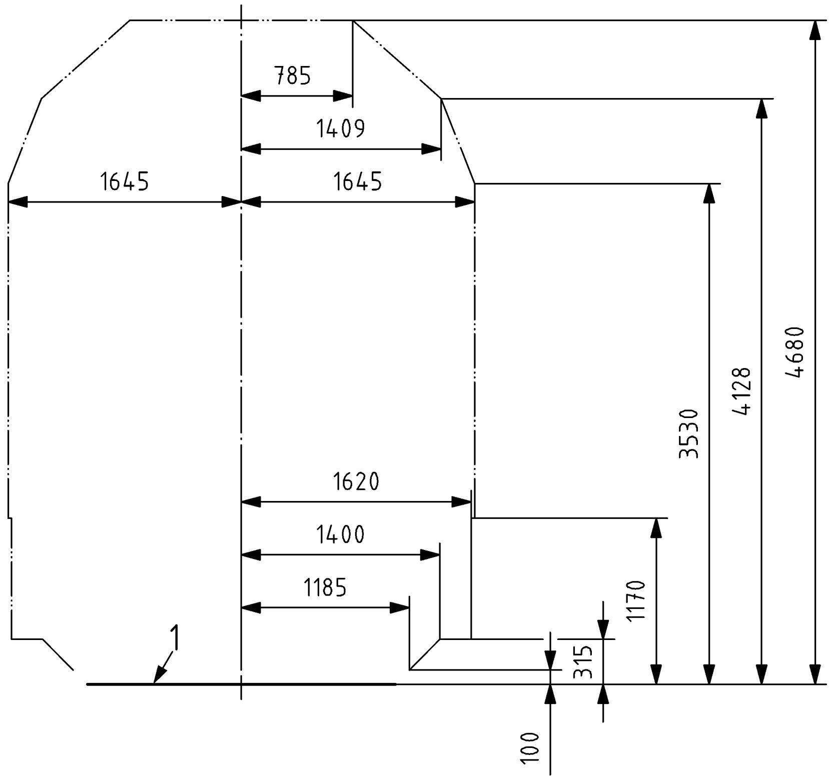
1 running surface

NOTE For the lower parts, the lower horizontal of the profile is extended as shown in Figure C.4.

Figure C.11 — Reference profile of gauge BE2

Figure C.12 shows the reference profile of gauge BE3.

Dimensions in millimetres



Key

1 running surface

NOTE For the lower parts, the lower horizontal of the profile is extended as shown in Figure C.4.

Figure C.12 — Reference profile of gauge BE3

C.6.3 Associated rules

C.6.3.1 Basic data

33 l_{nom} 1,435 m;

34 $l_{\max}$ 1,465 m;

35 L 1,5 m.

C.6.3.2 Additional overthrows

Table C.13 — Additional overthrows for *h* > 1,170 m

<table>
<tr><th>Additional overthrows</th><th>$150 \le R < 162{,}5$
m</th><th>$162{,}5 \le R < 250$
m</th><th>$250 \le R < 400$
m</th><th>$400 \le R < \infty$
m</th></tr>
<tr><td>$S_{i_{cin}}$</td><td>$\frac{40{,}5}{R} - 0{,}105 + \frac{l - 1{,}435}{2}$ (C.36)</td><td rowspan="2">$\frac{40{,}5}{R} - 0{,}105 + \frac{l - 1{,}435}{2}$
(C.37)</td><td rowspan="2">$\frac{28}{R} - 0{,}055 + \frac{l - 1{,}435}{2}$
(C.38)</td><td rowspan="2">$\frac{6}{R} + \frac{l - 1{,}435}{2}$
(C.39)</td></tr>
<tr><td>$S_{a_{cin}}$</td><td>$\frac{60}{R} - 0{,}225 + \frac{l - 1{,}435}{2}$ (C.40)</td></tr>
</table>

NOTE The value [A1⟩ F ⟨A1] is included in the semi-width of the kinematic reference profile.

Table C.14 — Additional overthrows for *h* ≤ 1,170 m

<table>
<tr><th>Additional overthrows</th><th>$165 > R \ge 150$
m</th><th>$1000 > R \ge 165$
m</th><th>$\infty \ge R \ge 1000$
m</th></tr>
<tr><td>$S_{i_{cin}}$</td><td>$\frac{26{,}47}{R} - 0{,}0215 + \frac{l - 1{,}435}{2}$
(C.41)</td><td rowspan="2">$\frac{26{,}47}{R} - 0{,}0215 + \frac{l - 1{,}435}{2}$
(C.42)</td><td rowspan="2">$\frac{5}{R} + \frac{l - 1{,}435}{2}$
(C.43)</td></tr>
<tr><td>$S_{a_{cin}}$</td><td>$\frac{60}{R} - 0{,}225 + \frac{l - 1{,}435}{2}$
(C.44)</td></tr>
</table>

NOTE The value F = 0 m for the lower parts of the kinematic reference profile.

C.6.3.3 Taking the roll into account

Table C.15 lists the values that take the roll into account.

Table C.15 — Values to be taken into account for the roll

L m	D_0 m	I_0 m	h_{c0} m	s_0	η_{0r}	D_{max} m	I_{max} m
1,5	0,050	0,050	0,5	0,4	1°	0,200	0,200

C.6.3.4 Vertical geometric overthrow upwards and vertical allowance of the infrastructure

The conventional values to be considered with regard to the vertical geometric overthrow are given in Annex F.

C.6.4 Kinematic reference profiles for the lower parts

The rules relating to the lower parts of gauge G1 are applicable.

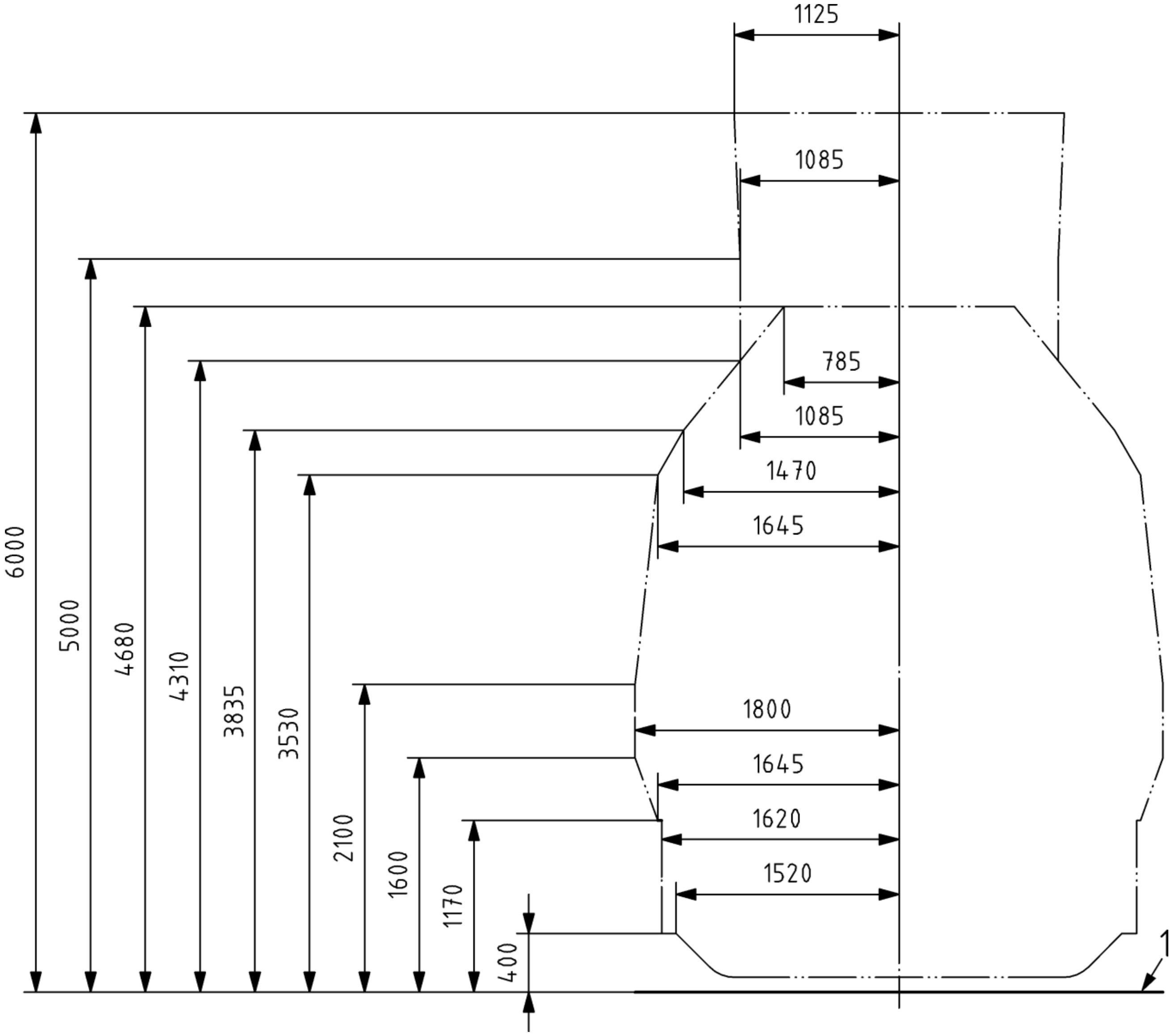
For heights less than 0,400 m, according to the radius, gauge G1 can be wider and, in this case, gauge G1 is used.

C.7 Kinematic gauges NL1 and NL2

C.7.1 Reference profiles of kinematic gauges NL1 and NL2

Figure C.13 shows the reference profile of kinematic gauge NL1.

Dimensions in millimetres



Key

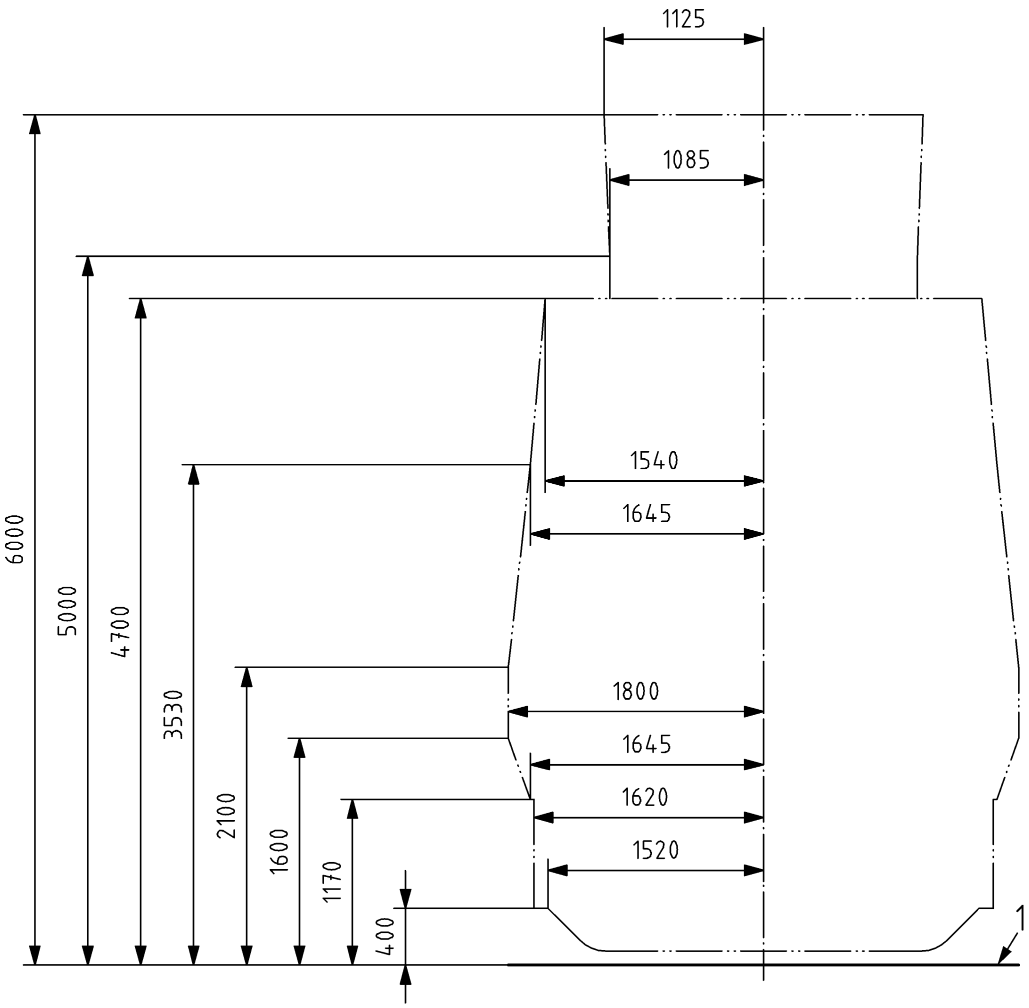
1 running surface

NOTE Lower parts according to Figure C.3 or Figure C.4.

Figure C.13 — Reference profile of kinematic gauge NL1

Figure C.14 shows the reference profile of kinematic gauge NL2.

Dimensions in millimetres



Key

1 running surface

NOTE Lower parts according to Figure C.3 or Figure C.4.

Figure C.14 — Reference profile of kinematic gauge NL2

C.7.2 Associated rules

The associated rules are identical to those of kinematic gauge G1, except for value l_{max} which may be reduced to 1,450 m.

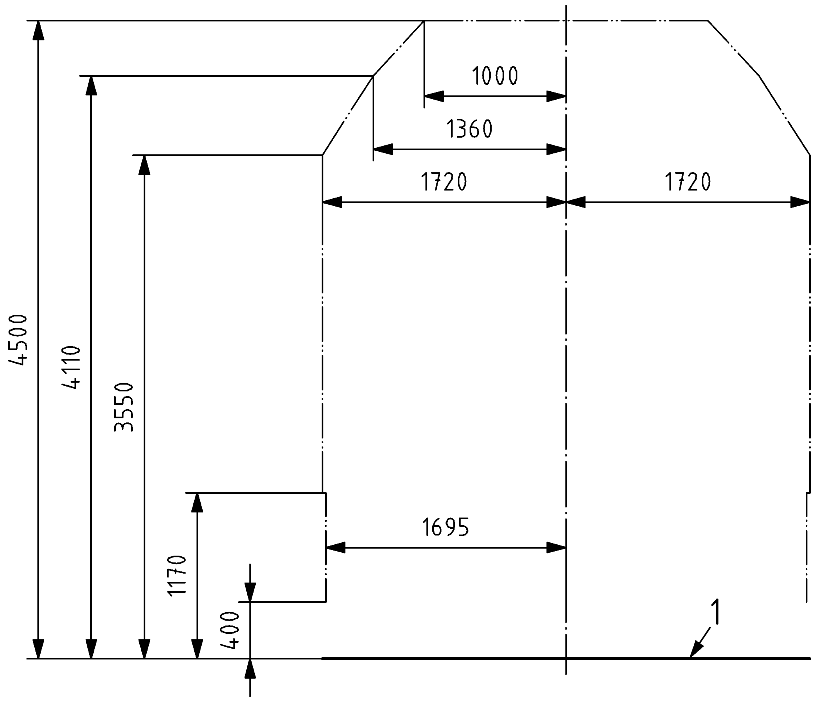
C.8 Kinematic gauges PTb, PTb+ and PTc

C.8.1 Lateral part

C.8.1.1 Kinematic reference profiles for the upper parts

Figure C.15 shows the reference profile of kinematic gauge PTb.

Dimensions in millimetres



Key

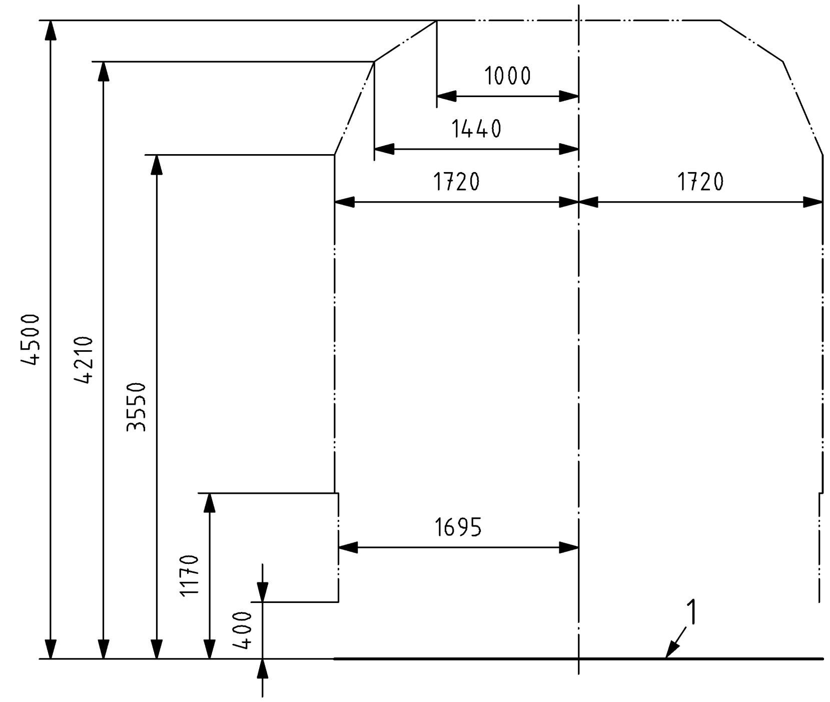
1 running surface

NOTE Lower parts according to Figure C.18 or Figure C.19.

Figure C.15 — Reference profile of kinematic gauge PTb

Figure C.16 shows kinematic profile of gauge PTb+.

Dimensions in millimetres



Key

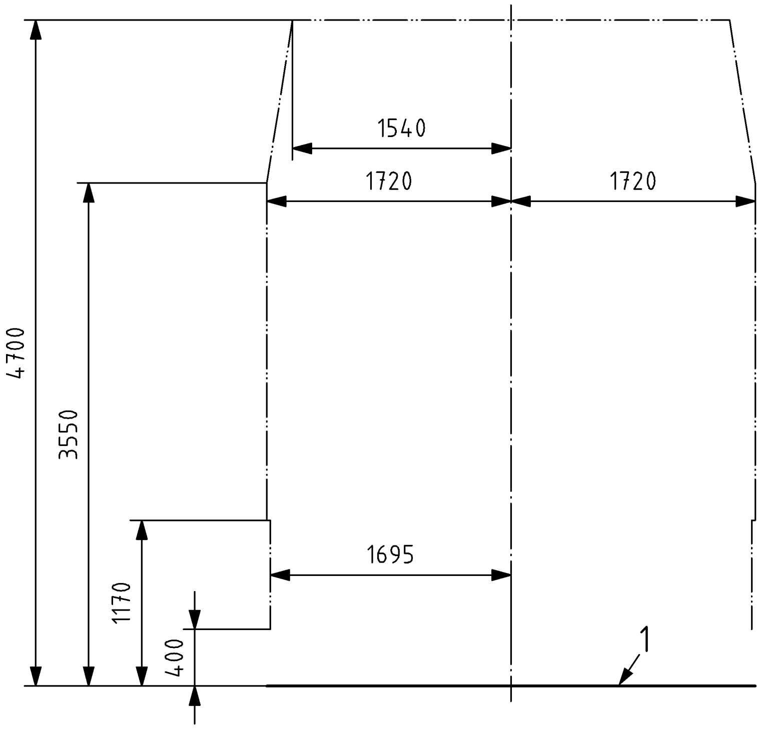
1 running surface

NOTE Lower parts according to Figure C.18 or Figure C.19.

Figure C.16 — Kinematic profile of gauge PTb+

Figure C.17 shows the reference profile of gauge PTc.

Dimensions in millimetres



Key

1 running surface

NOTE Lower parts according to Figure C.18 or Figure C.19.

Figure C.17 — Reference profile of gauge PTc

C.8.2 Associated rules

C.8.2.1 Basic data

— l_{nom} 1,668 m ;

— $l_{\max}$ 1,698 m ;

— L 1,733 m.

C.8.2.2 Additional overthrows

Table C.16 — Additional overthrows for kinematic gauges PTb, PTb+ and PTc

	$\infty \geq R \geq 250$				
h	$h < 0{,}4$ m	$0{,}4 \leq h \leq 0{,}7$	$0{,}700 < h < 1{,}170$	$1{,}170 \leq h \leq 3{,}550$	$h \geq 4{,}110$ (PTb) or $h \geq 4{,}210$ (PTb+)
$S_{i_{cin}} = S_{a_{cin}}$	$\frac{3{,}75}{R} + \frac{l - 1{,}668}{2}$ (C.45)	$\frac{23{,}25}{R} + 0{,}070 + \frac{l - 1{,}668}{2}$ (C.46)	$\frac{31{,}75}{R} + 0{,}029 + \frac{l - 1{,}668}{2}$ (C.47)	$\frac{31{,}75}{R} + 0{,}004 + \frac{l - 1{,}668}{2}$ (C.48)	$\frac{20}{R} + \frac{l - 1{,}668}{2}$ (C.49)

NOTE Value F is included in the semi-width of the kinematic reference profile.

C.8.3 Taking the roll into account

Table C.17 — Values to be taken into account for the roll

L m	D_0 m	I_0 m	h_{c0} m	s_0	η_{0r}	D_{max} m	I_{max} m
1,750	0,050	0,050	0,5	0,4	1°	0,200	0,200

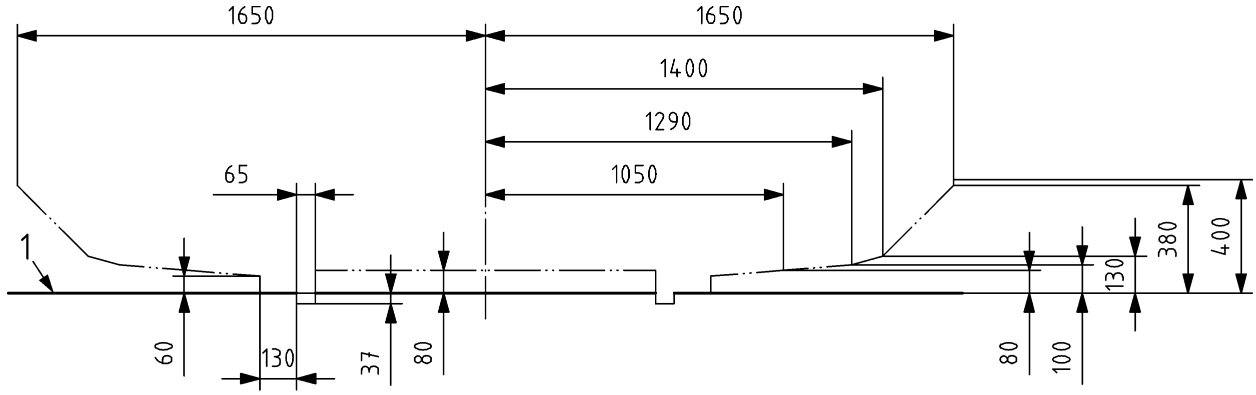
C.8.4 Vertical geometric overthrow upwards and vertical allowance of the infrastructure

The conventional values to be considered with regard to the vertical geometric overthrow are given in Annex F.

C.8.5 Kinematic reference profiles for the lower parts

Figure C.18 shows the lower zone not compatible with the marshalling humps.

Dimensions in millimetres



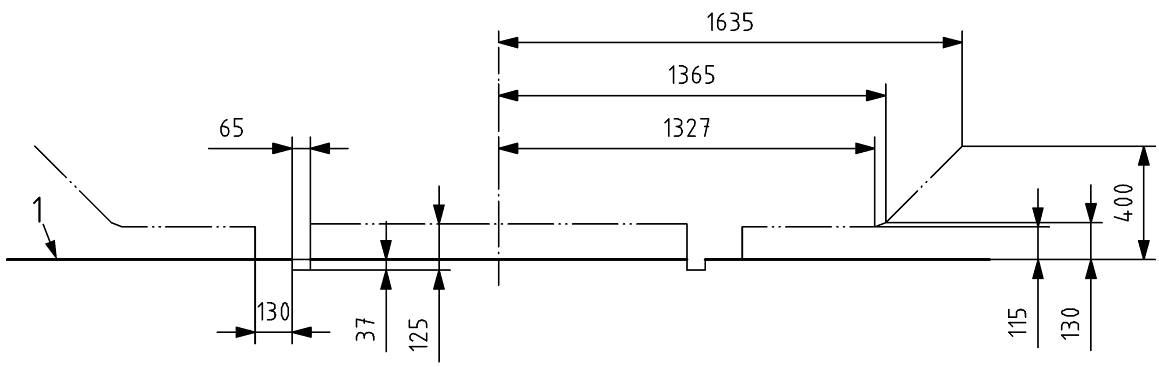
Key

1 running surface

Figure C.18 — Lower zone not compatible with the marshalling humps

Figure C.19 shows the lower zone compatible with the marshalling humps.

Dimensions in millimetres



Key

1 running surface

Figure C.19 — Lower zone compatible with the marshalling humps

C.8.6 Vertical geometric overthrow downwards and vertical allowance of the infrastructure

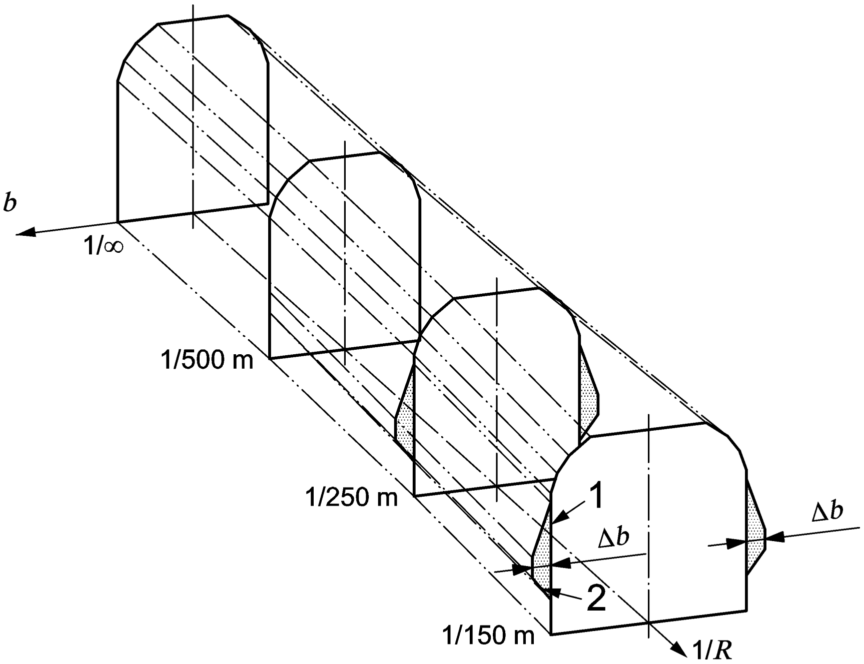
The conventional values to be considered with regard to the vertical geometric overthrow are given in Annex F.

C.9 Kinematic gauge DE1

C.9.1 General

As illustrated in Figure C.20, gauge DE1 is translated by an additional widening "Δ*b*" added to gauge G1 or gauge G2.

This addition "Δ*b*" has a positive value for curve radii *R* < 500 m.



Key

1	gauge G1 or G2
2	gauge DE1
Δ*b*	enlargement compared to gauge G1 or gauge G2 (see Table C.19)

Figure C.20 — Illustration of gauge DE1

C.9.2 Kinematic reference profiles

Figure C.21 shows the reference profile of kinematic gauge DE1.

Dimensions in millimetres

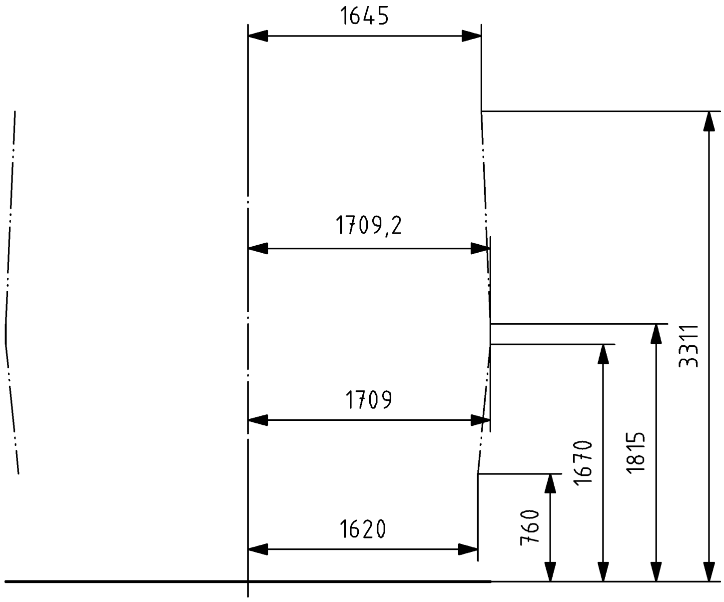


Figure C.21 — Reference profile of kinematic gauge DE1

NOTE The reference profile of kinematic gauge DE1 has been established for a curve radius R = 250 m.

This kinematic profile DE1 includes a roll $z_0 = \frac{s_0}{L} D_0 (h - h_c)$ that varies according to the height, established on the basis of the values listed in Table in C.20.

C.9.3 Associated rules

C.9.3.1 Basic data

— l_{nom} 1,435 m ;

— $l_{\max}$ 1,465 m ;

— L 1,500 m.

C.9.3.2 Additional overthrows

Table C.18 — Additional overthrows for kinematic gauge DE1

R m	**Additional overthrows** m
$250 \geq R \geq 150$	$S_{i_{cin}} = S_{a_{cin}} = \frac{45{,}906}{R} - 0{,}1684 + \frac{l - 1{,}435}{2}$ (C.50)
$\infty \geq R \geq 250$	$S_{i_{cin}} = S_{a_{cin}} = \frac{35{,}906}{R} - 0{,}1283 + \frac{l - 1{,}435}{2}$ (C.51)

From this, it results that for *h* = 1,815 m, the addition "*Δb*" relative to gauge G1 and gauge G2 is as listed in Table C.19.

Table C.19 — Addition *Δb* relative to gauge G1 and G2

R m	Δb_i m	Δb_a m
150	0,053	0,026
250	0,064	0,064
500	0	0

C.9.4 Taking the roll into account

Table C.20 — Values to be taken into account for the roll

L m	D_0 m	I_0 m	h_{c0} m	s_0	η_{0r}	D_{max} m	I_{max} m
1,500	0,050	0,050	0,7	0,28	1°	0,200	0,200

C.9.5 Vertical geometric overthrow downwards and vertical allowance of the infrastructure

The conventional values to be considered with regard to the vertical geometric overthrow are given in Annex F.

C.10 Kinematic gauge DE2

C.10.1 General

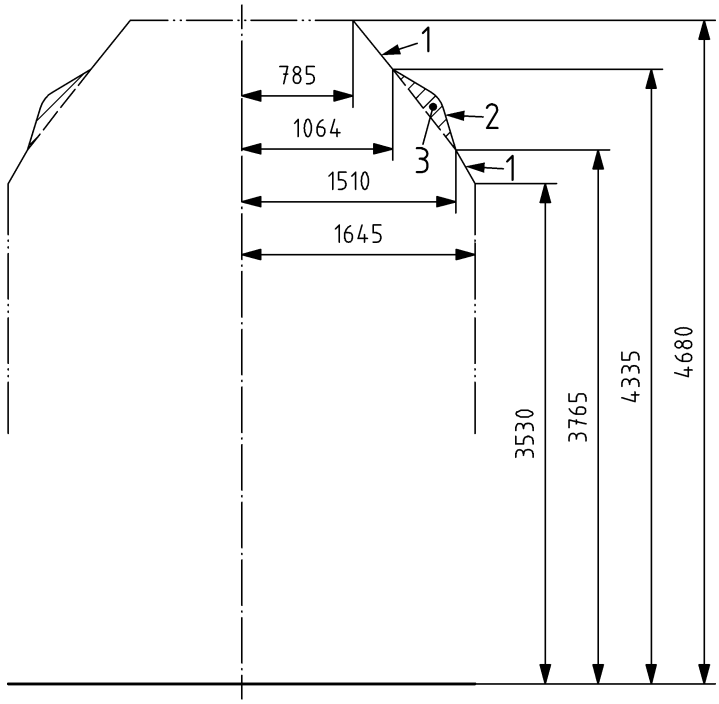
Gauge DE2 is generally used for double-decker coaches.

For heights between 3,765 m ≤ *h* ≤ 4,335 m, gauge DE2 is located between gauge G2 and gauge DE3.

C.10.2 Kinematic reference profiles

Figure C.22 illustrates gauge DE2.

Dimensions in millimetres



Key

1 reference profile of kinematic gauge G2

2 reference profile of kinematic gauge DE2

3 addition relative to gauge G2

Figure C.22 — Illustration of gauge DE2

Table C.21 — Coordinates of the points of the reference profile of kinematic gauge DE2

h_{CRcin} m	b_{CRcin} m	h_{CRcin} m	b_{CRcin} m	h_{CRcin} m	b_{CRcin} m	h_{CRcin} m	b_{CRcin} m
3,53	1,645	3,905	1,454	4,055	1,388	4,205	1,249
3,765	1,51	3,915	1,45	4,065	1,383	4,215	1,234
3,775	1,506	3,925	1,445	4,075	1,378	4,225	1,223
3,785	1,502	3,935	1,441	4,085	1,372	4,235	1,208
3,795	1,498	3,945	1,437	4,095	1,366	4,245	1,194
3,805	1,494	3,955	1,432	4,105	1,359	4,255	1,18
3,815	1,49	3,965	1,428	4,115	1,352	4,265	1,166
3,825	1,486	3,975	1,423	4,125	1,343	4,275	1,154
3,835	1,483	3,985	1,419	4,135	1,333	4,285	1,137
3,845	1,478	3,995	1,415	4,145	1,323	4,295	1,124
3,855	1,474	4,005	1,411	4,155	1,311	4,305	1,108
3,865	1,47	4,015	1,406	4,165	1,298	4,315	1,093
3,875	1,466	4,025	1,401	4,175	1,286	4,325	1,079
3,885	1,462	4,035	1,396	4,185	1,273	4,335	1,064
3,895	1,458	4,045	1,391	4,195	1,262	4,68	0,785

C.10.3 Associated rules

C.10.3.1 Basic data

36 l_{nom} 1,435 m;

37 $l_{\max}$ 1,465 m;

38 L 1,500 m.

C.10.3.2 Additional overthrows

The additional overthrows $S_{i_{cin}}$ and $S_{a_{cin}}$ are identical to those of gauge G2.

C.10.4 Taking the roll into account

Table C.22 — Values for heights between 3,765 m ≤ *h* ≤ 4,335 m

L m	D_0 m	I_0 m	h_{c0} m	s_0	η_{0r}	D_{max} m	I_{max} m
1,500	0,050	0,050	0,695	0,19	1°	0,200	0,200

For other heights, the rules for gauge G2 are applicable.

C.10.5 Vertical geometric overthrow downwards and vertical allowance of the infrastructure

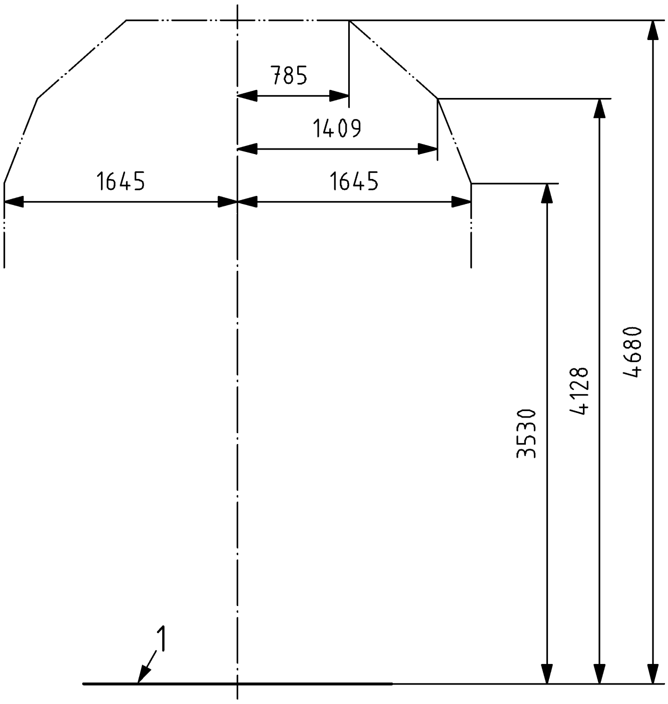
The conventional values to be considered with regard to the vertical geometric overthrow are given in Annex F.

C.11 Kinematic gauge DE3

C.11.1 Kinematic reference profiles

Figure C.23 shows the reference profile of kinematic gauge DE3.

Dimensions in millimetres



Key

1 running surface

NOTE — Lower parts according to Figure C.3, Figure C.4 or Figure C.8

— Reference profile of kinematic gauge G2 is applicable for heights less than 3,530 m.

Figure C.23 — Reference profile of kinematic gauge DE3

C.11.2 Associated rules

The associated rules for gauges G1 and G2 are applicable.

C.12 Spanish kinematic gauges GHE16, GEA16, GEB16, GEC16, GEC14, GEE10 and GED10

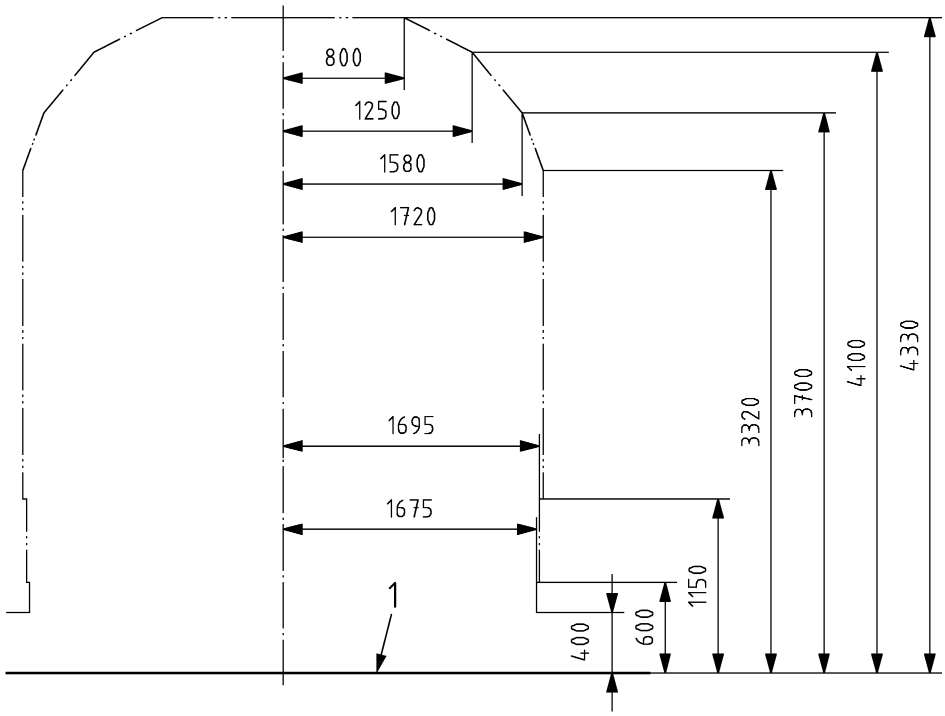
C.12.1 Reference profiles for kinematic gauges

C.12.1.1 Kinematic gauge GHE16

C.12.1.1.1 Kinematic reference profile for the lateral parts and upper parts

Figure C.24 shows the reference profile for kinematic gauge GHE16.

Dimensions in millimetres



Key

1 running surface

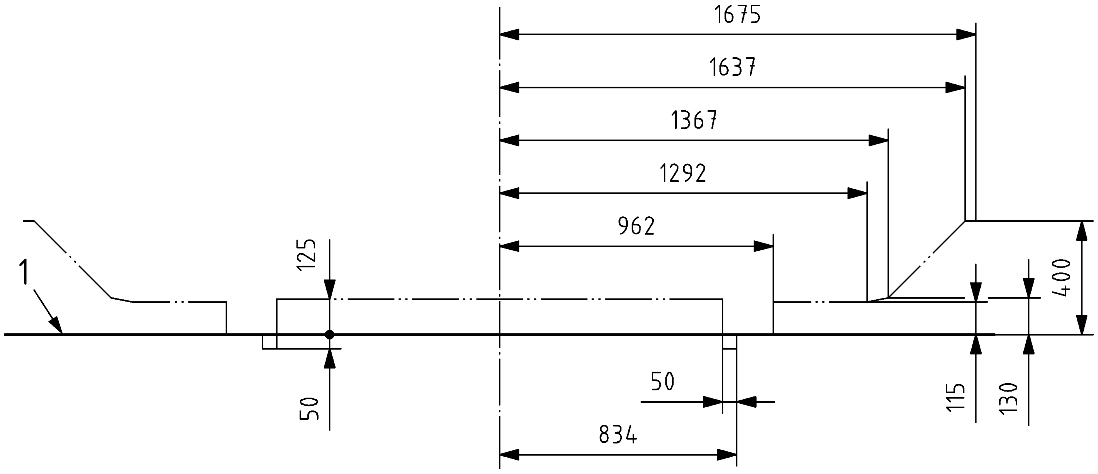
NOTE Lower parts according to Figure C.25 or Figure C.26.

Figure C.24 — Reference profile of kinematic gauge GHE16

C.12.1.1.2 Kinematic reference profiles for the lower parts

Figure C.25 shows the reference profile for kinematic gauge GHE16 for vehicles which can pass over rail brakes in an active position.

Dimensions in millimetres



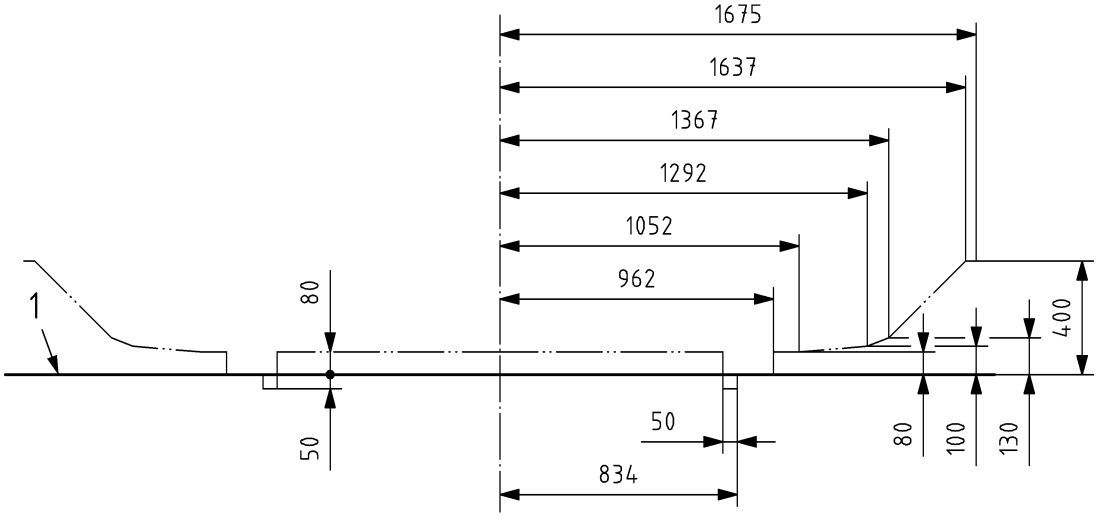
Key

1 running surface

Figure C.25 — Reference profile of lower parts of kinematic gauge GHE16 for vehicles which can pass over rail brakes in an active position

Figure C.26 shows the reference profile for kinematic gauge GHE16 for vehicles which may pass over rail brakes in a non-active position

Dimensions in millimetres



Key

1 running surface

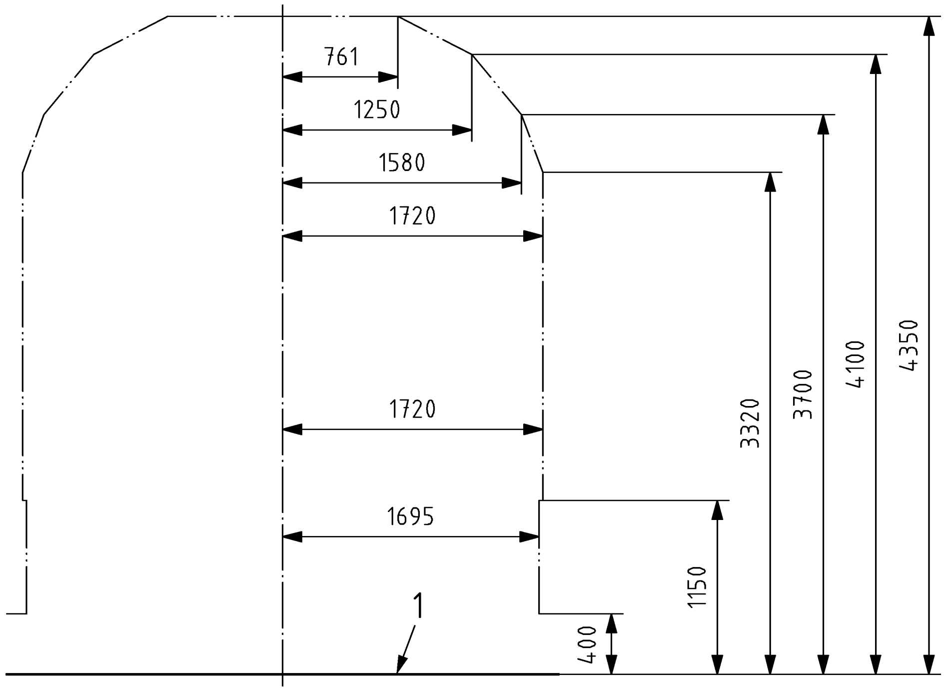
Figure C.26 — Reference profile of lower parts of kinematic gauge GHE16 for vehicles which may pass over rail brakes in a non-active position

C.12.1.2 Kinematic gauge GEA16

The reference profile for the lower parts of kinematic gauge GEA16 is the same as that shown for gauge GHE16.

Figure C.27 shows the reference profile for the upper parts of kinematic gauge GEA16.

Dimensions in millimetres



Key

1 running surface

NOTE Lower parts according to Figure C.25 or Figure C.26.

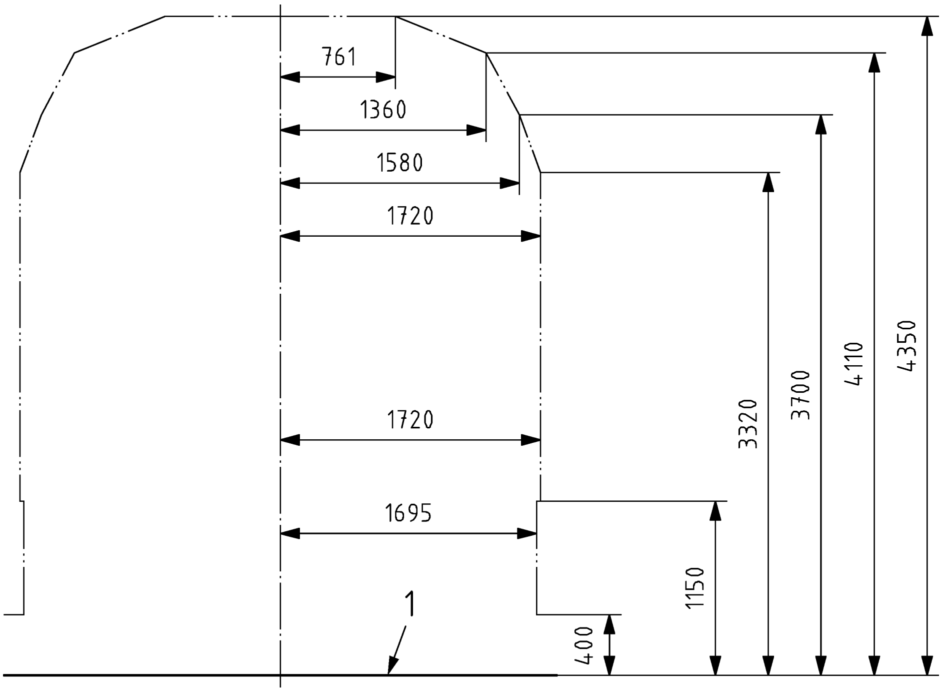
Figure C.27 — Reference profile of the upper parts of kinematic gauge GEA16

C.12.1.3 Kinematic gauge GEB16

The reference profile for the lower parts of kinematic gauge GEB16 is the same as that shown for gauge GHE16.

Figure C.28 shows the reference profile for the upper parts of kinematic gauge GEB16.

Dimensions in millimetres



Key

1 running surface

NOTE Lower parts according to Figure C.25 or Figure C.26.

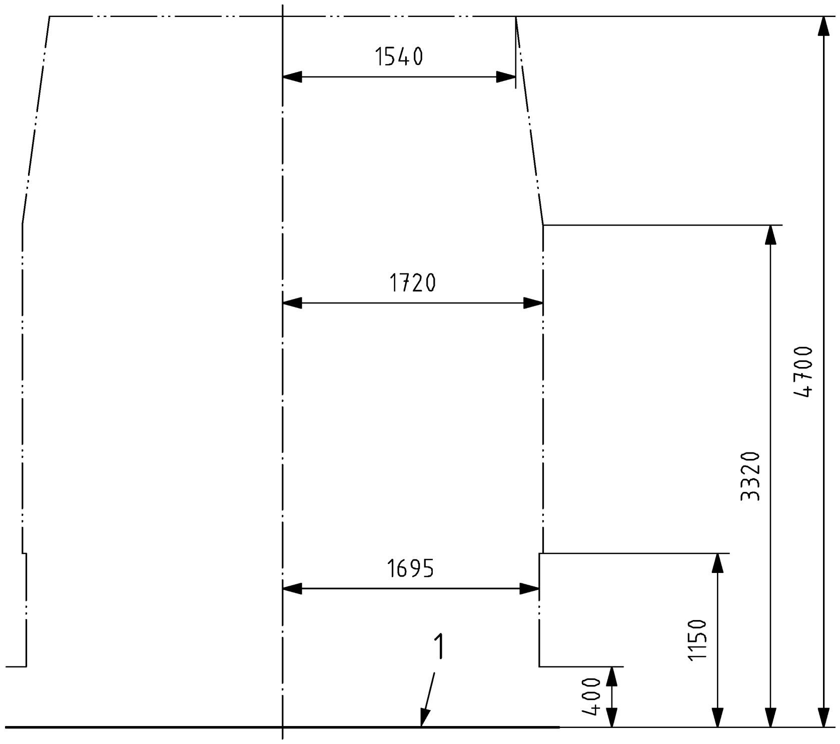
Figure C.28 — Reference profile of the upper parts of kinematic gauge GEB16

C.12.1.4 Kinematic gauge GEC16

The reference profile for the lower parts of kinematic gauge GEC16 is the same as that shown for gauge GHE16.

Figure C.29 shows the reference profile for the upper parts of kinematic gauge GEC16.

Dimensions in millimetres



Key

1 running surface

NOTE Lower parts according to Figure C.25 or Figure C.26.

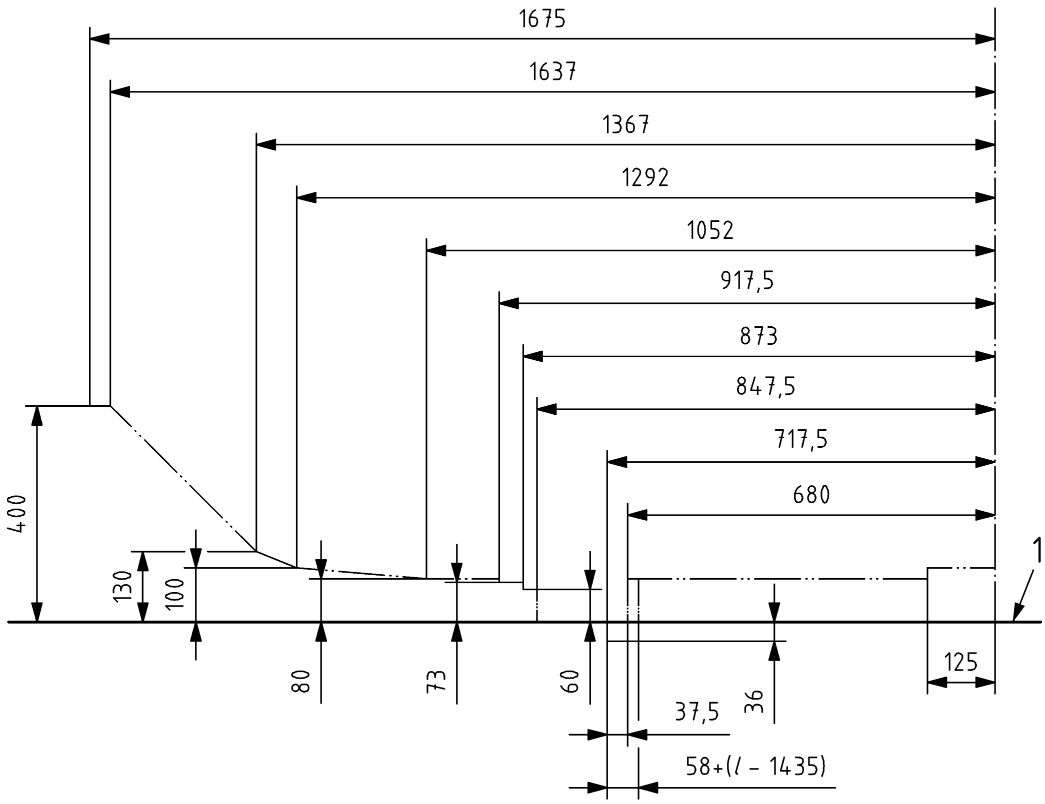
Figure C.29 — Reference profile of the upper parts of kinematic gauge GEC16

C.12.1.5 Kinematic gauge GEC14

The reference profile for the upper parts of kinematic gauge GEC14 is the same as that shown for gauge GEC16.

The reference profile for the lower parts is shown in Figure C.30.

Dimensions in millimetres



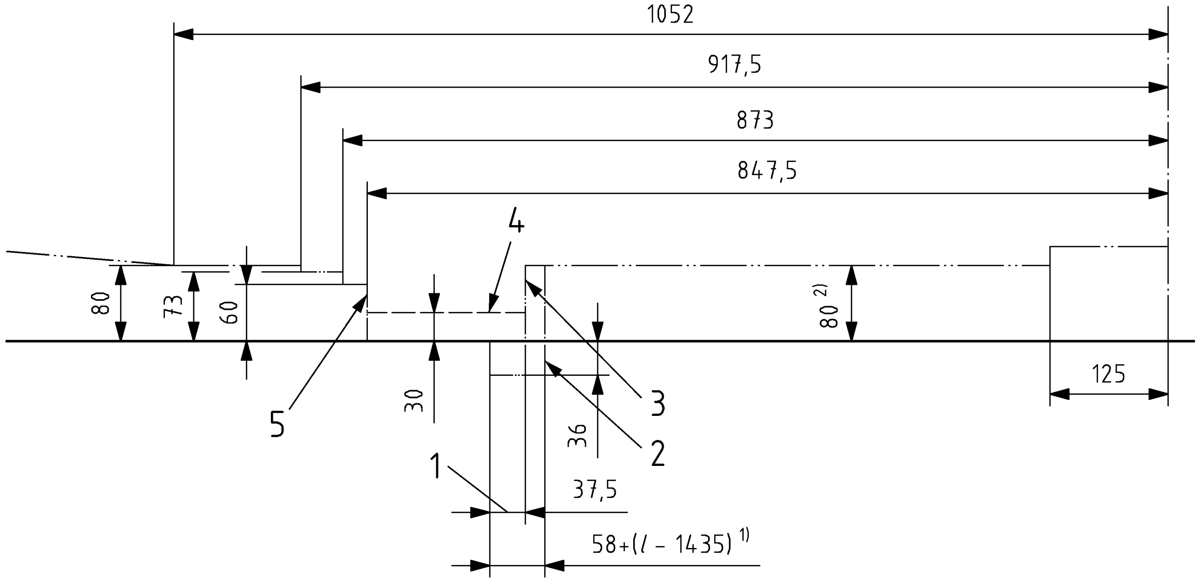
Key

1 running surface

Figure C.30 — Reference profile of the lower parts of kinematic gauge GEC14

Figure C.31 shows the lower parts of the rail area and the area between the rails.

Dimensions in millimetres



Key

1 maximum theoretical width of flange profile. Takes into consideration the existence of a possible angle of the wheelset on the rail

2 effective limit position of the inside surface of the wheel when the opposing wheel flange is in contact with the rail

3 maximum position of the check rails

4 lower limit position of parts mounted on the vehicle, except for wheels

5 limit position of the outside part of the wheel surface

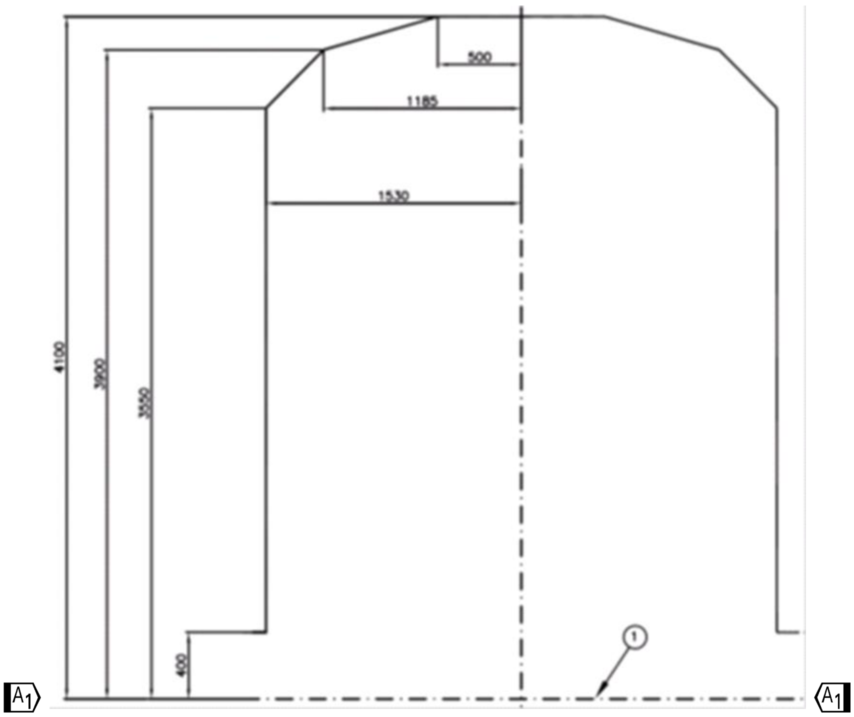
Figure C.31 — Reference profile of kinematic gauge GEC14. Lower parts of the rail area and the area between the rails

C.12.1.6 Kinematic gauge GEE10

C.12.1.6.1 Kinematic reference profile for the lateral parts and upper parts

Figure C.32 shows the reference profile for kinematic gauge GEE10.

Dimensions in millimetres



Key

1 running surface

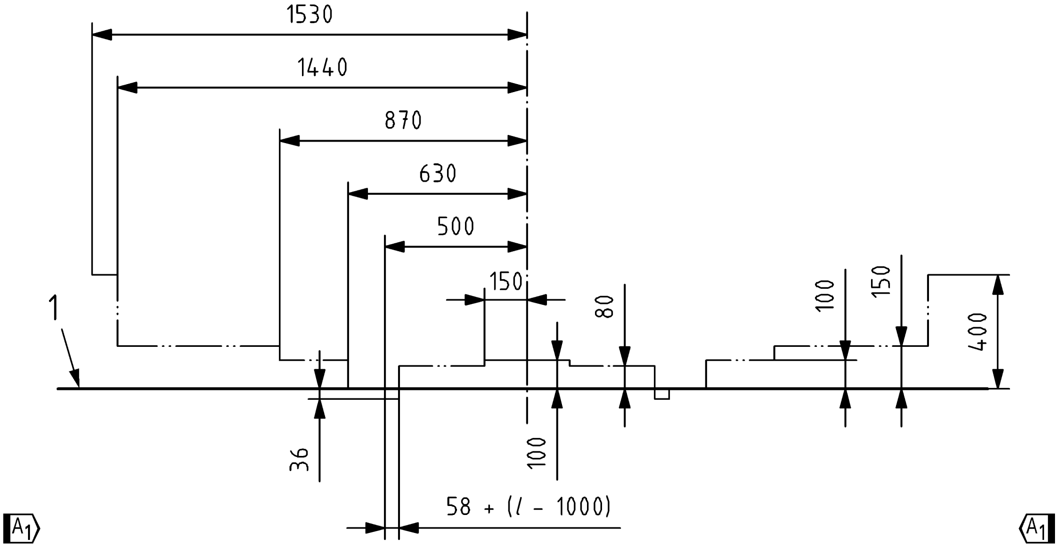
NOTE Lower parts as per Figure C.33.

Figure C.32 — Reference profile of kinematic gauge GEE10

C.12.1.6.2 Kinematic reference profiles for the lower parts

Figure C.33 shows the reference profile for kinematic gauge GEE10.

Dimensions in millimetres



Key

1 running surface

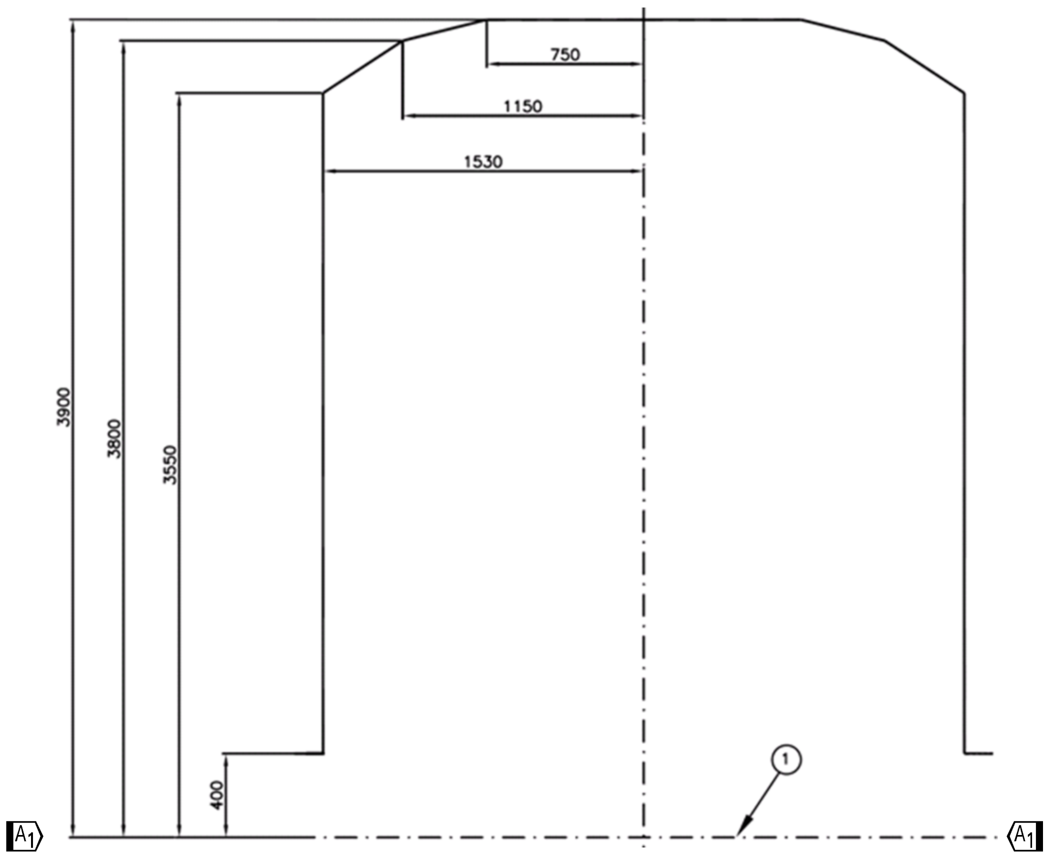
Figure C.33 — Reference profile for the lower parts of kinematic gauge GEE10

C.12.1.7 Kinematic gauge GED10

The reference profile for the lower parts of kinematic gauge GED10 is the same as that shown for gauge GEE10.

Figure C.34 shows the reference profile for the upper parts of kinematic gauge GED10.

Dimensions in millimetres



Key

1 running surface

NOTE Lower parts as per Figure C.33.

Figure C.34 — Reference profile of the upper parts of kinematic gauge GED10

C.12.2 Associated rules

C.12.2.1 Basic data

Table C.23 — Basic data

Gauges	l_{nom} m	l_{max} m	L m
GHE16, GEA16, GEB16 and GEC16	1,668	1,698	1,733
GEC14	1,435	1,465	1,500
GEE10 and GED10	1,000	1,030	1,055

C.12.2.2 Additional overthrows

Table C.24 — Additional overthrows

Additional overthrows for track gauge *"l"* and height *"h"* compared to the running surface					
Gauge	***Radius***	***h ≤ 0,4 m***	***h > 0,4 m***		***Pantograph zone***
GHE16 and GEC16	*250 ≤ R < ∞*	$S_{i_{cin}} = S_{a_{cin}} = \frac{2,5}{R} + \frac{l-1,668}{2}$	$S_{i_{cin}} = S_{a_{cin}} = \frac{3,75}{R} + \frac{l-1,668}{2}$		$S_{i_{cin}} = \frac{2,5}{R} + \frac{l-1,668}{2}$ $S_{a_{cin}} = \frac{2,5}{R} + \frac{l-1,668}{2}$
	150 ≤ R < 250	$S_{i_{cin}} = \frac{50}{R} - 0,19 + \frac{l-1,668}{2}$ $S_{a_{cin}} = \frac{60}{R} - 0,23 + \frac{l-1,668}{2}$	$S_{i_{cin}} = \frac{50}{R} - 0,185 + \frac{l-1,668}{2}$ $S_{a_{cin}} = \frac{60}{R} - 0,225 + \frac{l-1,668}{2}$		
GEA16 and GEB16	*250 ≤ R < ∞*	$S_{i_{cin}} = S_{a_{cin}} = \frac{2,5}{R} + \frac{l-1,668}{2}$	$S_{i_{cin}} = S_{a_{cin}} = \frac{3,75}{R} + \frac{l-1,668}{2}$	$S_{i_{cin}} = S_{a_{cin}} = \frac{3,75}{R} + \frac{16,25 \cdot k}{R} + \frac{l-1,668}{2}$	
	150 ≤ R < 250	$S_{i_{cin}} = \frac{50}{R} - 0,19 + \frac{l-1,668}{2}$ $S_{a_{cin}} = \frac{60}{R} - 0,23 + \frac{l-1,668}{2}$	$S_{i_{cin}} = \frac{50}{R} - 0,185 + \frac{l-1,668}{2}$ $S_{a_{cin}} = \frac{60}{R} - 0,225 + \frac{l-1,668}{2}$	$S_{i_{cin}} = \frac{50}{R} - 0,185 + 0,065k + \frac{l-1,668}{2}$ $S_{a_{cin}} = \frac{60}{R} - 0,225 + k\left(0,105 - \frac{10}{R}\right) + \frac{l-1,668}{2}$	

Table C.24 *(continued)*

Additional overthrows for track gauge *"l"* and height *"h"* compared to the running surface				
Gauge	***Radius***	***h ≤ 0,4 m***	***h > 0,4 m***	***Pantograph zone***
GEC14	*250 ≤ R < ∞*	$S_{i_{cin}} = S_{a_{cin}} = \frac{2,5}{R} + \frac{l-1,435}{2}$	$S_{i_{cin}} = S_{a_{cin}} = \frac{3,75}{R} + \frac{l-1,435}{2}$	$S_{i_{cin}} = \frac{2,5}{R} + \frac{l-1,435}{2}$ $S_{a_{cin}} = \frac{2,5}{R} + \frac{l-1,435}{2}$
	150 ≤ R < 250	$S_{i_{cin}} = \frac{50}{R} - 0,19 + \frac{l-1,435}{2}$ $S_{a_{cin}} = \frac{60}{R} - 0,23 + \frac{l-1,435}{2}$	$S_{i_{cin}} = \frac{50}{R} - 0,185 + \frac{l-1,435}{2}$ $S_{a_{cin}} = \frac{60}{R} - 0,225 + \frac{l-1,435}{2}$	
GEE10 and GED10	*100 ≤ R < ∞*	$S_{i_{cin}} = S_{a_{cin}} = \frac{1}{R} + \frac{l-1}{2}$	$S_{i_{cin}} = S_{a_{cin}} = \frac{1,5}{R} + \frac{l-1}{2}$	$S_{i_{cin}} = \frac{1}{R} + \frac{l-1}{2}$ $S_{a_{cin}} = \frac{1}{R} + \frac{l-1}{2}$
	80 ≤ R < 100	$S_{i_{cin}} = \frac{20}{R} - 0,19 + \frac{l-1}{2}$ $S_{a_{cin}} = \frac{24}{R} - 0,23 + \frac{l-1}{2}$	$S_{i_{cin}} = \frac{20}{R} - 0,185 + \frac{l-1}{2}$ $S_{a_{cin}} = \frac{24}{R} - 0,225 + \frac{l-1}{2}$	

With the values for flexibility coefficient and *k* defined in Table C.25 (Annex).

Table C.25 — Values of s_0 and k for calculations

Gauges	**Height** m	s_0	k
GHE16, GEC16, GEC14, GEE10 and GED10	For all heights	0,4	0
GEA16	$h \leq 3,32$	0,4	0
	$3,32 < h < 3,70$	$\frac{4,84 - h}{3,8}$	$\frac{h - 3,32}{0,38}$
	$h \geq 3,70$	0,3	1
GEB16	$h \leq 3,32$	0,4	0
	$3,32 < h < 4,11$	$\frac{6,48 - h}{7,9}$	$\frac{h - 3,32}{0,79}$
	$h \geq 4,11$	0,3	1

NOTE The value F = 0,045 y is included in the semi-width of the kinematic reference profile.

C.12.2.3 Taking the roll into account

Table C.26 — Values for calculations taking into account roll

Gauge	Height	L	D_0 m	I_0 m	h_{c0} m	s_0	η_{0r}	D_{max}	I_{max}
GEA16	$h \leq 3{,}32$	1,733	0,050	0,050	0,5	0,4	1°	0,160	0,160
	$3{,}32 < h < 3{,}70$	1,733	0,050	0,050	0,5	0,4 - 0,1 k	1°	0,160	0,160
	$h \geq 3{,}70$	1,733	0,050	0,050	0,5	0,3	1°	0,160	0,160
GEB16	$h \leq 3{,}32$	1,733	0,050	0,050	0,5	0,4	1°	0,160	0,160
	$3{,}32 < h < 4{,}11$	1,733	0,050	0,050	0,5	0,4 - 0,1 k	1°	0,160	0,160
	$h \geq 4{,}11$	1,733	0,050	0,050	0,5	0,3	1°	0,160	0,160
GEC16		1,733	0,050	0,050	0,5	0,4	1°	0,160	0,160
GHE16		1,733	0,050	0,050	0,5	0,4	1°	0,160	0,160
GEC14		1,5	0,050	0,050	0,5	0,4	1°	0,160	0,160
GEE10		1,055	0,070	0,070	0,5	0,4	1°	0,120	0,120
GED10		1,055	0,070	0,070	0,5	0,4	1°	0,120	0,120

C.12.2.4 Vertical geometric overthrow upwards and vertical allowance of the infrastructure

The fixed values to be considered for the vertical geometric overthrow can be found in Annex F.

Annex D
(normative)

Reference profiles and associated rules for dynamic gauges

D.1 General

General comment as a practical measure to facilitate the reading of the standard:

— the dimensions of the reference profiles are given in mm,

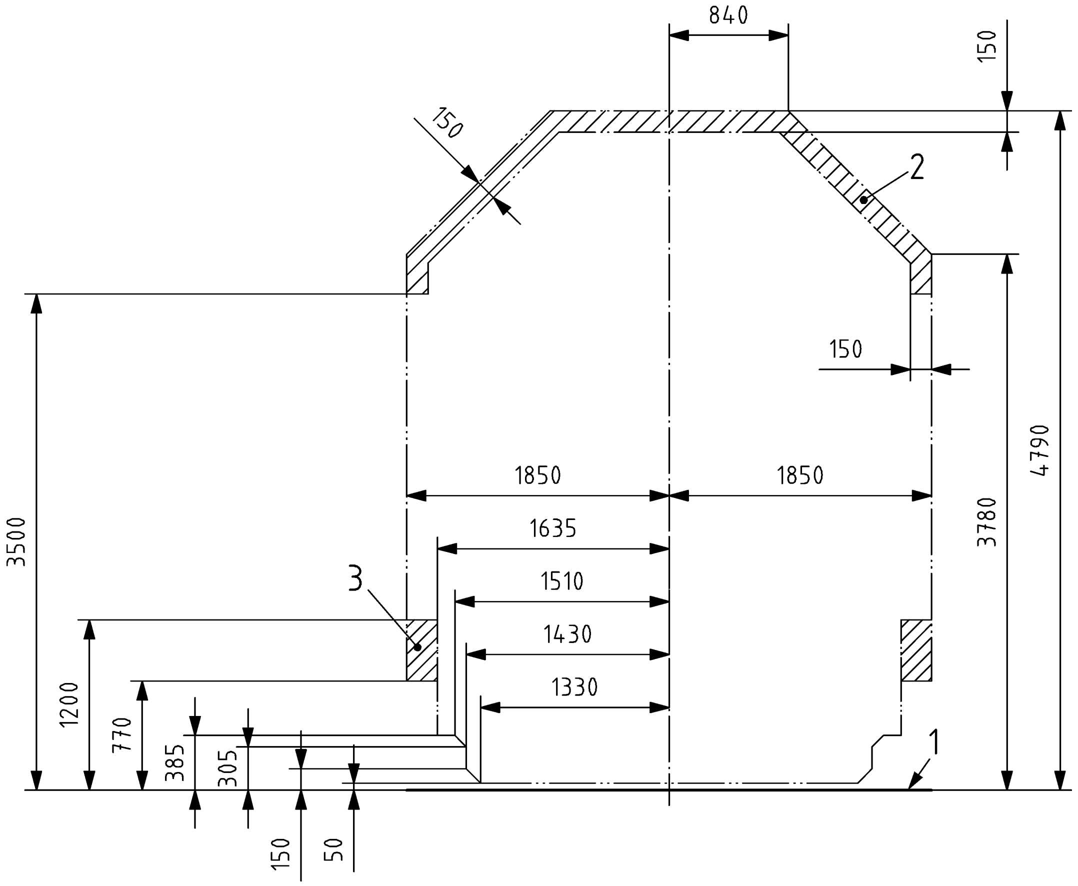
— the values to be used in the formulae are given in m, unless otherwise indicated.

D.2 Dynamic gauge SEa and SEc

D.2.1 Dynamic reference profile SEa

Figure D.1 shows the dynamic reference profile SEa.

Dimensions in millimetres



Key

1 running surface

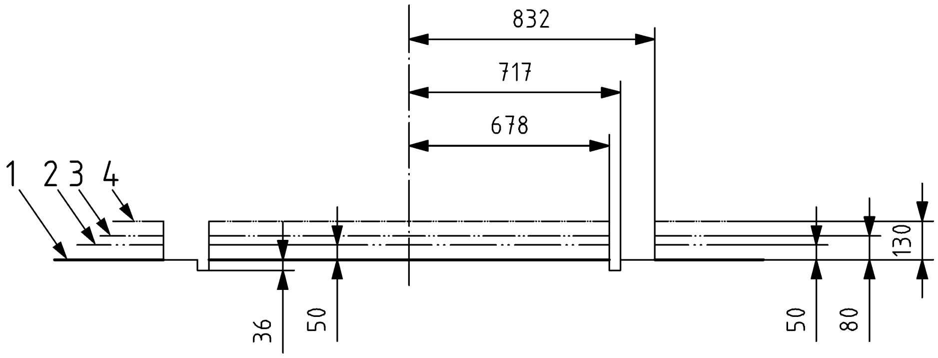
2 zone into which non-insulated parts likely to remain live shall not penetrate

3 area into which vehicles authorised to operate within 2.0 m of the loading platforms may not enter

Figure D.1 — Dynamic reference profile SEa

Figure D.2 shows the dynamic reference profile for the lower parts of gauge SEa and SEc.

Dimensions in millimetres



Key

1 running surface

2 reference profile for vehicles not authorised to cross rail brakes

3 reference profile for vehicles authorised to cross rail brakes in a non-active position

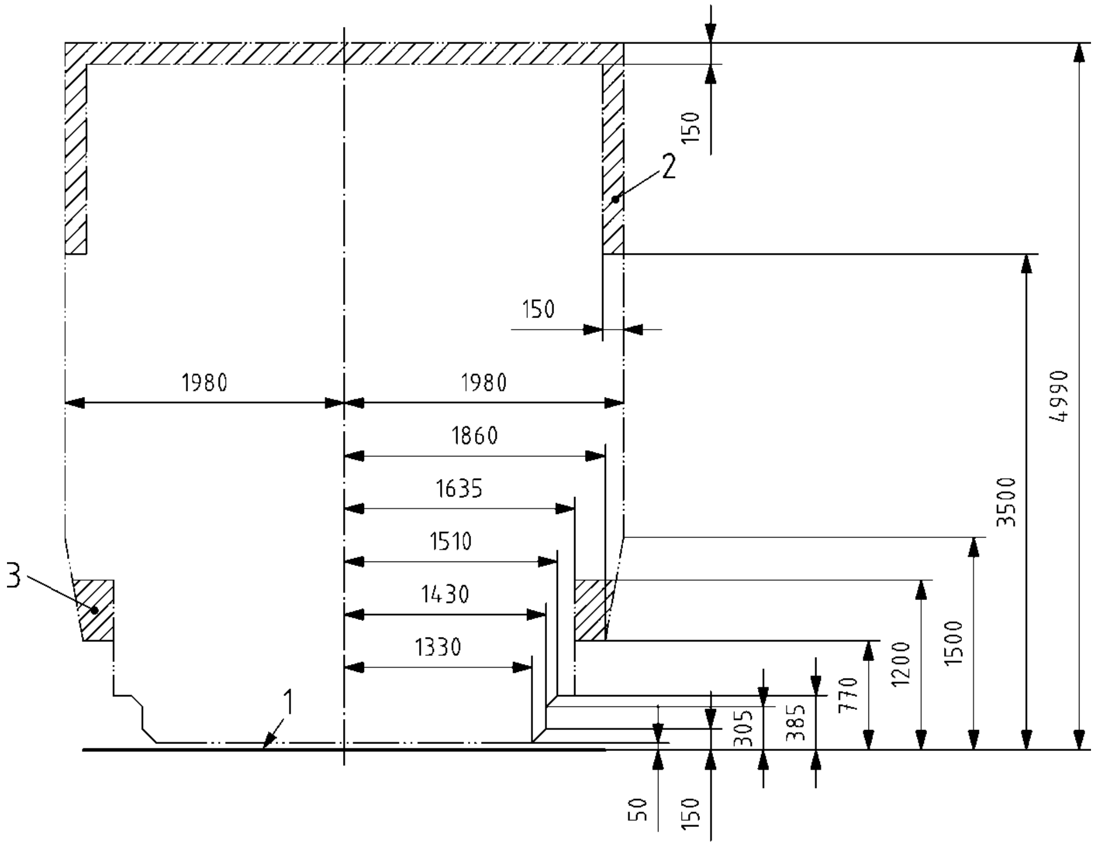
4 reference profile for vehicles authorised to cross rail brakes in an active position

Figure D.2 — Dynamic reference profile for the lower parts of gauge SEa and SEc

D.2.2 Dynamic reference profile SEc

Figure D.3 shows the dynamic reference profile for gauge SEc.

Dimensions in millimetres



Key

1 running surface

2 zone into which non-insulated parts likely to remain live shall not penetrate

3 area into which vehicles authorised to operate within 2.0 m of the loading platforms may not enter

Figure D.3 — Dynamic reference profile for gauge SEc

D.2.3 Associated rules

D.2.3.1 Basic data

l_{nom} 1,435 m;

l_{max} 1,465 m;

L 1,500 m.

D.2.3.2 Additional overthrows

Table D.1 lists the additional overthrows.

Table D.1 — Additional overthrows

Additional overthrows	$\infty \geq R \geq 200$
$S_{i\ dyn}$	$\frac{41}{R} + \frac{l - 1{,}435}{2}$ (D.1)
$S_{a\ dyn}$	$\frac{31}{R} + \frac{l - 1{,}435}{2}$ (D.2)

NOTE The value F = 0,035 m is included in the semi-width of the dynamic reference profile.

D.2.3.3 Taking the roll into account

Table D.2 lists the values that take the roll into account.

Table D.2 — Values to be taken into account for the roll

	L m	D_{max} m	D_{sup} m	I_{max} m	I_{sup} m	η_{0r}
$\infty \geq R \geq 275$	1,5	0,150	0,040	Maximum allowed by the vehicle	0,060	1°
$275 > R \geq 200$	1,5	$\frac{0{,}15}{225}(R-50)$ (D.3)	0,040	$\frac{0{,}15}{225}(R-50)$ (D.4) or the maximum value allowed by the rolling stock if it is lower	0,060	1°
$R < 200$	1,5	$\frac{0{,}15}{225}(R-50)$ (D.5)	0,040	0,100	0,060	1°

D.2.3.4 Vertical allowances of the infrastructure

Reserved.

Annex E
(normative)

Uniform gauges

E.1 General information on gauges GUC, GU1, GU2 and Z-GČD

Uniform gauges are structure gauges. These are given in EN 15273-3.

The vehicles are allowed according to Table E.1.

Table E.1 — Vehicles

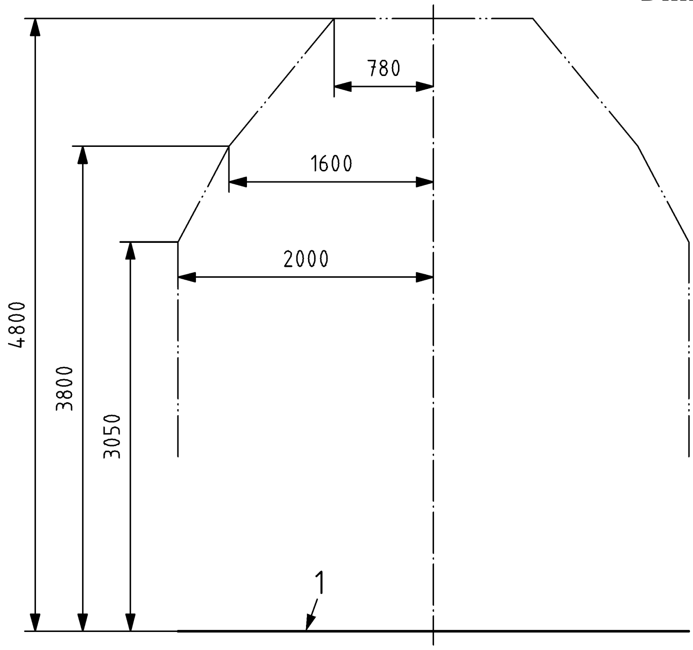
Uniform gauge	Maximum allowable rolling stock
GUC	GC
GU1	See below
GU2	G2, NL1
Z-GČD	G2

E.2 Uniform gauge GU1

E.2.1 General

Figure E.1 shows the nominal structure profile of GU1.

Dimensions in millimetres



Key

1 running surface

Figure E.1 — Nominal structure profile of GU1

E.2.2 Basic data

39 l_{nom} 1,435 m

40 $l_{\max}$ 1,465 m

41 L 1,5 m

The kinematic profile derived from this uniform gauge by applying the structure installation limit kinematic rules – and to which the vehicle construction rules could apply - depends on the authorised minimum radius considered, the cant and cant deficiency.

For example, if:

$S_{a_{cin}} = S_{i_{cin}} = 0{,}015 + \dfrac{1{,}465 - 1{,}435}{2}$ = 0,030 m in a curve of radius R = 250 m

D_{max} = 0,150 m

I_{max} = 0,150 m

Σ_2 calculated for the track characteristics where V < 80 km/h (see Table E.2).

Table E.2 — Calculation of a reference profile for uniform gauge GU1

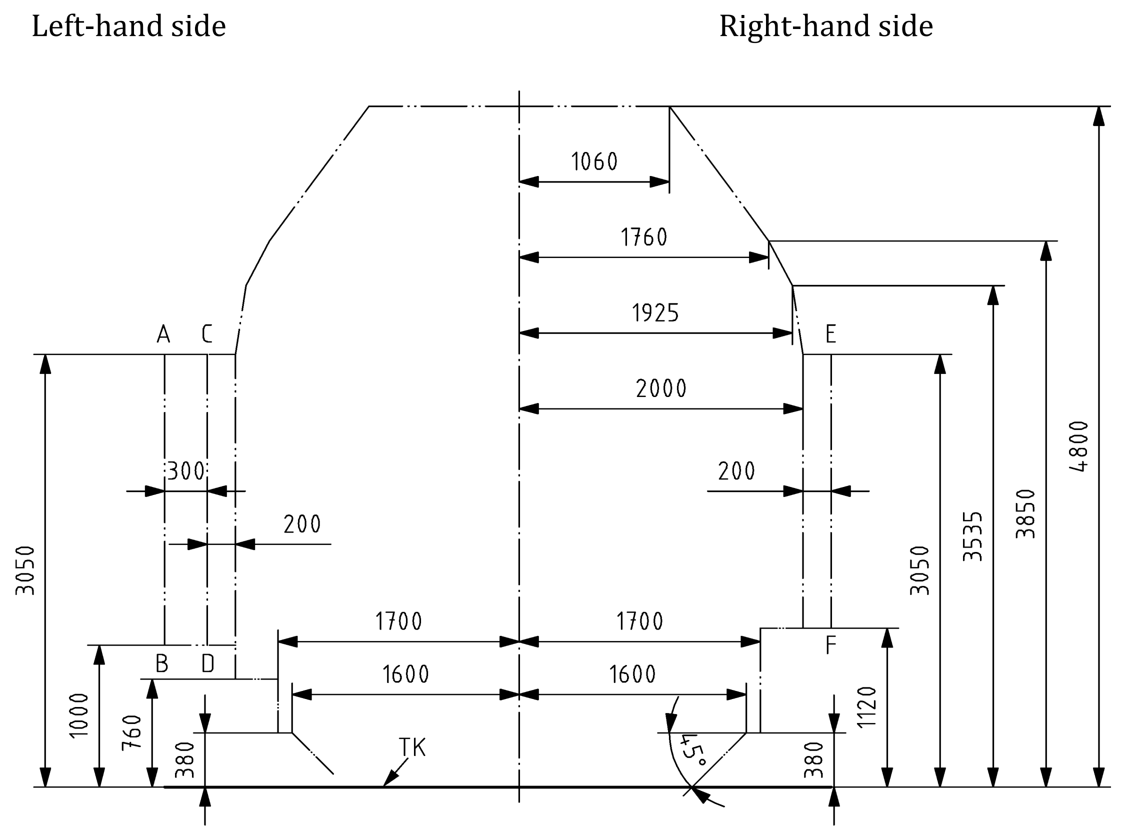
Height of the kinematic reference profile	3,25	3,31	3,53	3,835	4,680
Semi-width of the uniform gauge	1,8933		1,744	1,5713	0,8784
Reduction from the structure limit installation gauge to the reference profile of the rolling stock according to formula $S_a + K(I - 0{,}050) + \Sigma_{2a}$ (E.1)	0,2089		0,2257	0,2442	0,2952
Semi-width of the kinematic reference profile that can be used by the rolling stock	1,684	1,645	1,519	1,327	0,583

E.3 Uniform gauge Z -GČD

E.3.1 Uniform reference profile

Figure E.2 shows the gauge for Z -GČD structures.

Dimensions in millimetres



Key

Left-hand side:

— for all tracks (including in stations);

— for the main tracks in stations and in the crossing zone (including in stations);

— for main tracks in the points and crossing zone (e.g. marshalling yards);

— for secondary tracks where passenger trains are likely to run.

A – B for structures and equipment located outside the outer track

C – D for equipment located between tracks

Right-hand side:

— for other tracks (outside stations) and crossing zones (including in stations);

— for other tracks (than the main tracks) in the points and crossing zone (e.g. marshalling yards)

E – F for all structures and equipment

Figure E.2 — Gauge for Z-GČD structures

E.3.2 Basic data

42	l_{nom}	1,435 m
43	$l_{\max}$	1,470 m
44	L	1,500 m
45	$R_{\min}$	250 m
46	$R_{v\ \min}$	2 500 m
47	$D_{\max}$	0,160 m
48	$I_{\max}$	0,160 m

Annex F
(normative)

Specific rules in the vertical direction

F.1 General

With regard to the mainline gradient transitions for gauges connected with the reference profile GI2 for lower parts:

- Value $h_{u\,\min}$ = 0,080 m of reference profile GI2 (see Figure C.4) corresponds to a reference vehicle with a wheelbase $a_r \leq$ 17,8 m, operating on minimum vertical radii $R_{v\,\min}$ = 500 m;
- For vehicles with wheelbases $a >$ 17,8 m, the value $h_{u\,\min}$ shall be adjusted to allow passage over curves with minimum vertical radius $R_{v\,\min}$ = 500 m (see EN 15273-2).
- The infrastructure shall also add the vertical dimensions of the upper part of the reference profile of $\frac{50}{R}$ in the gradient transitions (see EN 15273-3:2013+A1:2016, A.3.4.1.6).
- The value M_v is defined by the infrastructure (see EN 15273-3).

F.2 Passing over link spans onto ferries

The vertical allowance to be considered by the rolling stock is at least M_{fb} = 0,060 m for coaches and 0,020 m for wagons.

The ferry ramp angle α'' to be adhered to both by the infrastructure and by the rolling stock used on this crossing is listed in Table F.1 below.

Table F.1 — Ferry ramp angle α''

CROSSING	Maximum angle of the movable gangway α''
Korsør – Nyborg	Reserved
Gedser - Warnermünde	2° 30’
	3° 30’
Rødby Færge - Puttgarden	Reserved
Sassnitz Hafen - Trelleborg	2° 30’
Villa S.G. - Messina	1° 30’
Reggio C. - Messina	1° 30’
Stockholm – Abo	Reserved
Ystad – Swinoujscie	Reserved
Trelleborg – Sassnitz	Reserved
CROSSING	Maximum angle of the movable gangway α''
Trelleborg - Rostock	Reserved
Malmö - Travemünde	Reserved

F.3 Marshalling humps

F.3.1 Convention for gauges in groups G1, G2, GA, GB, GB1, GB2, GC, FR3.3, BE1, BE2, BE3, GHE16, GEA16, GEB16, GEC16, GEC14, GEE10 AND GED10, etc.

F.3.1.1 General

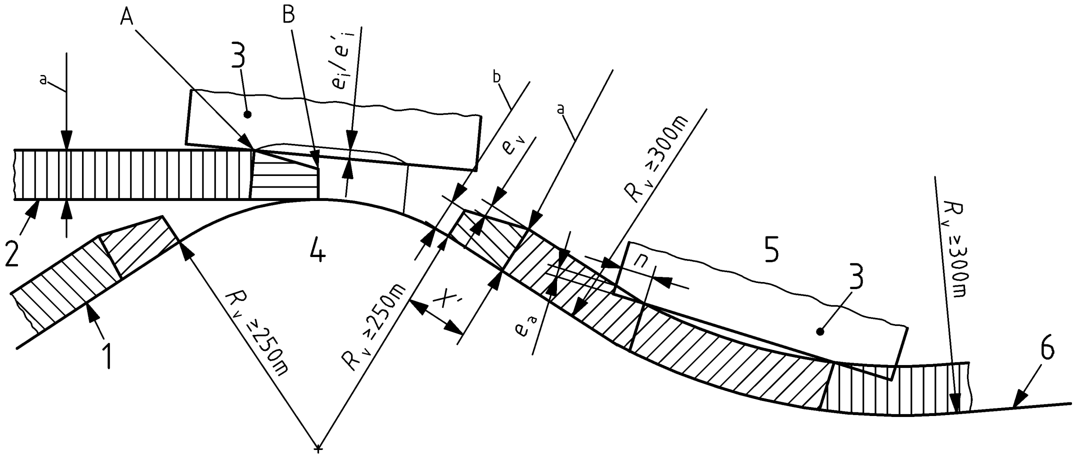
These gauges use two types of marshalling humps, the classic humps and special humps for low-floor wagons.

With regard to the lower horizontal of the reference profile, for the two types of humps, the height $h_{u\,\min}$ = 0,125 m is based on a reference vehicle with a_r = 15,8 m.

In contrast, when calculating the height h_{max} reserved for the infrastructure, the value e_v is calculated using different reference vehicles, a_r = 17,8 m for classic humps and a_r = 15,8 m for special humps for low-floor wagon.

F.3.1.2 Classic humps

Progressive reduction of h_{max} over a distance X = 3 m to allow for empty coaches, vans and empty or loaded wagons (see Figure F.1).



Key

a	(0,115 m or 0,125 m) or 0,080 m
b	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;
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

Figure F.1 — Classic hump

The value e_v is specified for reference vehicles with a_r = 17,8 m.

The rail brakes can be included in concave radius gradient transitions $R_v \geq 300$ m and at the limit of convex radius transitions $R_v \geq 250$ m.

For the infrastructure, as the height difference is 0,040 m between point A and point B (see Figure F.1 and Figure 34).

$$e_v = 0{,}040 . \frac{250}{R_v} . \frac{3-x}{3} \qquad \text{(F.1)}$$

For the rolling stock:

— for short vehicles with $a \leq 17{,}8$ m;

for crossing point A, which is the determining factor when $n_i <$ (a-3)/3

$$e_i = \frac{n_i}{a}\frac{(a - n_i - 3)^2}{2R_v} \quad \text{(F.2)}$$

for crossing point B, which is the determining factor when $n_i \geq$ (a-3)/3

$$e_i = \frac{(a-3)^3}{3375a} \quad \text{(F.3)}$$

— for longer vehicles with $a > 17{,}8$ m;

for crossing point A, which is the determining factor when $n_i <$ (a-3)/3

$$e'_i = \frac{27}{4}.\frac{n_i}{a-3}.\left(1 - \frac{n_i}{a-3}\right)^2.\left(\frac{a^2}{3375} - 0{,}040\right) \quad \text{(F.4)}$$

for crossing point B, which is the determining factor when $n_i \geq$ (a-3)/3

$$e'_i = \frac{a^2}{3375} - 0{,}040 \quad \text{(F.5)}$$

for crossing the top of the hump with the central part of the vehicle

$$e_i = \frac{an_i - n_i^2 + \dfrac{p^2}{4}}{2R_v} - h_{u_{\min}} = \frac{an_i - n_i^2 + \dfrac{p^2}{4}}{500} - 0{,}125 \quad \text{(F.6)}$$

With standard values for R_v and $h_{u_{\min}}$ of a classic hump.

F.3.1.3 Special humps for low-floor wagons

Progressive reduction $h_{\max}$ over a distance X = 5 m to allow, in addition to vehicles capable of passing over the classic humps, special wagons intended for combined rail-road traffic or pocket wagons (see Figure F.1 restricted condition).

The value e_v is specified for reference vehicles with a_r = 15,8 m.

The rail brakes can be included in concave radius gradient transitions $R_v \geq 300$ m and at the limit of convex radius transitions $R_v \geq 250$ m.

For the infrastructure:

$$e_v = \left[\frac{(15{,}80 - x)^3}{53325} - 0{,}024\right]\frac{250}{R_v} \qquad \text{(F.7)}$$

For the vehicle:

— for short vehicles with $a \leq 15{,}8$ m;

for crossing point A, which is the determining factor when $n_i <$ (a-5)/3

$$e_i = \frac{n_i}{a}\frac{(a - n_i - 5)^2}{500} \qquad \text{(F.8)}$$

for crossing point B, which is the determining factor when $n_i \geq$ (a-5)/3

$$e_i = \frac{(a-5)^3}{3375a} \qquad \text{(F.9)}$$

— for longer vehicles with $a > 15{,}8$ m;

for crossing point A, which is the determining factor when $n_i < (a - 5)/3$

$$e'_i = \frac{27}{4}.\frac{n_i}{a-5}.\left(1 - \frac{n_i}{a-5}\right)^2.\left(\frac{a^2}{3375} - 0{,}050\right) \qquad \text{(F.10)}$$

for crossing point B, which is the determining factor when $n_i \geq (a - 5)/3$

$$e'_i = \frac{a^2}{3375} - 0{,}050 \qquad \text{(F.11)}$$

for crossing the top of the hump with the central part of the vehicle

$$e_i = \frac{a^2 + p^2}{2000} - 250 + \sqrt{62500 - (\frac{a}{2} - n_i)^2} - 0{,}125 \qquad \text{(F.12)}$$

F.3.2 Other agreements

F.3.2.1 Marshalling hump used in Finland

Figure F.2 shows the Finnish marshalling hump, rail brake position.

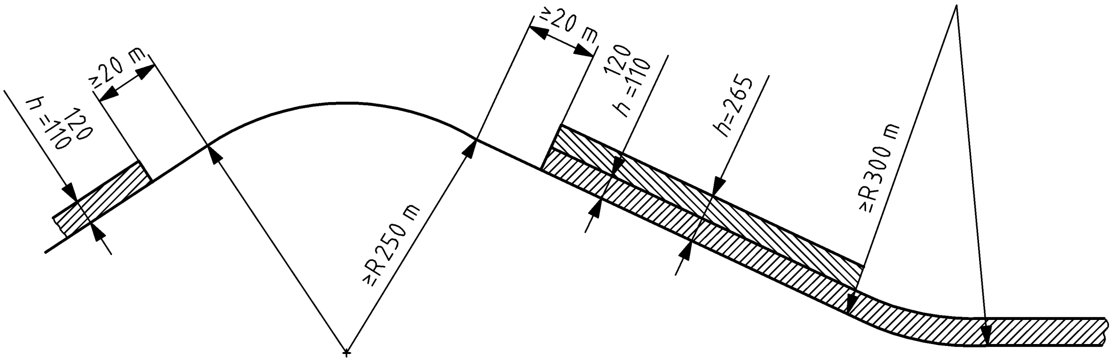
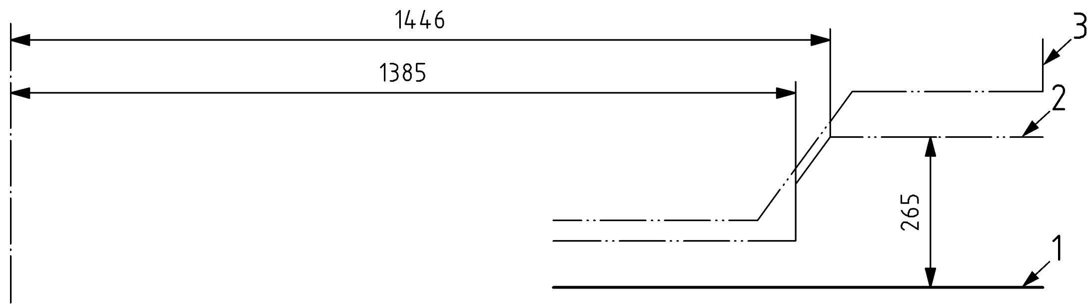


Figure F.2 — Finnish marshalling hump, rail brake position

Figure F.3 shows the rail brake gauge on the approaches to the Finnish marshalling humps.

Dimensions in millimetres



Key

1 running surface

2 maximum rail brake gauge

3 rolling stock gauge

Figure F.3 — Rail brake gauge on the approaches to the Finnish marshalling humps

If the rail brake is installed on a curve, the values 1,385 m and 1,446 m are to be increased by the widening value 36/R.

Annex G
(normative)

Rules relating to pantographs

G.1 Catalogue of standard heads

Except in special cases, the dimensions of the standard heads and the semi-width b_w are listed in EN 50367.

The head used by the rolling stock shall be compatible with that taken into account by the infrastructure.

G.2 Reference vehicle parameters

Table G.1 lists the reference vehicle parameters.

Table G.1 — Reference vehicle parameters

	Gauges G1, G2, GA, GB, GB1, GB2, GC, etc.	Gauges BE1, BE2 and BE3	Dynamic gauges SEa, SEc	Gauges GHE16, GEA16, GEB16 and GEC16	Gauge GEC14	GEE10
b_w	EN 50367	0,880 m (3kV) 0,800 m (25kV) as per EN 50367	0,900 m	EN 50367	EN 50367	1,7 m
d	1,410 m	1,410 m	1,410 m		1,410 m	
L	1,500 m	1,500 m	1,500 m	1,733 m	1,5 m	1,055 m
$l_{\max}$	1,465 m	1,465 m	1,465 m	1,698 m	1,465 m	1,030 m
$q_r + w_r$	0,0375 m	0,065 m	*Reserved*	0,0375 m	0,0375 m	
K'	0,04	0,05	0			
s'_0	0,225	0,4	*Reserved*	0,225	0,225	0,225
I'_0, D'_0	0,066 m	0,066 m	*Reserved*	0,066 m	0,066 m	0,07 m
$I_{\max}; D_{\max}$	0,200 m	0,200 m	*Reserved*	0,160 m	0,160 m	0,120 m
h_{c0}	0,5 m	0,5 m	*Reserved*	0,5 m	0,5 m	0,5 m
h'_u	5 m	5 m	*Reserved*	5 m	5 m	4,3 m

Table G.1 *(continued)*

t	0,030 m	0,030 m	0,030 m	0,03 m	0,03 m	0,03 m
	Gauges G1, G2, GA, GB, GB1, GB2, GC, etc.	Gauges BE1, BE2 and BE3	Dynamic gauges SEa, SEc	Gauges GHE16, GEA16, GEB16 and GEC16	Gauge GEC14	GEE10
τ	0,01 m	0,01 m	0,010 m	0,01 m	0,01 m	0,01 m
Θ	0,005 rad	0,005 rad	0	0,005 rad	0,005 rad	0,005 rad
S_0	$\frac{2{,}5}{R}+\frac{l-1{,}435}{2}$	$\frac{2{,}5}{R}+\frac{l-1{,}435}{2}$	$\frac{21}{R}+\frac{l-1{,}435}{2}$	$\frac{2{,}5}{R}+\frac{l-1{,}668}{2}$	$\frac{2{,}5}{R}+\frac{l-1{,}435}{2}$	$\frac{1}{R}+\frac{l-1{,}000}{2}$
$e_{p_{u\,cin}}$	0,110 m $(h'_u = 5)$	0,170 m $(h'_u = 5)$	$e_{p_{u\,dyn}(h'_u=5{,}9)} =$ *Reserved*	0,110 m $(h'_u = 5)$	0,110 m $(h'_u = 5)$	0,082 m $(h'_u = 4{,}3)$
$e_{p_{o\,cin}}$	0,170 m $(h'_o = 6{,}5)$	0,245 m $(h'_o = 6{,}5)$	*Reserved*	0,170 m $(h'_o = 6{,}5)$	0,170 m $(h'_o = 6{,}5)$	0,150 m $(h'_o = 5{,}5)$

G.3 Electrical insulating allowances

A distinction is made between two types of insulating allowances:

— a fixed value used by the rolling stock to define the zone of the non-insulated roof-mounted live parts;

— a variable value used by the infrastructure depending on the environment of the live parts and their displacements.

Table G.2 lists the values of the two types of insulating allowances.

Table G.2 — Values of the two types of insulating allowances

	Content	**Infrastructure**
25 kV AC	0,170 m	EN 50119
15 kV AC	0,150 m	
3 kV DC	0,100 m	
1.5 kV DC	0,100 m	
750 V	*Reserved*	

G.4 Characteristics of the collection system

Table G.3 lists characteristics of the collection system.

Table G.3 — Characteristics of the collection system

	Content	Infrastructure
f_s	*Reserved*	*Reserved*
f_{wa}	*Reserved*	*Reserved*
f_{ws}	0,060 m	*Reserved*

G.5 Specific cases

G.5.1 Pantograph gauges linked to gauges BE1, BE2 and BE3, 3kV network

On the part of the Belgian network with 3 kV power supply, a specific pantograph gauge in the collection position is achieved by the infrastructure to on the one hand enable the operation of locomotives fitted with pantographs with a width of 1,760 m ($b_w = 0{,}880$ m; $e_{p_o} = 0{,}245$ m and $e_{p_u} = 0{,}170\,\text{m}$) with no insulating horn, as shown in Figure G.1 with $s \leq 0{,}4$ and transverse clearance, $q + w \leq 0{,}065$ m and on the other hand the operation of traction units fitted with pantographs with a width of 1,950 m fitted with insulating horns, in accordance with EN 50367 ($b_w = 0{,}975$ m; $e_{p_o} = 0{,}170$ m and $e_{p_u} = 0{,}110\,\text{m}$) with $s = 0{,}225$ and transverse clearance, $q + w$ $\leq 0{,}0375$ m as stipulated in the rules for gauge G1.

The specific reference profile in Figure G0.2 is established for $I'_0{}^{ou}\; D'_0 = 0{,}066\text{m}$ and its associated rules allow the rolling stock to verify that the 3 kV pantographs in the raised position fit the gauge.

Dimensions in millimetres

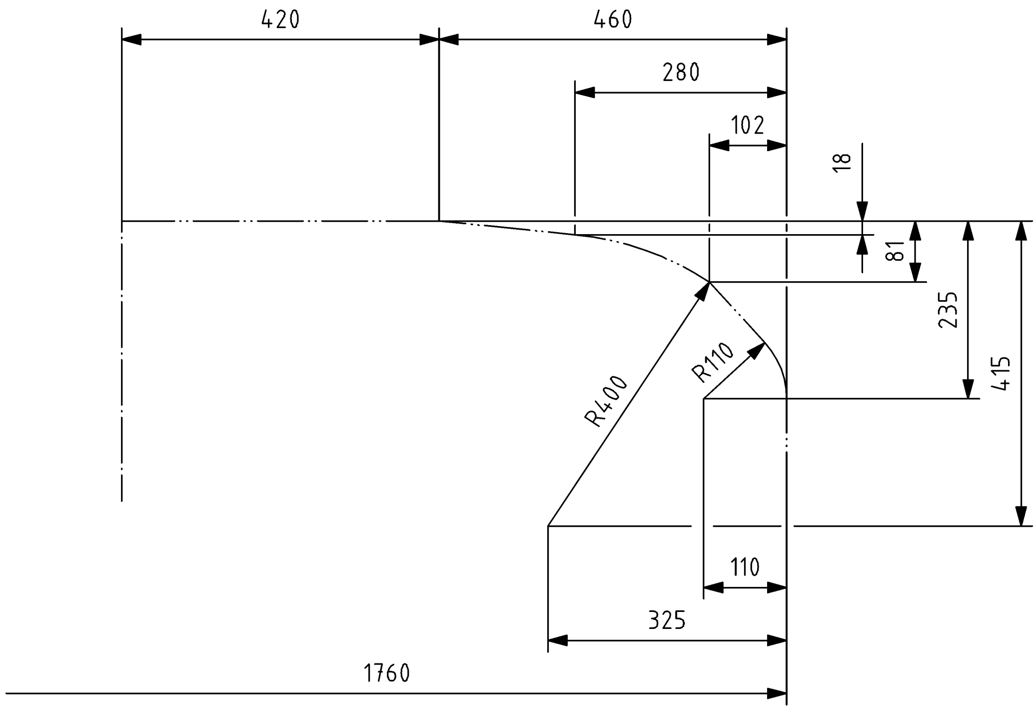
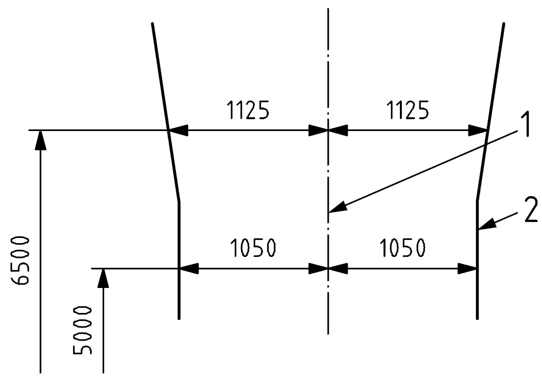


Figure G.1 — Head with 1,760 m width

Dimensions in millimetres



Key

1 centreline common to the vehicle and the track

2 kinematic reference profile ($b_w = 0{,}880$ m; $e_{p_o} = 0{,}245$ m and $e_{p_u} = 0{,}170$ m)

Figure G.2 — Kinematic reference profile for 3 kV pantographs in the raised position for gauges BE1, BE2 and BE3

G.5.2 Pantograph gauges linked to gauges BE1, BE2 and BE3, 25 kV network

With regard to the Belgian network supplied with 25 kV, the infrastructure is cleared for the 1,600 m wide head ($b_w = 0{,}800$ m; $e_{p_o} = 0{,}245$ m and $e_{p_u} = 0{,}170$ m) according to EN 50367 with $s \leq 0{,}4$ and a transverse clearance $q + w \leq 0{,}065$ m.

The specific reference profile in Figure G.3 is established for $I'_0{}^{ou} D'_0 = 0{,}066\text{m}$ and its associated rules allow the rolling stock to verify that the 25 kV pantographs in the raised position fit the gauge.

Dimensions in millimetres

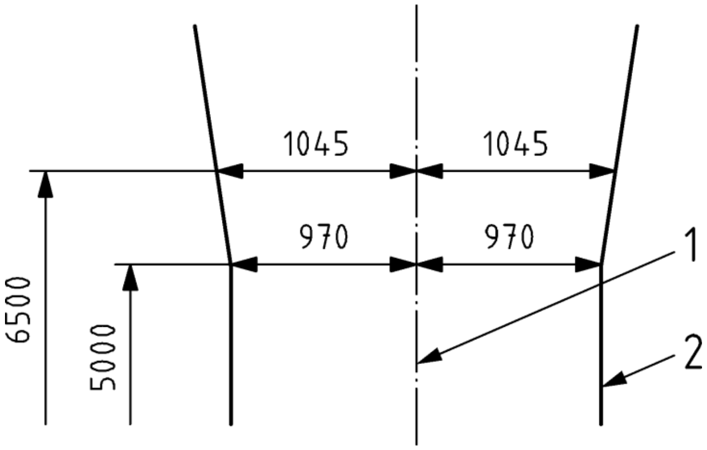


Figure G.3 — Kinematic reference profile for 25 kV pantographs in the raised position for gauges BE1, BE2 and BE3

For tilting body vehicles, the rules of gauge G1 are applicable, but the formulae shall be adapted to take into account the difference in e_p .

Annex H
(normative)

Rules relating to access steps and platform installation

H.1 Actual and conventional gap between step and platform: general

This Annex only covers platforms of height greater than 0,400 m.

Platforms of height less than 0,400 m are not taken into account given that, for these platforms, the horizontal gap is negligible or non-existent.

Platforms are to be considered as structures that, to ensure their function, shall be located as close as possible to the stationary rolling stock whilst allowing trains to pass at full speed.

The platforms shall be installed according to the installation rules of the largest structure limit gauge cleared on the route while meeting the rules in force.

The vehicle steps shall be positioned and dimensioned according to the rules set down in EN 15273-2, in compliance with the gauge used for the construction of the vehicle.

The actual gap $b_{lac\ réel}$ varies greatly given that it depends on

firstly:

- any difference between the gauge used for the infrastructure and that used for the vehicle;
- the effect of the curves and the transitions in plan view and in cross-section;
- the presence of switches and crossings;
- gauge widening, platform installation and maintenance tolerances;
- the local allowances required by the infrastructure;
- the effect of cant;

and also:

- the random position of the vehicle relative to the track centreline;
- the design of the rolling stock;
- the position of the doors;
- the functional characteristics and clearance.

In practice, the actual gap may be greater than the conventional gap (see Figure H.1).

A conventional gap "b_{lac0}" imposed by the regulations in force shall be adhered to by the rolling stock in relation to the position of the platforms.

For this:

— the platform is considered to be a conventional distance b_{q0i} or b_{q0a} from the centreline of the track, corresponding to the structure installation limit dimension;

— the vehicle is considered, stopped and perfectly centred on the track, without cant, while taking into account the geometric overthrow dg_i or dg_a in the middle of the step height in the minimum curve specified by the regulation in force;

— the step tread is located at a distance b from the centreline of the vehicle.

Thus

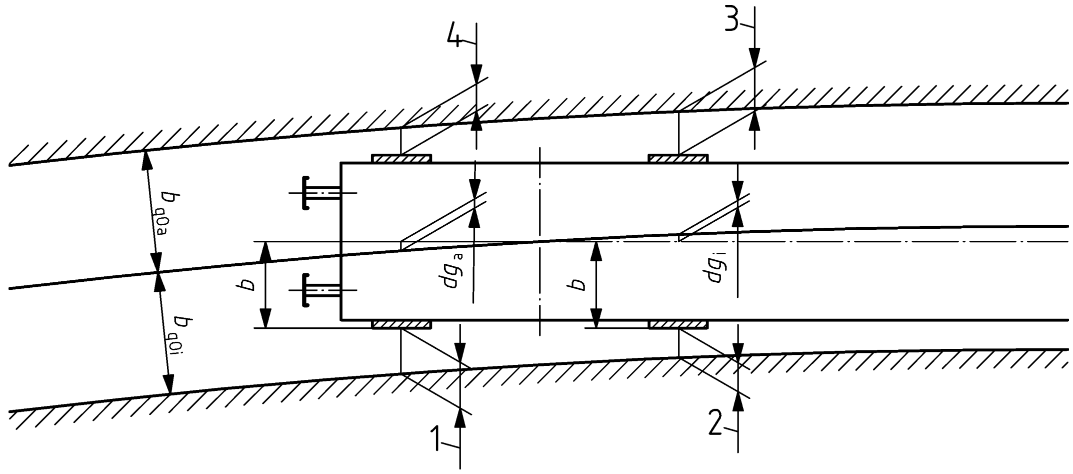


Figure H.1 — Illustration of the conventional gap

— on the inside of the curve

$$b_{lac0} = b_{q0i} - b + dg_a \quad \text{(H.1)}$$

for doors beyond the bogie centres;

$$b_{lac0} = b_{q0i} - b - dg_i \quad \text{(H.2)}$$

for doors located between the bogie centres;

— on the outside of the curve

$$b_{lac\,0} = b_{q0a} - b + dg_i \tag{H.3}$$

for doors located between the bogie centres;

$$b_{lac\,0} = b_{q0a} - b - dg_a \tag{H.4}$$

for doors located between the bogie centres.

H.2 Actual and conventional gap between step and platform: position of the platforms

H.2.1Actual position of the platforms

The platforms are installed at a distance b_q from the track centreline, taking into account the widest gauge to be cleared (see Figure H.2).

To fit the gauge, the limit value needs to be cleared $b_{q\,\lim}$:

for the static gauge

$$b_{q\,\lim} = b_{CR\,st} + S_{st} + z_0 + \left[qs_i \overset{ou}{} qs_a \right] + \Sigma_{2cin} + \delta_{qa} \tag{H.5}$$

for the kinematic gauge

$$b_{q\,\lim} = b_{CR\,cin} + S_{cin} + \left[qs_i \overset{ou}{} qs_a \right] + \Sigma_{2cin} + \delta_{qa} \tag{H.6}$$

for the dynamic gauge

$$b_{q\,\lim} = b_{CR\,dyn} + S_{dyn} + \Sigma_{2dyn} + \delta_{q\,a} \tag{H.7}$$

With:

$$\delta_{q\,a} = \left[\left(\frac{D}{L} \right) h_{nez} \right]_{\leq \delta_{qa\max}} \tag{H.8}$$

for platforms on the outside of the curve with edge copings;

$$\delta_{q\,a} = \left[\left(\frac{D}{L} \right) \left(h_q - h_{\min CR} \right) \right]_{\leq \delta_{qa\max}} \tag{H.9}$$

for platforms on the outside of the curve without edge copings.

It should be noted that the value δ_{qa} relating to the installed cant may be compensated for by a projecting edge coping extending the edge of the platform, overhanging the space required for the gauge roll, perpendicular to the running surface. The part exceeding the maximum value δ_{qa} allowed by the regulation in force shall be compensated for.

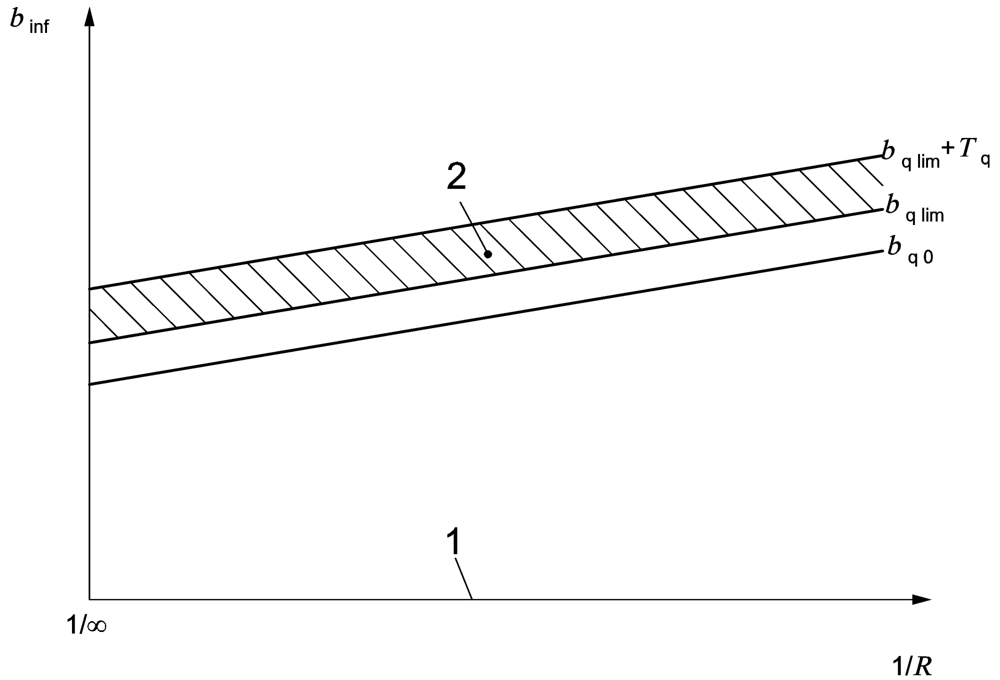
The regulatory tolerances "T_q" required for installation and maintenance may be added to value $b_{q\lim}$.

In order to fit both the structure limit gauge and the minimum possible gap, the distance b_q shall be between the following limits:

$$b_{q\lim} \leq b_q \leq b_{q\lim} + T_q \quad \text{(H.10)}$$

It is then assumed that:

$b_{q0} \leq b_q$



Key

1 track centreline

2 platform installation zone

Figure H.2 — Position of the platforms

Where there are switches and crossings, the additional overthrows S_{st}, S_{cin}, S_{dyn} and the quasi-static effect $\lfloor qs_i^{ou} qs_a \rfloor$ shall be adapted to the local situation.

For practical control relative to the rail running edge, the infrastructure may verify the dimension

$$b'_q = b_q - \frac{l_{\text{réel}}}{2} \qquad \text{(H.11)}$$

measured parallel to the running surface.

The amount of the maintenance allowance $M_{(2)}$ used in $\Sigma_{(2)}$ depends on the regulation in force on the route concerned. The verification value $\Sigma_{(1)}$ shall be defined by the infrastructure.

H.2.2 Conventional position of the platforms

H.2.2.1 Agreement

In relation to calculating the conventional gap $b_{lac\,0}$, account is taken of a conventional value $b_{q\,0}$ in which the presence of gauges of different widths, the presence of switches and crossings, the effect of the quasi-static roll $\left\lfloor qs_i \overset{ou}{} qs_a \right\rfloor$, the installation and maintenance tolerances T_q of the platforms, the value δ_{qa} and gauge widening are not taken into account.

Thus

for the static gauge

$$b_{q0} = b_{CR\,st} + S_{st} + z_0 + \Sigma_{2\,cin} \qquad \text{(H.12)}$$

for the kinematic gauge

$$b_{q0} = b_{CR\,cin} + S_{cin} + \Sigma_{2\,cin} \qquad \text{(H.13)}$$

for the dynamic gauge

$$b_{q0} = b_{CR\,dyn} + S_{dyn} + \Sigma_{2\,dyn} \qquad \text{(H.14)}$$

H.2.2.2 Conventional values to be considered for the position of the platforms

H.2.2.2.1 General case for gauges G1, G2, GA, GB, GB1, GB2, GC, etc.

Platform height	$R \geq 250\,m$
$h \geq 0{,}400\,\text{m}$	$b_{q0} = 1{,}650 + \frac{3{,}75}{R}$ (H.15)

H.2.2.2.2 Specific cases

For Finland

$$b_{q0} = 1{,}800 + \frac{36}{R} \tag{H.16}$$

For Poland

$$b_{q0} = 1{,}725 + \frac{36}{R} \tag{H.17}$$

For Italy

$$b_{q0} = 1{,}650 + \frac{3{,}75}{R} + 0{,}0115 \tag{H.18}$$

For the United Kingdom (platforms 0,915 m high)

Standard platforms

$\infty \geq R \geq 360m$	$360m \geq R \geq 160m$
$b_{q_0} = 1{,}4475$ (H.19)	$b_{q_0} = 1{,}3755 + \frac{26}{R}$ (H.20)

Platforms on routes operating with (Class 373) Eurostar rolling stock.

$\infty \geq R \geq 360m$	$360m \geq R \geq 160m$
$b_{q_0} = 1{,}4775$ (H.21)	$b_{q_0} = 1{,}4055 + \frac{26}{R}$ (H.22)

Platform on goods routes operating with containers 2,6 m wide.

	$\infty \geq R \geq 500m$	$500m \geq R \geq 160m$
Inside curve	$b_{q0} = 1{,}4475$ (H.23)	$b_{q0} = 1{,}3815 + \frac{33}{R}$ (H.24)

	$\infty \geq R \geq 360m$	$360m \geq R \geq 160m$
Outside curve	$b_{q0} = 1{,}4475$ (H.25)	$b_{q0} = 1{,}3755 + \frac{26}{R}$ (H.26)

For Belgium

$R \geq 1000m$	$R < 1000m$
$b_{q0} = 1{,}650 + \frac{5}{R}$ (H.27)	$b_{q0} = 1{,}650 + \frac{26{,}47}{R} - 0{,}0215$ (H.28)

For Sweden SEa and SEc

$$b_{q0} = 1{,}670 + \frac{41}{R} \tag{H.29}$$

inside of the curve,

$$b_{q0} = 1{,}670 + \frac{31}{R} \tag{H.30}$$

on the outside of the curve.

For Spain

For kinematic gauges GHE16, GEA16, GEB16 and GEC16

$$b_{qo} = 1{,}72 + \frac{3{,}75}{R} \tag{H.31}$$

H.3 Actual and conventional gap between step and platform: position of the steps

The steps shall be positioned in order to ensure the maximum conventional gap $b_{lac\,0}$ in the curves between the straight track and the minimum verification radius R specified in the regulation in force.

The geometric overthrow of vehicle dg_a or dg_i, considered at mid-width of the step height in the curve shall not exceed:

— on the inside of the curve;

$$dg_{i_{\max}} = b_{q0i} - b - b_{lac\,0} \quad \text{(H.32)}$$

for doors located between the bogie centres,

$$dg_{a_{\max}} = b + b_{lac\,0} - b_{q0i} \quad \text{(H.33)}$$

for doors located beyond the bogie centres,

— on the outside of the curve;

$$dg_{i_{\max}} = b + b_{lac\,0} - b_{q0a} \quad \text{(H.34)}$$

for doors located between the bogie centres,

$$dg_{a_{\max}} = b_{q0a} - b - b_{lac\,0} \quad \text{(H.35)}$$

for doors located beyond the bogie centres.

Therefore, the positioning of the doors relative to the bogie centres may be limited; EN 15273-2 gives the rules to be followed for the design of the steps.

Annex I
(informative)

Widening of the vehicles according to the possibilities offered by the infrastructure

I.1 General

This Annex is reserved for **kinematic gauges** in which the infrastructures may offer extra space for the rolling stock.

This Annex authorizes the establishment of certain specific agreements with regard to **limited interoperability** on infrastructures that offer possibilities for widening the vehicles.

This agreement requires a prior agreement of the infrastructure manager(s) concerned, regarding the application of specific maintenance rules for the minimum distances between the track centres, for the cant modification limits, for the structure limit position, etc.

This agreement corresponds to a new, quite specific kinematic gauge and simultaneous operating restrictions with extraordinary transportation that generally already uses this same reserve.

The principle retained is to use the difference between the allowances taken into account by the infrastructure, either fixed or by calculation according to the reference vehicle parameters, and those effectively required for the rolling stock under examination and in relation to those possibly already allowed for these same infrastructures.

The reserve available for the rolling stock shall exist both on the structure side and on the track centre side.

I.2 Possible gain on the track centre side

I.2.1 Basic principle

The following calculation method, taken from EN 15273-3, makes it possible to determine the sum of the safety allowances Σ'_{EA2} capable of being used in the definition of the limit distance between the track centres (see Figure I.1):

$$\Sigma'_{EA2} = \sqrt{\left(\Sigma'^{2}_{2,i}\right) + \left(\Sigma'^{2}_{2,a}\right)} \qquad \text{(I.1)}$$

where

$$\Sigma'_{2,i/a} = k\sqrt{T^{2}_{voie} + \left[\frac{T_D}{L}h + s_0\frac{T_D}{L}\left[h - h_{C0}\right]_{>0}\right]^2 + \left[tg\left(T_{susp}\right)\left[h - h_{C0}\right]_{>0}\right]^2 + \left[tg\left(T_{charge}\right)\left[h - h_{C0}\right]_{>0}\right]^2 + \left[\frac{s_0}{L}T_{osc}\left[h - h_{C0}\right]_{>0}\right]^2} \qquad \text{(I.2)}$$

According to the principle explained in 7.3.1.9.2 and the practical indications given in EN 15273-3, on a straight track, $\sum'_{2,i}$ is considered to be equal to $\sum'_{2,a}$, and therefore, Σ'_{EA2} may be reduced to:

$$\Sigma'_{EA2} = \sum'_{2,a} \sqrt{2} \qquad \text{(I.3)}$$

Generally, this allowance is calculated for the height of point P.

The values of the terms k, T_{track}, T_D, T_{susp}, T_{charge} and T_{osc} shall be defined by the infrastructure. For information, some recommended values are given in [A1⟩ EN 15273-3:2013+A1:2016 ⟨A1], A3.

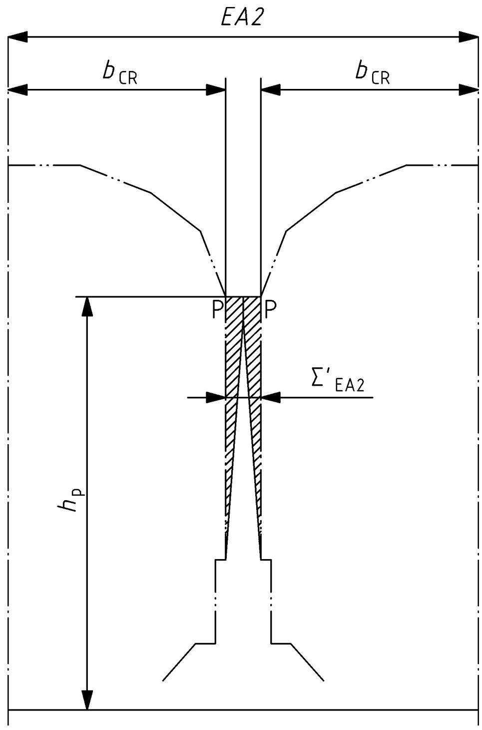


Figure I.1 — Limit distance between the track centres with allowance calculated on a straight track

Where the infrastructure uses fixed allowances, Figure I.2 becomes:

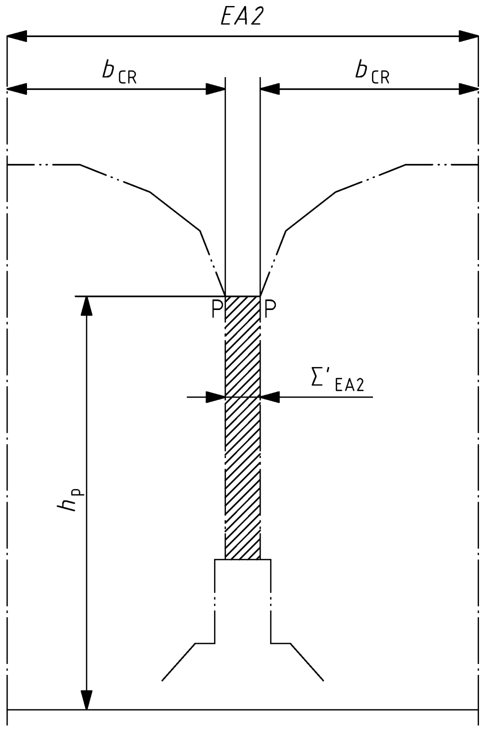
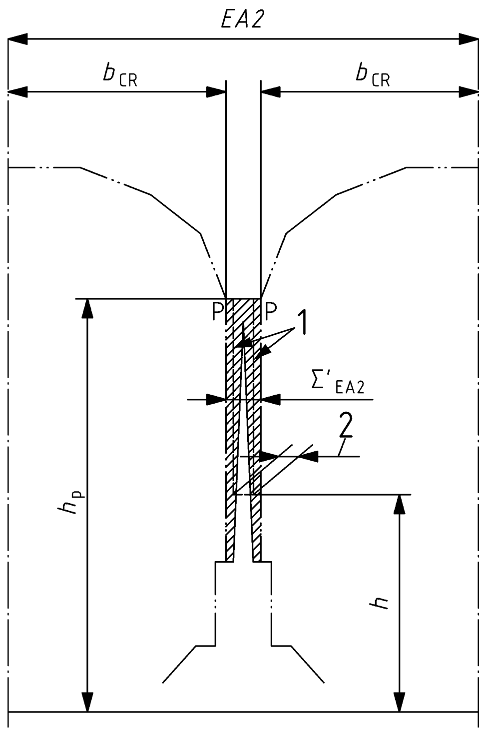


Figure I.2 — Limit distance between the track centres on a straight track with fixed allowance

I.2.2 Application

I.2.2.1 Case of calculated allowances

Assuming that there is no cant difference ΔD having a negative effect on the value of the distance between the track centres along the route under consideration, the difference between the allowance obtained by the infrastructure for the height of point P and that calculated for any height with the parameters of the vehicle under examination provides a possibility of increasing the width of the rolling stock for the height considered (see Figure I.3).



Key

1 allowance calculated with the parameters of the vehicle under examination

2 possibility of widening the rolling stock for height *h*

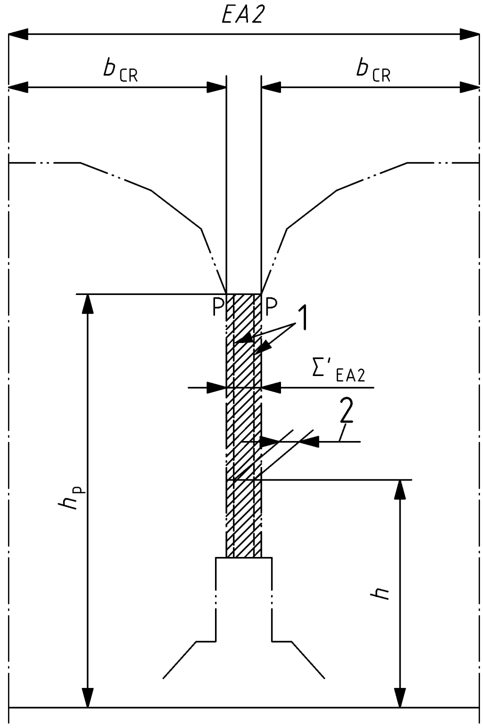
Figure I.3 — Possibility of widening the rolling stock on the track centre side, in the case of calculated infrastructure allowances

$$Réserve = k\sqrt{2}\left[\begin{array}{l}\sqrt{T_{voie}^2 + \left[\frac{T_D}{L} h_P + s_0 \frac{T_D}{L}\left[h_P - h_{C0}\right]_{>0}\right]^2 + \left[tg\left(T_{susp}\right)\left[h_P - h_{C0}\right]_{>0}\right]^2 + \left[tg\left(T_{charge}\right)\left[h - h_{C0}\right]_{>0}\right]^2 + \left[\frac{s_0}{L} T_{osc}\left[h_P - h_{C0}\right]_{>0}\right]^2} \\ -\sqrt{T_{voie}^2 + \left[\frac{T_D}{L} h + s \frac{T_D}{L}\left[h - h_C\right]_{>0}\right]^2 + \left[tg\left(T_{susp}\right)\left[h - h_C\right]_{>0}\right]^2 + \left[tg\left(T_{charge}\right)\left[h - h_C\right]_{>0}\right]^2 + \left[\frac{s}{L} T_{osc}\left[h - h_C\right]_{>0}\right]^2}\end{array}\right] \quad (I.4)$$

I.2.2.2 Case of fixed allowances

Assuming that there is no cant difference ΔD having a negative effect on the value of the distance between the track centres along the route under consideration, the difference between the fixed allowance taken into account by the infrastructure and that calculated for any height with the parameters of the vehicle under examination provides a possibility of increasing the width of the rolling stock for the height considered (see Figure I.4).

Dimensions in millimetres



Key

1 allowance calculated with the parameters of the vehicle under examination

2 possibility of widening the rolling stock for height *h*

Figure I.4 — Possibility of widening the rolling stock on the track centre side, in the case of a fixed infrastructure allowance

$$Réserve = \Sigma'_{EA2} - k\sqrt{2}\sqrt{T_{voie}^2 + \left[\frac{T_D}{L}h + s\frac{T_D}{L}[h - h_C]_{>0}\right]^2 + \left[tg(T_{susp})[h - h_C]_{>0}\right]^2 + \left[tg(T_{charge})[h - h_C]_{>0}\right]^2 + \left[\frac{s}{L}T_{osc}[h - h_C]_{>0}\right]^2} \quad (I.5)$$

I.3 Possible gain on the structure side

On the routes concerned, the infrastructure shall check the reserve available.

The rules relating to the allowances M_1, M_2 and M_3 of the kinematic gauge as defined in this standard as well as in EN 15273-3 are applicable.

The maintenance rules of the infrastructure shall be adapted to take into account the space given over to the rolling stock.

Annex J
(normative)

Application of the probability theory in conjunction with the limit values taking into account the oscillations and dissymmetry in the determination of allowance M1

J.1 General

This annex justifies the gauging method given in 7.3 and applied in [A1⟩ EN 15273-3:2013+A1:2016 ⟨A1], Annex A for the kinematic gauge example.

The same principle may also be applied to other types of gauges.

J.2 Reminder of some principles of the probability theory

Given a random variable T_1 satisfying the normal distribution law (Gauss' law) and whose distribution is symmetrical in relation to the value $t_1 = 0$, when the standard deviation δ_1 is selected as the x-axis unit, the value t_1 of variable T_1 has a probability as shown in Figure J.1.

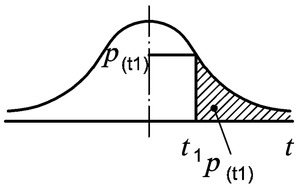


Figure J.1 — Probability of value t_1

$$p(t_1) = \frac{1}{\sqrt{2\pi}} e^{-\frac{t_1^2}{2}} \qquad \text{(J.1)}$$

The reference to Gauss' law is perfectly normal here. It is shown that if a regular distribution law for a random element is assumed of the type shown in (a) opposite (very unfavourable case), the conjunction of two similar independent elements obey a distribution law of type (b) opposite (2 straight lines). With 3 elements, the distribution is of type (c) 3 parabolic arcs tangential to each other. Beyond that, the resulting distribution becomes ever closer to the Gauss distribution.

And the probability of having a value of T_1 greater than t_1 is:

$$p(t_1)=\frac{1}{\sqrt{2\pi}}\int_{t_1}^{\infty} e^{\left(-\frac{t^2}{2}\right)}dt=\frac{1}{2}-\frac{1}{\sqrt{2\pi}}\int_{0}^{t_1} e^{\left(-\frac{t^2}{2}\right)}dt \qquad \text{(J.2)}$$

(tables give these values).

If several random independent variables T_1, T_2, T_3, etc. to T_n each follow a normal law, any linear function of these variables will also follow a normal law.

If U is the resultant of these variables according to the relationship:

$U = T_1 + T_2 + T_3 + \text{etc. to} + T_n$

and if T_1 etc. to T_n have a symmetrical distribution relative to the value 0, U follows a normal mean 0 and standard deviation law:

$$\sigma_n=\sqrt{\sigma_1^2+\sigma_2^2+\ldots\ldots+\sigma_n^2} \qquad \text{(J.3)}$$

I.e. t_1, t_2 etc. to t_n of the values for T_1, T_2 etc. to T_n are equally likely to be exceeded:

$$\frac{t_1}{\sigma_1}=\frac{t_2}{\sigma_2}=\ldots\ldots=\frac{t_n}{\sigma_n}=k\Leftrightarrow P(t_1)=P(t_2)=\ldots=P(t_n)=P(t) \qquad \text{(J.4)}$$

the value u of U such that $P(u)=P(t)$ is

$$u=k\sigma_u=\sqrt{k^2\sigma_1^2+k^2\sigma_2^2+\ldots\ldots+k^2\sigma_n^2}=\sqrt{t_1^2+t_2^2+\ldots\ldots t_n^2} \qquad \text{(J.5)}$$

That is to say that, considering several independent random variables T_1, T_2, etc. to T_n whose values t_1, t_2 etc. to t_n have the same probability $P(t)$ of being exceeded, the value of the resulting $U = T_1 + T_2 + \text{etc. to} + T_n$ such as $P(u)=P(t)$ is

$$u=\sqrt{t_1^2+t_2^2+\ldots\ldots t_n^2} \qquad \text{(J.6)}$$

That is to say that, two sets of n independent random variables (T_1, T_2 etc. to T_n), (T'_1, T'_2 etc. to T'_n) whose values $t_1 = t'_1$, $t_2 = t'_2$ etc. to $t_n = t'_n$ have the same probability $P(t)$ of being exceeded.

The value of the resulting

$U = (T_1 + T_2 + \text{etc. to} + T_n) + (T'_1 + T'_2 + \text{etc. to} + T'_n)$ such as $P(u)=P(t)$ is:

$$u=\sqrt{\left(t_1^2+t_2^2+\ldots\ldots t_n^2\right)+\left(t_1^{'2}+t_2^{'2}+\ldots\ldots t_n^{'2}\right)}=\sqrt{\left(t_1^2+t_2^2+\ldots\ldots t_n^2\right)}\cdot\sqrt{2} \qquad \text{(J.7)}$$

J.3 Taking into account oscillations and dissymmetry in the determination of allowance M1

J.3.1 General

The random displacements considered in this Annex are:

T_{voie} = T_1 - the transverse displacement of the track between two maintenance periods;

T_D = T_2 - cant defects (geometric effect and dynamic effect);

T_{osc} = T_3 - oscillations (other than those generated by a crosslevel error);

T_{susp} = T_4 – the construction or adjustment dissymmetries of the vehicles;

T_{charge} = T_5 – loading dissymmetries.

By way of example, applying the rules given in J.2.1 and J.2.2 to the limit values specified in EN 15273-3, these values will be taken at the height of 3,250 m above the running surface for V > 80 km/h on the outside of a curved track in a well-maintained condition.

$$\left.\begin{array}{l} t_1 = 0{,}025\,\text{m} \\ t_2 = 0{,}01 \cdot 3{,}250 + 0{,}015 \cdot \dfrac{4}{15}(3{,}250 - 0{,}5) = 0{,}0435\,\text{m} \\ \text{(effect of a cant deficiency of } 0{,}015\,\text{m)} \\ t_3 = 0{,}039 \cdot \dfrac{4}{15}(3{,}250 - 0{,}5) = 0{,}0286\,\text{m} \\ \text{(effect of an oscillation angle of } 0{,}6°\text{)} \\ t_4 + t_5 = 0{,}065 \cdot \dfrac{4}{15}(3{,}250 - 0{,}5) = 0{,}0476\,\text{m} \\ (1°\ \text{dissymmetries}); \\ (\text{where } t_4 = 0{,}011\,\text{m}\,;\, t_5 = 0{,}0366\,\text{m} \end{array}\right\} \sum_{1}^{5} t_n = 0{,}1447\,\text{m}$$

Although the above values are given as maxima, it is possible that they would be reached, even exceptionally exceeded; however, it can be regarded that exceeding these same values increased by 20 % is a highly improbable scenario. Their conjunction U would have the same reduced probability of exceeding:

$$u = 1{,}2\sqrt{0{,}025^2 + 0{,}0435^2 + 0{,}0286^2 + 0{,}011^2 + 0{,}0366^2} = 0{,}083\,\text{m}$$

which represents 57,4 % of the sum of the base values $\sum_{1}^{5} t_n$ i.e. a reduction of approximately 40 %.

The rules given above in I.2.2 justify a greater reduction (60 %) for the calculation of the allowances relating to the space between the tracks.

However, if one of the displacements is invalidated or its maximum value is reduced because of circumstances, the reduction percentages are noticeably smaller.

The same is true if a point at a height less than that of the cantrail is considered.

J.3.2 Additional comments

The oscillation values t_3 due to the dynamic interaction of the track and the rolling stock include those generated by the crosslevel error, already included in part in displacement T_2.

The maximum value indicated is therefore probably greater than that of the actual oscillations (other than those generated by a crosslevel error). As for values t_4 and t_5, the probability of their exceeding the overall limit of 1° should be zero for the infrastructure as the rolling stock shall take into account any possibility of exceeding the angle η_0 = 1.

The above consideration does not take account:

— of the fact that a train stop on the inside track of a curve appears in the calculations as an certainty;

— of the fact that the crossing of a train at maximum speed with a train stopped at a reduced gauge point represents a reduced-probability conjunction;

— of the fact that the probability of having the maximum additional overthrows S_i or S_a decreases when leaving the basic radius of 250 m.

These comments are made for the sake of safety, more or less according to the parts of the tracks considered (radius, presence of stop signals, etc.).

They confirm the highly improbable character of exceeding 20 % (coefficient k = 1,2 in [A1⟩ EN 15273-3:2013+A1:2016 ⟨A1], Annex A) of the set of limit values introduced into the above calculation for the sake of safety.

Annex K
(informative)

A–deviations

A-deviation: National deviation due to regulations, the alteration of which is for the time being outside the competence of the CEN/CENELEC national member.

This European Standard falls under Directive 2008/57/EC.

NOTE (from CEN/CENELEC Internal Regulations Part 2: 2006, 2.17): Where standards fall under EC Directives, it is the view of the Commission of the European Communities (OJ No C 59; 1982-03-09) that the effect of the decision of the Court of Justice in case 815/79 Cremonini/Vrankovich (European Court Reports 1980, p. 3583) is that compliance with A-deviations is no longer mandatory and that the free movement of products complying with such a standard should not be restricted except under the safeguard procedure provided for in the relevant Directive.

A-deviations in an EFTA-country are valid instead of the relevant provisions of the European Standard in that country until they have been removed.

In view of the national law in force, Switzerland requests the following A-deviations:

In Switzerland, the dimensions of the gauges and their scope of application are specified in the provisions for the implementation of the railways ordinance (DE-OCF, RS 742.141.11 / http://www.admin.ch/ch/d/sr/c742_141_11.htm):

— for the kinematic reference profiles in article 18.2/47.1,

— for the free space profile for the infrastructure in article 18,

— for the vehicle gauge in article 47.

In accordance with these regulations, for all types of gauge (e.g.: OCF O1, OCF O2, OCF O4), the rules associated with the kinematic reference profile correspond to [A1⟩ EN 15273-1:2013, +A1:2016 ⟨A1] Annex C, C.1.1. (notably the Formulae (C.1), (C.2) and (C.3)), for all values of height h.

In Switzerland, the use of the rules for the calculation of kinematic gauges given in [A1⟩ EN 15273-1:2013, +A1:2016 ⟨A1] Annex C, C.2.2 and C.2.3 (notably Formulae (C.8), (C.9), (C.10) and (C.11)) is not authorised for the upper part (h > 3,250 m).

As a result, the compatibility of OCF gauges with the international gauges of EN 15273-2 is as follows:

— Gauge G1:
Admission without restrictions.

— Gauge GA:
Admission with restrictions for gauge OCF O1. The formulae associated with gauge G1 are to be applied for the calculation of the kinematic gauge of the rolling stock (upper part), for all heights h. In Switzerland, the use of the features provided for in EN15273-2:2013+A1:2016”, Annex B, B.3.3.1, B.3.4.1, B.3.5.1, B.3.6.1 is not authorised for heights h > 3,250 m. Gauge OCF O1 accepts standard loads for gauge GA, specified in File UIC506:2008, Annex B article B.1.1.

— Gauge GB:
Admission with restrictions for gauge OCF O2. The formulae associated with gauge G1 are to be applied for the calculation of the kinematic gauge of the rolling stock (upper part), for all heights h.
In Switzerland, the use of the features provided for in EN 15273-2:2013+A1:2016", Annex B, B.3.3.1, B.3.4.1, B.3.5.1, B.3.6.1 is not authorised for heights h > 3,250 m. Gauge OCF O2 accepts standard loads for gauge GB, specified in File UIC506:2008, article B.1.2.

— Gauge GC:
Admission without restrictions for gauge OCF O4.

The gauge for the infrastructure (upper part) for all types of gauge (OCF O1, OCF O2, OCF O4) is calculated according to EN 15273-3:2013+A1:2016”, Annex C C.2.1, Table C.1 (respectively Annex C, C.2.3, Table C.4).

In Switzerland, the use of the formulae given in EN 15273-3:2013+A1:2016”, Annex C, Tables C.2 and C.3, is not authorised for heights h > 3,250 m.

RATIONALE

In Switzerland, the provisions for the implementation of the railways ordinance (DE-OCF, RS 742.141.11 / http://www.admin.ch/ch/d/sr/c742_141_11.html) shall be complied with in order to ensure the interoperability of the different gauges.

Switzerland has never accepted the features for the upper part (h > 3,250) in accordance with File UIC 506, notably for gauges GA and GB, now contained in EN 15273-1, EN 15273-2 and EN 15273-3.

Bibliography

[1] GOST 9238-83, *The obstacle and vehicle gauges for railways with track gauge of 1520 mm* (*rules applicable to international traffic vehicles towards the East of Finland)*[1)]

[2] UIC 503:2007, *Continental wagons running in Great Britain (via the Channel Tunnel and on Network Rail Infrastructure) — General conditions (reference profile, axle-load, etc.) for the acceptance, in international traffic with Great-Britain, of 2-axle and bogie wagons registered with other UIC member RUs*[2)]

[3] UIC 505-4:1977, *Effects of the application of the kinematic gauges defined in the 505 series of leaflets on the positioning of structures in relation to the tracks and of the tracks in relation to each other*[2)]

[4] UIC 505-5:1977, *Basic conditions common to leaflets 505-1 to 505-4; notes on the preparation and provisions of these leaflets*[2)]

[5] UIC 505-6: 2006, *General rules for interoperable rolling stock gauges (without unloading freight or disembarking passengers) in cross-border traffic between UIC and OSJD*[2)]

[6] UIC 506:2008, *Rules governing application of the enlarged GA, GB and GC gauges*[2)]

[7] UIC 606-1:1987, *Consequences of the application of the kinematic gauge defined by UIC Leaflets in the 505 series on the design of the contact lines*[2)]

[8] UIC 608:2003, *Conditions to be complied with for the pantographs of tractive units used in international services* [2)]

[9] UIC 741:2005, *Passenger stations — Height of platforms — Regulations governing the positioning of platform edges in relation to the track*[2)]

[10] European Directive COST 335, *Passenger's Accessibility of Heavy Rail Systems*[3)]

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1) May be purchased from: The Federal Agency on Technical Regulating and Metrology, Leninsky Prospekt, 9 RU-Moscow, V-49, GSP-1, 119991, Russia

2) May be purchased from: Editions Techniques Ferroviaires (ETF), 16 rue Jean Rey, F-75015 Paris, France

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