

BS EN 15273-3:2013+A1:2016



BSI Standards Publication

Railway applications — Gauges

Part 3: Structure gauges

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National foreword

This British Standard is the UK implementation of EN 15273-3:2013+A1:2016. It supersedes BS EN 15273-3:2013, which is withdrawn.

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

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

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

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

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

0 km/h has an equivalent value of 0 mile/h
70 km/h has an equivalent value of 43 mile/h
80 km/h has an equivalent value of 50 mile/h
140 km/h has an equivalent value of 90 mile/h
160 km/h has an equivalent value of 100 mile/h
200 km/h has an equivalent value of 125 mile/h
250 km/h has an equivalent value of 155 mile/h

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

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

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

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

Mandatory European requirements relating to structure gauges are set out in the High Speed Infrastructure Technical Specification for Infrastructure (HS INF TSI), and the Conventional Rail Infrastructure Technical Specification for Interoperability (CR INF TSI). Both TSIs contain GB specific cases relating to structure gauge in the case of renewal or upgrading of infrastructure. These should be read in conjunction with BS EN 15273.

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

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

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

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

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

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

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English Version

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des obstacles

Bahnanwendungen - Begrenzungslinien - Teil 3:
Lichtraumprofile

This European Standard was approved by CEN on 15 December 2012 and includes Amendment 1 approved by CEN on 31 July 2016.

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European foreword

This document (EN 15273-3:2013+A1:2016) has been prepared by Technical Committee CEN/TC 256 "Railway applications", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2017, and conflicting national standards shall be withdrawn at the latest by May 2017.

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

This document includes Amendment 1, which was approved by CEN on 31 July 2016.

This document replaces document EN 15273-3:2013.

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

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

A1 *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 third of a series of three parts of the European Standard covering gauges:

- EN 15273-1 covers general principles, phenomena shared by the infrastructure and by the rolling stock, reference profiles and their associated rules;
- EN 15273-2 gives the rules for dimensioning the vehicles as a function of their specific characteristics for the relevant gauge and for the related calculation method;
- EN 15273-3 gives the rules for dimensioning the infrastructure in order to allow vehicles built according to the relevant gauge and taking account of the specific constraints to operate within it.

1 Scope

This standard:

- defines the various profiles needed to install, verify and maintain the various structures near the structure gauge;
- lists the various phenomena to be taken into account to determine the structure gauge;
- defines a methodology that may be used to calculate the various profiles from these phenomena;
- lists the rules to determine the distance between the track centres;
- lists the rules to be complied with when building the platforms;
- lists the rules to determine the pantograph gauge;
- lists the formulae needed to calculate the structure gauges in the catalogue.

The defined gauge includes the space to be gauged 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 methodologies to demonstrate gauge compatibility between infrastructure and rolling stock.

This standard defines the responsibilities of the following parties:

- a) for the infrastructure:
 - 1) gauge clearance;
 - 2) maintenance;
 - 3) infrastructure monitoring.
- b) for the rolling stock:
 - 1) compliance of the operating rolling stock with the gauge concerned;
 - 2) maintenance of this compliance over time.

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

- specific rolling stock is used (for example: underground trains, trams, etc. operating on two rails);
- use occurs in other ranges of radii;
- others, etc.

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

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 13232-1, *Railway applications — Track — Switches and crossings — Part 1: Definitions*

EN 13232-3, *Railway applications — Track — Switches and crossings — Part 3: Requirements for wheel/rail interaction*

EN 13232-9, *Railway applications — Track — Switches and crossings — Part 9: Layouts*

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

EN 15273-1:2013+A1:2016 ^{A1}, *Railway applications — Gauges — Part 1: General — Common rules for infrastructure and rolling stock*

EN 15273-2: 2013+A1:2016 ^{A1}, *Railway applications — Gauges — Part 2: Rolling stock gauge*

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

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

3 Terms and definitions

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

3.1 structure gauge

defines the space, relative to the track used called the reference track, to be cleared of all objects or structures and relative to the traffic on adjacent tracks in order to permit safe operation on this reference track.

Note 1 to entry: The structure gauge is defined on the basis of the reference profile by applying the associated rules.

Three types of structure gauge are defined as follows:

3.1.1 structure verification limit gauge

space not to be encroached upon at any time which sets the limit for normal operation

Note 1 to entry: This is used to ensure that structures allow free passage. It is essential that no structure enters this at any time.

3.1.2 structure installation limit gauge

space not to be encroached upon taking into account a maintenance allowance

Note 1 to entry: This is used to define the structure installation limit. It is essential that no structure shall be installed if free passage is desired following normal maintenance operations.

3.1.3 structure installation nominal gauge

space to be cleared of any structure in order to enable train operations and track maintenance by incorporating allowances for safety, maintenance as well as reserve allowances defined by the person responsible for the infrastructure

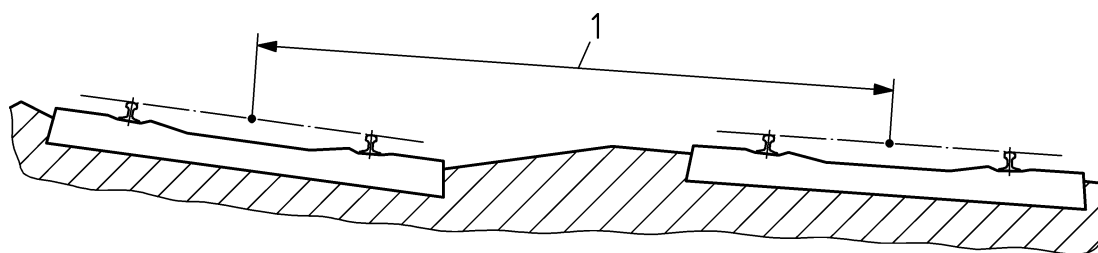
Note 1 to entry: This space for example takes into account exceptional dynamic movements, possible increases in speed, crosswinds, aerodynamic effects, etc.

3.2 distance between track centres

distance between the centres of the two adjacent tracks concerned, measured parallel to the running surface of the track with the least cant, called the reference track

Note 1 to entry: On the track, the distance between centres is often determined on the basis of the space between centres which is the distance between the two rails of the adjacent tracks. The exact measurement references (guideline, field face, rail centrelines) differ from one network to another.

Note 2 to entry: The definition of distance between centres adopted in this standard may differ from those used in other applications, such as installation for example. It is the responsibility of the infrastructure manager to determine the various conversion rules.



Key

1 distance between track centres

Figure 1 — Distance between track centres

3.2.1 verification limit distance between centres

minimum distance to be maintained at all times between adjacent tracks to ensure completely safe passage of traffic within the gauge used on the two tracks by avoiding any risk of interference between the vehicles

Note 1 to entry: This distance varies according to the local track parameters (e.g. cant, curve radius, etc.)

3.2.2 installation limit distance between centres

minimum distance between adjacent tracks to ensure completely safe passage of traffic within the gauge used on the two tracks by avoiding any risk of interference between the vehicles

Note 1 to entry: This distance varies according to the local track parameters (e.g. cant, curve radius, etc.). It takes into account maintenance allowances.

3.2.3 installation nominal distance between centres

distance between the axes of the two adjacent tracks that generally has a suitable allowance to permit ease of design, laying, monitoring and maintenance, the operation of special transport or any other aspect (including aerodynamic effects, for example)

Note 1 to entry: The nominal distance between centres is often fixed, except in areas with small radii.

4 Symbols, abbreviations and subscripts

4.1 Symbols and abbreviations

Table 1 — Symbols and abbreviations

Symbol	Designation	Unit
a	Distance between end wheelsets of vehicles not fitted with bogies or between bogie centres	m
$A_{i/a}$	Coefficients dependent on the reference vehicle for the calculation of additional overthrows. The index i is used for inside curves; indice a for outside curves	
b	Semi-width or distance parallel to the running surface, relative to the centreline of the track or of the vehicle	m
b'	Semi-width of the pantograph gauge	m
b'_q	Actual installation distance of the platforms, measured from the rail running edge	m
b_{CR}	Semi-width of the reference profile	m
b_{elec}	Electrical insulation distance	m
b_{lac0}	Standard width of the gap between the platform and the step	m
$b_{obstacle}$	Distance parallel to the running surface between the structure and the track centreline	m
b_q	Semi-width of the platform installation	m
b_{veh}	Semi-width of the vehicle	m
b_w	Semi-width of the pantograph head	m
$B_{i/a}$	Coefficients dependent on the reference vehicle for the calculation of additional overthrows. The index i is used for inside curves; indice a for outside curves	
C_0	Reference roll centre	
c_w	Width of the pantograph head insulating horn	m
dg	Geometric overthrow of the vehicle	m
dg_i	Geometric overthrow of the vehicle on the inside of the curve	m
dg_a	Geometric overthrow of the vehicle on the outside of the curve	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_{max}	Standard maximum cant to allow for enlargement of the kinematic gauge	m
δD	Cant difference (between two tracks)	m

Table 1 (continued)

Symbol	Designation	Unit
e_p	Offset of the pantograph due to the vehicle characteristics	m
e_{po}	Offset of the pantograph at the upper verification point	m
e_{pu}	Offset of the pantograph at the lower verification point	m
e_v	Lowering of track components	m
EA	Distance between track centres	m
f_s	Raising of the contact wire	m
f_{dyn}	Allowance to take into account dynamic movement of the contact wire	m
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
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'_{c0}	Value of h_c used for the agreement between the rolling stock and the infrastructure, for pantograph gauges	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

Table 1 (continued)

Symbol	Designation	Unit
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
$h_{\min}$	Lower height of the reference profile to be taken into consideration when determining the reference vehicles	m
$h_{u\min}$	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
$h_{u\min(2)}$	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	m
$h_{\min CR}$	Height of the bottom corner of the reference profile	m
h_{nez}	Height of the platform coping stone edge	m
h_{obstacle}	Height of the structure above the running surface	m
h_p	Height of point P	m
h_q	Height of the platforms	m
h_{omin}	Minimum height specified for the vertical geometric displacements of the rolling stock above the reference profile according to the vertical curve of the track.	
I	Cant deficiency	m
I'_c	Intermediate cant deficiency value between 0 and I_c	m
I'_p	Intermediate cant deficiency value taken into account for tilting body vehicles	m
I_c	Maximum cant deficiency in conventional vehicles used by the infrastructure manager for his routes	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
k	Factor of safety to take into account track irregularities	
k'	Factor of safety to take into account track irregularities, for pantograph gauges	

Table 1 (continued)

Symbol	Designation	Unit
l	Track gauge, distance between the rail running edges	m
l_{nom}	Nominal track gauge	m
L	Standard distance between the centrelines of the rails of the same track	m
$M_{(1)}$	Mandatory allowance	m
$M_{(2)}$	Infrastructure maintenance allowance	m
$M_{(3)}$	Additional infrastructure allowance	m
$M_{\text{EA}j}$	Horizontal allowance for the distance between centres covering certain random phenomena ($j = 1, 2$ or 3)	m
n_a	n for the sections outside the wheelsets or bogie centres	m
n_i	n for the sections between the wheelsets or bogie centres	m
P	Upper point of the reference profile lateral face which is the determining factor for the distance between centres	
PT	End lateral point of the reference profile upper face	
q	Transverse clearance between wheelset and bogie frame, or wheelset and body for vehicles not fitted with bogies	m
qs	Displacement due to the quasi-static roll taken into account by the infrastructure	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
qs'_a	Displacement due to the quasi-static roll on the outside of the curve, for pantograph gauges	m
qs'_i	Displacement due to the quasi-static roll on the inside of the curve, for pantograph gauges	m
R	Horizontal curve radius	m
R_v	Vertical curve radius of longitudinal profile	m
$R_{v\text{min}}$	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	

Table 1 (continued)

Symbol	Designation	Unit
S	Allowed additional overthrow	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_i	Allowed additional overthrow on the inside of the curve	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
T_{osc}	Crosslevel difference selected for calculation of oscillations caused by track irregularities	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'_c	Intermediate value of the standard train speed	km/h
V'_p	Intermediate value of the tilting train speed	km/h
w	Transverse clearance between bogie and body	m
$w_{a(R)}$	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
x	Distance taken into account from the point of origin O for the calculation of e_v	m
x_q	Horizontal coordinate of the platform edge	m
$x_{q,i}$	Horizontal coordinate of the platform edge on the inside of the curve	m
$x_{q,a}$	Horizontal coordinate of the platform edge on the outside of the curve	m
y_q	Vertical coordinate of the platform edge	m

Table 1 (continued)

Symbol	Designation	Unit
$y_{q,i}$	Vertical coordinate of the platform edge on the inside of the curve	m
$y_{q,a}$	Vertical coordinate of the platform edge on the outside of the curve	m
z_0	Fixed value available to the rolling stock on the outside of the static reference profile to allow quasi-static roll of the rolling stock	m
α	Additional angle of roll of the body due to the clearance to the side bearers	degree
α_{PT}	Maximum angle of rotation around the roll centre for point PT	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 [switches and crossings] entry angle	radian
Δ_a	Fixed term corresponding to: $n_a(a + n_a) - \frac{P^2}{4}$	m ²
Δb	Variation in semi-width b	m
Δh	Variation in height h	m
Δh_{dyn}	Vertical movement of the vehicle taken into account for the dynamic gauges	m
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
Σ_j	Sum of (horizontal) allowances for the structure gauge, covering certain random phenomena (j = 1, 2 or 3)	m
Σ_v	Sum of the values of the allowances taken into account by the infrastructure in the vertical direction	m
η_0	Angle of dissymmetry of a vehicle due to construction tolerances, to suspension adjustment and to unequal load distributions	degree
η_{0r}	Reference angle η_0 taken into account in the agreement	degree
θ	Angle resulting from the suspension adjustment tolerances	radian
τ	Pantograph construction and installation tolerance	m

4.2 Subscripts

Subscript a:	refers to the outside of the curve
Subscript i:	refers to the inside of the curve
Subscript 0:	reference value, refers to the agreements made between the rolling stock and the infrastructure
Subscript st:	refers to the static calculation rules. This subscript is often omitted when the context makes it clear that the static parameter is being referred to
Subscript cin:	refers to the kinematic calculation rules. This index is often omitted when the context makes it clear that the kinematic parameter is being referred to
Subscript dyn:	refers to the dynamic calculation rules. This index is often omitted when the context makes it clear that the dynamic parameter is being referred to
Subscript réel:	refers to the actual local value, i. e. measured on the track
Subscript CR:	refers to the reference profile
Subscript lac:	refers to the gap at platform level
Subscript q:	refers to the platform installation dimensions
Subscript nom:	refers to either the nominal or design value or to the installation nominal gauge
Subscript lim:	refers to the installation limit gauge
Subscript ver:	refers to the limit verification gauge
Subscript max:	refers to the maximum value that may appear according to the tolerances
Subscript o:	refers to the upper verification level of the pantograph gauge
Subscript u:	refers to the lower verification level of the pantograph gauge
Subscript P:	refers to tilting trains
Subscript C:	refers to classic trains
Subscript veh:	refers to the actual vehicle
Subscript elec:	refers to the electrical insulation value

4.3 Notations

$[]_{>0}$:	means that this value is to be considered as long as it is positive. A negative value shall be considered as zero
$\max(,)$:	means that the maximum value of the terms in brackets shall be used

5 General information on all the gauging methods

5.1 The reference profile and its associated rules

This clause covers the main gauging rules. For more detailed information, see EN 15273-1.

A gauge is defined by a reference profile and its associated rules.

The gauge is generally split into two parts: its upper parts and its lower parts. The limit between the two parts shall be defined for each gauge. There are specific rules associated with each part.

The reference profile is normally determined for a straight, flat, nominal gauge, cant-free track. The profile takes into account the vehicle envelope and certain displacements. The reference profile is an intermediate profile that is part of the agreement but that shall not be confused with the construction gauge nor the structure gauge (on straight track or other).

Generally added to this profile is widening according to the line (radius, cant) and speed (cant deficiency) and certain allowances to cover random phenomena and to ensure track maintenance. These are called the associated rules.

This widening corresponds to the displacements of the reference vehicles that are the basis for defining the gauge considered (see [A1](#) EN 15273-1:2013+A1:2016 [A1](#), Clause 7) for more detailed explanations).

Transverse and vertical widening at the running surface are often dealt with separately.

5.2 Transverse widening

5.2.1 Gauge variations depending on the local situation

5.2.1.1 General

The gauge variations depend on the calculation method used and particularly on the gauge used. Generally, there are two parts:

- the additional overthrows that give the variability in a curve;
- the quasi-static effect that gives the variability from the body roll.

5.2.1.2 Additional overthrows

The additional overthrows define the sum of the following phenomena:

- the effect of the track widening;
- the geometric effect in the curve of the reference vehicles.

The general formulations are set out in [A1](#) EN 15273-1:2013+A1:2016 [A1](#), 7.3.1.1. The specific formulae to be used for each gauge are given in the Annex.

5.2.1.3 Quasi-static effect

The quasi-static effect gives the reference vehicle body roll in a curve for the upper parts:

- outside of the curve, under the cant deficiency effect;
- inside of the curve, under the cant effect.

The first is at its maximum when the trains reach their maximum authorized speed.

The second is at its maximum when the train is stationary.

It should be noted that, depending on the gauge type, the rolling stock already takes a part into account up to values I_0 and D_0 ; the infrastructure only takes the addition into account.

The general formulations are given in [\[A1\]](#) EN 15273-1:2013, +A1:2016 [\[A1\]](#), 7.3.1.4. The specific formulae to be applied for the gauge used are given in the Annex.

For the lower parts, this phenomenon is taken into account by the rolling stock.

5.2.2 Random transverse phenomena

Random phenomena to be considered is dependent on the gauge used.

The following phenomena are considered to be the responsibility of the Infrastructure Manager.

5.2.2.1 Vehicle oscillations generated by track irregularities (T_{osc})

Track geometry irregularities are the cause of the vehicle oscillations. The amplitude depends on the track condition, suspension characteristics and speed. Insofar as these phenomena are taken into account by the infrastructure, these oscillations are expressed in the form of equivalent crosslevel errors (T_{osc}). Depending on the flexibility of the vehicle, they are located at the base of an inclination around the roll centre and thus the following widening:

$$\Delta b = \frac{s_0}{L} T_{osc} (h - h_{c0})_{>0} \quad (1)$$

NOTE Other methods exist for taking this phenomenon into account. For example, in the case of the dynamic gauge, this phenomenon is taken into account by the rolling stock.

5.2.2.2 Track displacement (T_{voie})

The track position is likely to change between two track inspections owing to the traffic loads and to the track maintenance. The maximum transverse displacement T_{voie} depends on the maintenance guidelines in force and the frequency of the operations.

When the track design does not allow any movement in relation to the structure, this allowance may be disregarded.

5.2.2.3 Cant deviation (T_D)

Due to the maintenance tolerances and to the traffic, the cant of the track can vary in relation to its nominal value. This cant variation T_D has a double effect:

- the reference profile rotates around the track centreline at an angle corresponding to the maximum variation $\frac{T_D}{L}$, which causes the following widening:

$$\Delta b = \frac{T_D}{L} h \quad (2)$$

- the vehicle will tend to turn around the roll centre, affected by the flexibility of its suspension, which will cause an additional widening of parts located above the roll centre:

$$\Delta b = s_0 \frac{T_D}{L} (h - h_{c0})_{>0} \quad (3)$$

- these two phenomena have an effect towards the inside of the curve and the outside of the curve, but also (to a lesser extent) on a straight track.

It shall be noted that the two phenomena are always present simultaneously and are therefore not independent.

5.2.2.4 Dissymmetry (η_0)

A vehicle will never be perfectly symmetrical; the main reasons for this are as follows, depending on the type of gauge:

- variations in suspension adjustment resulting in a body roll T_{susp} ;
- loading dissymmetry which makes the vehicle body roll in its suspension gear and which results similarly in a rotation of the vehicle T_{charge} .

In both cases, the vehicle body rotates around its roll centre C_0 . The sum of the two angles corresponds to the agreed reference angle η_0 :

$$\eta_0 = T_{\text{charge}} + T_{\text{susp}} \quad (4)$$

5.3 Superelevation and lowering perpendicular to the running surface

5.3.1 General

In most cases, the rolling stock takes into account vertical displacements (including tolerances) unless specified otherwise. The following vertical displacements shall only be considered by the infrastructure manager.

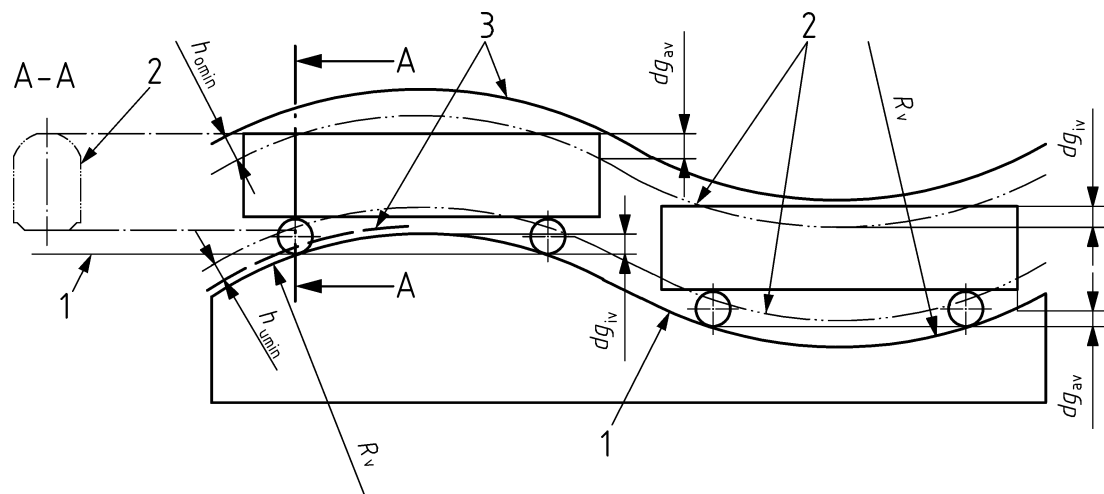
Such displacements can occur in both directions. In terms of the position of the point on the reference contour, superelevation or lowering should be considered in order to take into account the worst case.

5.3.2 Vertical superelevation or lowering for longitudinal profile transition curves

Track gradients are interconnected by vertical curves of radius R_V . The reference profile is extended into the upper and lower parts in order to take account of the vertical displacement of the mid-section or overhanging section of the vehicle body relative to the track centreline.

As the vertical radii are relatively large compared to those in the horizontal plane, this phenomenon is only considered for the highest and lowest profile points.

The general formulations are set forth in [EN 15273-1:2013+A1:2016](#) [7.2.2](#). The phenomenon to be considered is defined in this standard, and its determination is the responsibility of the infrastructure manager. See also the following figure:



Key

- 1 running surface
- 2 reference profile
- 3 infrastructure limit

Figure 2 — Illustration of the vertical geometric overthrow

5.3.3 Vertical effect of the roll

5.3.3.1 Upper parts

For reference profiles with a sizable flat in the horizontal upper part, as is the case in gauges used for the transportation of containers, the roll may generate vertical movement of this part. This results in superelevation of the vertical part of the gauge.

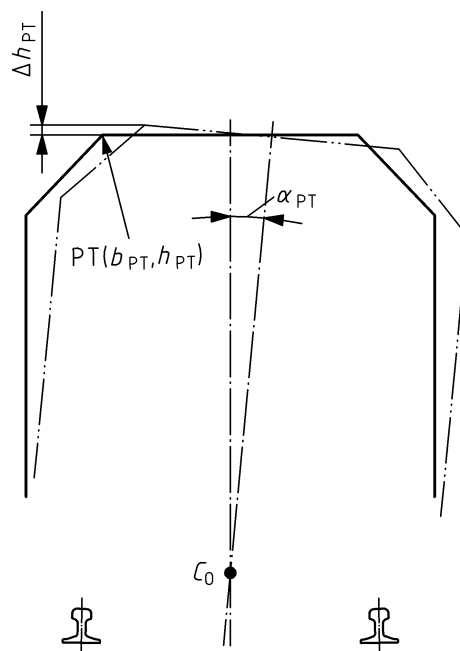


Figure 3 — Vertical effect of the roll

The rotations resulting from the following phenomena shall be taken into consideration:

- quasi-static effect (total or non depending on the gauge type) (see 5.2.1.3);
- cant deviation T_D (see 5.2.2.3);
- oscillations caused by track irregularities T_{osc} (see 5.2.2.1);
- dissymmetry η_0 (see 5.2.2.4).

The superelevation resulting from the quasi-static effect is determined by the following formula:

$$\Delta h_{PT,a} = b_{PT} \sin \alpha_{PT,a} - (h_{PT} - h_{c0}) (1 - \cos \alpha_{PT,a}) \text{ equivalent to } \Delta h_{PT,a} \cong b_{PT} \sin \alpha_{PT,a} \quad (5)$$

where

$\alpha_{PT,a}$: the rotation of the gauge due to the quasi-static effect. This value can differ between the inside of the curve and the outside of the curve.

h_{PT} , b_{PT} : the coordinates of the point considered PT .

The angle of rotation taken into account depends on the gauge type.

The rotations due to the random parameters are to be considered when determining Σ_V .

NOTE To date, Δh_{PT} has only been used for gauge GC. For future gauges not yet defined in this standard, the use of this parameter will be left to the discretion of the infrastructure manager.

5.3.3.2 Lower parts

The same principle can be used for the lower parts but it is taken into account by the rolling stock in terms of the train architecture (for example: tilting trains).

5.3.4 Uplift

For the static gauge, the infrastructure shall take into account the uplift of the vehicle in the suspension. This allowance is added only in the upper part of the gauge.

5.3.5 Vertical random phenomena

The infrastructure manager can add allowances to take into account the following phenomena:

- lowering of the track due, amongst other things, to ballast settlement;
- track raising during maintenance operations.

5.4 Additional allowances

In addition to allowances covering random phenomena, the infrastructure manager can decide to introduce additional allowances to permit:

- speed increases;
- running of special consignments;
- opening of doors and safety of train crew in certain situations (for example, platforms, holding siding, etc.);
- amendments to the layout or future gauge;
- the definition of an invariable gauge that can be easily managed by the maintenance and monitoring services where the actual allowances are adequate;
- consideration of aerodynamic effects and cross winds.

These allowances can be both vertical and transverse.

5.5 Gauge types

5.5.1 Gauge methodologies

The structure gauge is defined on the basis of a reference profile and its associated rules that form an agreement between the infrastructure and the rolling stock and are therefore inseparable. The agreement dictates how the various possible displacements of a vehicle on the track are distributed and taken into account.

There are various calculation methodologies; details are given in [A1](#) EN 15273-1: 2013+A1:2016 [A1](#). (Clause 6). It is essential to specify the methodology used. The main methodologies used in Europe and which are specified in more detail in this standard are:

- the static method used for specific, non-interoperable applications;
- the kinematic method used in Europe, essentially on interoperable networks;
- the dynamic method used on certain networks with the aim of optimizing the space available for sizing non-interoperable vehicles.

5.5.2 Structure gauge types

For each of the gauges (listed in the catalogue), there are different structure gauge types depending on the required application (see also 6.2, 7.2 and 8.2):

- the **structure verification limit gauge** only takes into account widening and certain allowances that ensure safety of operations during control with the parameters measured on site. The grouping of these parameters is called $M_{(1)}$;
- the **structure installation limit gauge** takes into account the structure verification limit gauge and all the displacements and wear that may occur between two maintenance periods by means of an additional allowance $M_{(2)}$. Fitting this gauge ensures that clearance is maintained between the various maintenance and checking operations;
- besides allowances $M_{(1)}$ and $M_{(2)}$, the **structure installation nominal gauge** also takes into account an additional allowance $M_{(3)}$ determined in 5.4. Fitting this gauge ensures that clearance is maintained in practically all conditions and allows more possible uses such as for special consignments, even the installation of temporary structures, etc.

The allowance $M_{(1)}$ corresponds to Σ_1 .

The sum of the allowances $M_{(1)}$ and $M_{(2)}$ is determined by Σ_2 .

The sum of the allowances $M_{(1)}$ to $M_{(3)}$ is determined by Σ_3 .

5.5.3 Uniform gauge

When the infrastructure manager has sufficient space available, he can define a non-variable gauge with a design that permits easier management for the maintenance managers. This gauge, which generally incorporates additional allowances, is a nominal type structure gauge called a uniform gauge.

Uniform gauges are often used in Europe by several networks. They are given in Annex G. Their application rules may differ according to the networks.

Some examples are given below.

EXAMPLE 1

Infrastructure managers who have chosen to define a uniform gauge corresponding to the worst case situation, i.e. the smallest radius or the maximum cant or cant deficiency.

This gauge type is often used in the metro when the tunnel cross-section is constant and determined for the worst case situation.

EXAMPLE 2

Different infrastructure managers have chosen to define a gauge with two profiles:

- one profile applicable on a straight or curved track with very large radii and no cant;
- one profile on a curved track designed on the basis of the worst case cant and radius situation.

This method creates an additional allowance compared to the basic gauge used and is only possible if adequate space is available on site.

The infrastructure manager shall always check the conditions on which this gauge is based and shall always return to the basic gauge when these conditions are not met any longer.

It is necessary, therefore, not to forget the choice of gauge used and the conditions it has been based on.

NOTE The uniform gauge may also be the gauge used. By subtracting all the allowances and widening/lowering from the method used, a new reference profile can be determined, often larger than the original one which allows use by the rolling stock.

5.6 Choice of gauge

5.6.1 Gauge and methodology choice

The gauge choice is up to the infrastructure managers. For this, the infrastructure manager takes into account:

- the interoperability directives in force;
- the bilateral or multilateral agreements;
- international technical specifications in force;
- the consignments authorized to travel on his infrastructure;
- the space available on the lines concerned;
- the specific restrictions imposed by the infrastructure.

The gauge chosen is called the used gauge in the following.

The infrastructure manager is responsible for the maintenance of the used gauge over time.

The methodology choice is strongly linked to the gauge choices. For reasons of interoperability, only the kinematic gauge is used.

5.6.2 Structure gauge choice

For this/these used gauge(s), the infrastructure manager may choose one or more of the structure gauges listed in 5.5.2., according to his requirements.

When constructing new lines the nominal gauge shall be used. In the case of major reconstruction it is advisable to use the nominal gauge. In existing situations and when there is deemed to be sufficient space, it can be cleared wherever it is thought necessary.

Depending on requirements or when the local situation is such that the nominal gauge cannot be cleared, a structure installation limit gauge may be defined and cleared.

A verification limit gauge may need to be defined when the infrastructure manager wants to verify the free running of the trains in a degraded situation.

5.6.3 Taking account of the allowances

5.6.3.1 Structure limit gauge

The phenomena to be considered and the calculation methodology for the sums of the allowances Σ_1 and Σ_2 depend to a large extent on the methodology for the chosen gauge and are therefore defined later in the standard.

The calculation methodology is often similar for the verification limit gauge and for the structure installation limit gauge.

Whereas the phenomena to be considered are always clearly defined in this standard, their determination remains the responsibility of the infrastructure managers. For the infrastructure managers without any specific rules, this standard gives a calculation methodology and recommended values.

5.6.3.2 Nominal gauge

There is no common methodology to allow the nominal gauge to be determined in view of the different allowances to be included or not according to the choices of the infrastructure manager. The nominal gauge will therefore be determined following a feasibility study based on the objectives laid down and the resulting technical and economic consequences.

One way to obtain a larger safety allowance whose only aim is to facilitate the management of structures approaching the structure gauge is to total all the random allowances together arithmetically instead of by a root mean square. It shall be noted that this methodology is generally accepted but rarely used on the different networks.

5.6.4 Catalogue of gauges

Technical interoperability conditions are defined in [\[A1\]](#) EN 15273-1:2013+A1:2016 [\[A1\]](#), Annex A. The application of international or reduced interoperability gauges depends on international regulations or even bilateral or multilateral agreements. The gauge choice is fixed by each network.

A distinction is made between:

- gauges “interoperable internationally”. These are listed in Annex C;
- and other gauges for bilateral or multilateral agreements or national applications. These are listed in Annex D.

6 Rules for determination of the static gauge

6.1 General

NOTE 1 In this clause, the index “*sf*” is omitted from all parameters in order to improve legibility.

NOTE 2 The original static method defined in “**The Technical Unit**” did not clearly define the allowances to be taken into account by the infrastructure for the effects of roll and random phenomena. The method proposed here enables the recalculation of the static gauge when the necessary values are available.

Where possible, the infrastructure uses the corresponding kinematic calculation. In the absence of a corresponding kinematic gauge or adequate allowances, the method with the rules given below may be used.

The static structure gauge is defined on the basis of the static reference profile and its associated rules that form an agreement between the infrastructure and the rolling stock and are therefore inseparable.

The transverse and vertical displacements are dealt with separately.

The static reference profile is determined for a flat straight track, of nominal rail gauge without cant. The gauge is variable, depending on local track parameters (cant, curve radius and track gauge).

The random phenomena, explained in 5.2, are often taken into account by a fixed allowance.

All the parameters are to be taken into account as positive values to the right or the left of the vertical centreline depending on the case.

6.2 Associated rules

In the absence of an equivalent kinematic gauge, the structure gauge is determined on the basis of the static reference profile.

The position of the structure in the width plane shall include the sum of all the phenomena:

$$b_{\text{obstacle}} \geq b_{\text{CR}} + S_{i/a} + qS_{i/a} + \Sigma_j \quad (6)$$

where

- b_{CR} is the semi-width of the static reference profile;
- $S_{i/a}$ are the additional overthrows (see 5.2.1.2);
- with a fixed value of $F = (A)q_r + (A)w_r + (A)\frac{l_{\text{nom}} - d}{2}$ taken into account outside the static reference profile (see EN 15273-1:2013+A1:2016, Annex B). $\sqrt{A_1}$
- $qS_{i/a}$ is the quasi-static effect with the following general formulation:

$$\text{— inside of the curve: } qS_i = z_0 + \frac{s_0}{L} [D - D_0]_{>0} [h - h_{c0}]_{>0} \quad (7)$$

$$\text{— outside of the curve: } qS_a = z_0 + \frac{s_0}{L} [I - I_0]_{>0} [h - h_{c0}]_{>0} \quad (8)$$

$$\text{— with } z_0 \text{ as a constant value} \quad z_0 = \frac{s_0(D_0 \text{ ou } I_0)}{L} (h_{\text{max}} - h_{c0}) \quad (9)$$

$$\text{— or with } z_0 \text{ as a variable-height value} \quad z_0 = \frac{s_0(D_0 \text{ ou } I_0)}{L} (h - h_{c0}) \quad (10)$$

- The sum of the allowances Σ_j to cover the random phenomena.

In the height plane, the position of the structure shall ensure that:

$$h_{\text{obstacle}} \geq h_{\text{CR}} + \Delta h_{\text{Rv}} + \Delta h_{\text{susp}} + \Delta h_{\text{PT}} + \Sigma_v \quad (11)$$

where

- h_{CR} is the height of the reference profile;
- Δh_{Rv} is the superelevation/lowering in the transition curve (see 5.3.2.);
- Δh_{susp} is the vehicle uplift due to the suspension flexibility;
- Δh_{PT} is the superelevation of the upper parts due to the vertical effect of the roll (see 5.3.3).

where

$$\sin \alpha_{\text{PTia}} = \frac{s_0}{L} \cdot (D, I) \quad (12)$$

In contrast to transversal movements, it is important to take into account the effect of cant deficiency on the inside of the curve and the effect of cant on the outside of the curve.

There is an additional allowance Σ_V for random phenomena.

6.3 Transverse clearances

6.3.1 Phenomena considered

Allowances are defined to take into account the random phenomena. The various phenomena are grouped according to their character.

$M_{(1)}$ includes the effect of all the random phenomena due to actual movements of the vehicles. This allowance determines the limit of the point reached by the rolling stock. $M_{(1)}$ is determined on the basis of:

- oscillations characterized by tolerance T_{osc} ;
- dissymmetry η_0 due to poor suspension adjustment and load distribution not exceeding 1° .

$M_{(2)}$ includes the random effects that make the best use of allowances to ensure track maintenance at the chosen frequencies and resources. $M_{(2)}$ is determined on the basis of:

- widening in order to take account of the track displacements T_{voie} between two maintenance operations;
- the geometric part and the additional quasi-static effect due to the crosslevel error of the track T_D .

$M_{(3)}$ is an allowance that allows easy management of the gauge in the long term and offers additional possibilities for special consignments, temporary installations or others.

6.3.2 Determination of the sum of allowances Σ_j

The effective value of Σ_j may be chosen:

- either as a fixed value, determined on the basis of the experience the infrastructure manager has on his network;
- or as a value calculated on the basis of the maintenance tolerances with the following calculation method:

when determining the limit gauge, it shall be regarded that the simultaneous occurrence of the extreme values of all the phenomena given in 5.2 is very improbable. This is why the arithmetic sum of the allowances is not acceptable. It can be shown that an acceptable level of certainty can be obtained by using the following general formula:

$$\Sigma_j = k \sqrt{\sum_j \Delta b_{T_j}^2} \quad (13)$$

where T_j is the allowance of the various phenomena to be considered (see 6.2). Parameters that are not independent shall be considered together, i.e. in an arithmetic sum.

Coefficient k determines the safety level ($k \geq 1$).

Further explanations can be found in [\[A1\]](#) EN 15273-1:2013+A1:2016 [\[A1\]](#), 7.1.8 and 7.2.1.9.2.

6.4 Vertical allowances for random phenomena

6.4.1 Phenomena considered

An allowance is defined to take into account the following tolerances:

- vertical effect of the roll due to random phenomena (see 5.3.3) (only for the upper horizontal parts of the upper parts);
- vertical displacement of the track between two periods of maintenance T_N ;
- vertical tolerances;
- additional allowances.

6.4.2 Determination of the sum of vertical allowances Σ_V

The effective value of Σ_V may be chosen:

- either as a fixed value, determined on the basis of the experience the infrastructure manager has on his network;
- or as a value calculated on the basis of the maintenance tolerances with the following calculation method.

when determining the limit gauge, it shall be regarded that the simultaneous occurrence of the extreme values of all the phenomena given in 5.3 is very improbable. This is why the arithmetic sum of the allowances is not acceptable. It can be shown that an acceptable level of certainty can be obtained by using the following general formula:

$$\Sigma_V = k \sqrt{(\Delta h_{T_1})^2 + (\Delta h_{T_2})^2 + \dots (\Delta h_{T_n})^2} \quad (14)$$

where T_j is the allowance of the various phenomena to be considered (see 6.2). Parameters that are not independent shall be considered together, i.e. in an arithmetic sum.

Coefficient k determines the safety level ($k \geq 1$).

More detailed explanations are given in EN 15273-1.

7 Rules for determination of the kinematic gauge

7.1 General

NOTE In this clause, the subscript “*cin*” is omitted from all parameters in order to improve legibility.

The reference profile is determined for a flat straight track, of nominal rail gauge without cant. The gauge varies depending on local track parameters (cant, curve radius and track gauge).

The random phenomena, explained in 5.2, are taken into account by the sum of allowances Σ_j .

All the parameters are to be taken into account as positive values to the right or the left of the vertical centreline depending on the case.

7.2 Associated rules

The position of the structure shall cover the sum:

$$b_{\text{obstacle}} \geq b_{\text{CR}} + S_{i/a} + qS_{i/a} + \Sigma_j \quad (15)$$

with:

- b_{CR} is the semi-width of the kinematic reference profile;
- $S_{i/a}$ are the additional overthrows (see 5.2.1.2);
 - without the value F , which is specific to the vehicle and taken into account inside the kinematic reference profile.”.
- $qS_{i/a}$ is the quasi-static effect with the following general formulation:

$$\text{inside of the curve: } qS_i = \frac{S_0}{L} [D - D_0]_{>0} [h - h_{c0}]_{>0} \quad (16)$$

$$\text{outside of the curve: } qS_a = \frac{S_0}{L} [I - I_0]_{>0} [h - h_{c0}]_{>0} \quad (17)$$

- Σ_j is the sum of the allowances to cover the random phenomena as defined below:

On the upper parts, the position of the structure shall ensure that:

$$h_{\text{obstacle}} \geq h_{\text{CR}} + \Delta h_{\text{RV}} + \Delta h_{\text{PT}} + \Sigma_v \quad (18a)$$

where

- h_{CR} is the height of the reference profile;
- Δh_{RV} is the superelevation/lowering in the transition curve (see 5.3.2.);
- Δh_{PT} is the superelevation of the upper parts due to the vertical effect of the roll (see 5.3.3).

where

$$\sin \alpha_{\text{PTi,a}} = \frac{S_0}{L} (D - D_0, I - I_0) \quad (19)$$

In contrast to transversal movements, it is important to take into account the effect of cant deficiency on the inside of the curve and the effect of cant on the outside of the curve.

- There is an additional allowance Σ_v for random phenomena.

On the lower parts, the position of the structure shall ensure that:

$$h_{\text{obstacle}} \leq h_{\text{CR}} + \Delta h_{\text{RV}} - \Sigma_v \quad (18b)$$

where

- h_{CR} is the height of the reference profile;
- Δh_{RV} is the superelevation/lowering in the transition curve (see 5.3.2.);

There is an additional allowance Σ_V for random phenomena.

7.3 Transverse allowances for random phenomena

7.3.1 Phenomena considered

Allowances are defined to take into account the random phenomena. The various phenomena are grouped according to their character.

$M_{(1)}$ includes the effect of all the random phenomena due to actual movements of the vehicles. This allowance determines the limit of the point reached by the rolling stock. $M_{(1)}$ is determined on the basis of:

- oscillations characterized by tolerance T_{osc} ;
- dissymmetry η_0 due to poor suspension adjustment and load distribution not exceeding 1°.

$M_{(2)}$ includes the random effects that make the best use of allowances to ensure track maintenance at the chosen frequencies and resources. $M_{(2)}$ is determined on the basis of:

- widening in order to take account of the track displacements T_{voie} between two maintenance operations;
- the geometric part and the additional quasi-static effect due to the crosslevel error of the track T_D .

$M_{(3)}$ is an allowance that allows easy management of the gauge in the long term and offers additional possibilities for special consignments, temporary installations or others.

7.3.2 Determination of the sum of transverse allowances Σ_j

The effective value of Σ_j may be chosen:

- either as a fixed value, determined on the basis of the experience the infrastructure manager has on his network;
- or as a value calculated on the basis of the maintenance tolerances with the following calculation method.

When determining the limit gauge, it shall be regarded that the simultaneous occurrence of the extreme values of all the phenomena given in 5.2 is very improbable. This is why the arithmetic sum of the allowances is not acceptable. It can be shown that an acceptable level of certainty can be obtained by using the following general formula:

$$\Sigma_j = k \sqrt{(\Delta b_{T_1})^2 + (\Delta b_{T_2})^2 + \dots + (\Delta b_{T_n})^2} \quad (20)$$

where T_j is the allowance of the various phenomena to be considered (see 7.2). Parameters that are not independent are grouped in an arithmetic sum.

Coefficient k determines the safety level ($k \geq 1$).

Further explanations can be found in [\[A1\]](#) EN 15273-1:2013+A1:2016 [\[A1\]](#), 7.2.1.9.2.

An example of the calculation and the values recommended for the tolerances are given in Annex A and Annex B.

7.4 Vertical allowances for random phenomena

7.4.1 Phenomena considered

An allowance is defined to take into account the following tolerances:

- vertical effect of the roll due to random phenomena (see 5.3.3) (only for the upper horizontal part of upper parts, commonly referred to as the roof or sky);
- vertical displacement of the track between two periods of maintenance- T_N ;
- vertical tolerances;
- additional allowances.

7.4.2 Determination of the sum of vertical allowances Σ_V

The effective value of Σ_V may be chosen:

- either as a fixed value, determined on the basis of the experience the infrastructure manager has on his network;
- or as a value calculated on the basis of the maintenance tolerances with the following calculation method.

when determining the limit gauge, it shall be regarded that the simultaneous occurrence of the extreme values of all the phenomena given in 5.3 is very improbable. This is why the arithmetic sum of the allowances is not acceptable. It can be shown that an acceptable level of certainty can be obtained by using the following general formula:

$$\Sigma_V = k \sqrt{(\Delta h_{T_1})^2 + (\Delta h_{T_2})^2 + \dots (\Delta h_{T_n})^2} \quad (21)$$

where T_j is the allowance of the various phenomena to be considered (see 6.2). Parameters that are not independent shall be considered together, i.e. in an arithmetic sum.

Coefficient k determines the safety level ($k \geq 1$).

Further explanations can be found in [\[A1\]](#) EN 15273-1:2013+A1:2016 [\[A1\]](#), 7.2.2.2.1.

An example of the calculation and the values recommended for the tolerances are given in Annex A and Annex B.

8 Rules for determination of the dynamic gauge

8.1 General

NOTE In this clause, the index “*dyn*” is omitted from all parameters in order to improve legibility.

The reference profile is determined for a flat straight track, of nominal rail gauge. The gauge is variable, depending on the situation of the local track (cant, curve radius and rail gauge).

The random phenomena, explained in 5.2, are taken into account by the sum of allowances Σ_j .

All the parameters are to be taken into account as positive values to the right or the left of the vertical centreline depending on the case.

8.2 Associated rules

The position of the structure shall cover the sum of all phenomena:

$$b_{\text{obstacle}} \geq b_{\text{CR}} + S_{i/a} + \Sigma_j \quad (22)$$

where

- b_{CR} is the semi-width of the dynamic reference profile;
- $S_{i/a}$ are the additional overthrows (see 5.2.1.2);
- Σ_j is the sum of the allowances to cover the random phenomena as defined below:

On the upper parts, the position of the structure shall ensure that:

$$h_{\text{obstacle}} \geq h_{\text{CR}} + \Delta h_{\text{R}_v} + \Sigma_v \quad (23a)$$

where

- h_{CR} is the height of the reference profile;
- Δh_{R_v} is the superelevation/lowering in the transition curve (see 5.3.2.);
- there is an additional allowance Σ_v for random phenomena.

On the lower parts, the position of the structure shall ensure that:

$$h_{\text{obstacle}} \leq h_{\text{CR}} + \Delta h_{\text{R}_v} - \Sigma_v \quad (23b)$$

where

- h_{CR} is the height of the reference profile;
- Δh_{R_v} is the superelevation/lowering in the transition curve (see 5.3.2.);
- there is an additional allowance Σ_v for random phenomena.

8.3 Transverse allowances for random phenomena

8.3.1 Phenomena considered

Allowances are defined to take into account the random phenomena cited in 1.4.2. The various phenomena are grouped according to their character.

$M_{(1)}$ includes the effect of certain random phenomena due to actual movements of the vehicles. This allowance determines the limit of the point reached by the rolling stock. $M_{(1)}$ is determined on the basis of:

- dissymmetry η_0 due to poor suspension adjustment and load distribution not exceeding 1° .

$M_{(2)}$ includes the random effects that make the best use of allowances to ensure track maintenance at the chosen frequencies and resources. $M_{(2)}$ is determined on the basis of:

- widening in order to take account of the track displacements T_{voie} between two maintenance operations;

- the geometric part only ($h \frac{T_D}{L}$) due to the crosslevel error of the track T_D (the quasi-static part shall be taken into account by the rolling stock).

$M_{(3)}$ is an allowance that allows easy management of the gauge in the long term and offers additional possibilities for special consignments, temporary installations or others.

8.3.2 Determination of the sum of allowances Σ_j

The effective value of Σ_j may be chosen:

- either as a fixed value, determined on the basis of the experience the infrastructure manager has on his network;
- or as a value calculated on the basis of the maintenance tolerances with the following calculation method.

When determining the limit gauge, it shall be regarded that the simultaneous occurrence of the extreme values of all the phenomena given in 5.2 is very improbable. This is why the arithmetic sum of the allowances is not acceptable. It can be shown that an acceptable level of certainty can be obtained by using the following general formula:

$$\Sigma_j = k \sqrt{(\Delta b_{T_1})^2 + (\Delta b_{T_2})^2 + \dots (\Delta b_{T_n})^2} \quad (24)$$

where T_j is the allowance of the various phenomena to be considered. Parameters that are not independent are grouped in an arithmetic sum.

Coefficient k determines the safety level ($k \geq 1$).

Further explanations can be found in [\[A1\]](#) EN 15273-1:2013+A1:2016 [\[A1\]](#), 7.2.2.1.

An example of the calculation and the values recommended for the tolerances are given in Annex A and Annex B.

8.4 Vertical allowances for random phenomena

8.4.1 Phenomena considered

An allowance is defined to take into account the following tolerances:

- the vertical effect of roll due to random phenomena (see 5.3.3.) only for the upper horizontal part of upper parts, commonly referred to as the roof or sky);
- track vertical tolerance T_N ;
- vertical tolerances;
- additional allowances.

8.4.2 Determination of the sum of vertical allowances Σ_V

With there being no series of random parameters as in the case of the semi-width, the height is determined by the arithmetical sum of the various elements to be considered.

The effective value of Σ_V may be chosen:

- either as a fixed value, determined on the basis of the experience the infrastructure manager has on his network;

— or as a value calculated on the basis of the maintenance tolerances with the following calculation method.

when determining the limit gauge, it shall be regarded that the simultaneous occurrence of the extreme values of all the phenomena given in 5.3 is very improbable. This is why the arithmetic sum of the allowances is not acceptable. It can be shown that an acceptable level of certainty can be obtained by using the following general formula:

$$\Sigma_v = k \sqrt{(\Delta h_{T_1})^2 + (\Delta h_{T_2})^2 + \dots (\Delta h_{T_n})^2} \quad (25)$$

where T_j is the allowance of the various phenomena to be considered (see 6.2). Parameters that are not independent shall be considered together, i.e. in an arithmetic sum.

Coefficient k determines the safety level ($k \geq 1$). More detailed explanations are given in EN 15273-1. An example of the calculation and the values recommended for the tolerances are given in Annex A and Annex B.

9 Distance between track centres

9.1 General

The distance between track centres is determined to allow normal, simultaneous traffic on adjacent tracks and without restriction. The distance between track centres is established on the basis of the gauge chosen and takes into account the same phenomena as those taken into account in the actual structure gauge.

The infrastructure manager defines one or more distances between centres in order to allow him to ensure clearance of the chosen gauge:

- for **verification** of the distance between centres, the **verification limit distance between centres** defining the limit never to be crossed shall be determined;
- for track installation, the **installation limit distance** between centres that defines the installation limit distance between tracks shall be determined;
- in every case, it is advised to keep an additional allowance; for this, a **nominal distance between centres** is defined permitting management flexibility, particularly for track maintenance and verification and also, where necessary an allowance for the running of special consignments.

9.2 Determination of the limit distance between track centres

9.2.1 General

The limit distance between track centres is determined to prevent the gauge of one track from interfering with the gauge of the adjacent track while taking into account both the reference profiles and associated rules and also a sum of allowances Σ_{AEi} , determined in the same way as for the limit gauge.

Generally, the limit distance between centres is determined by the upper point of the vertical part of the gauge, designated below by the letter P (see Figure 5).

Only the widening defined in 5.2 has an effect on the determination of the limit distance between centres.

The following values are to be considered for each of the two tracks:

- the additional overthrows $S_{i/a}$ (see 5.2.1.2);
- the quasi-static effect: $q_{s_{i/a}}$ (see 5.2.1.3);
- the effect of the cant difference between two tracks: $\Delta b_{\delta h}$ (see below);
- the allowances M_j , taking into account the track tolerances and certain load tolerances.

The formulae for the first two points and the random phenomena to be considered depend on the gauge type used as defined in the above clauses.

The effect of whether the space between the centres is on the inside or outside of the curve of the track considered shall always be taken into account.

EXAMPLE In the case of two concentric curved tracks, all the phenomena on the inside of the curve are considered for the outside track and the phenomena of the outside of the curve for the inside track.

In the case of two tracks of opposing curves, all the phenomena on the outside of each of the two tracks are considered each with its own radius, cant and running speed.

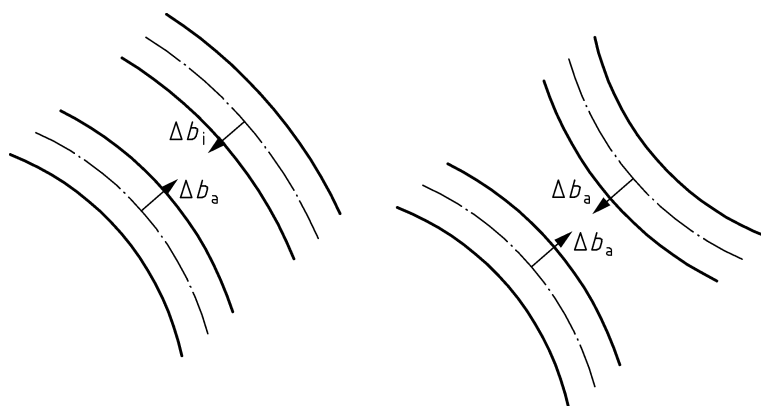


Figure 4 — Distance between centres

9.2.2 Effect of cant difference $\Delta b_{\delta D}$

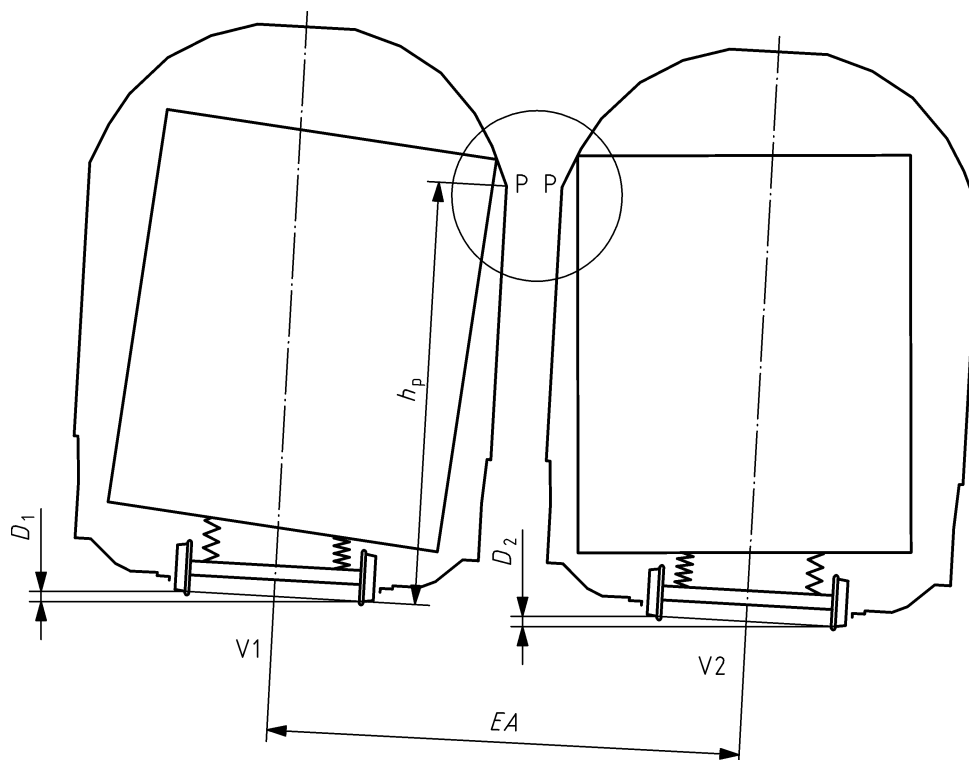
When the two tracks considered have a different cant or transverse crosslevel, the two gauges tend to get closer to each other or further away at the top of the vertical part. This has major consequences on the distance between centres measured at the running surface.

If the cant difference brings the two contours together at point *P* (see Figure 5), the distance between the centres shall be increased. If the two gauges move further apart at point *P*, a reduction in the distance between the track centres could be allowed up to the moment when the gauges touch at the bottom; this reduction is often disregarded.

Under the above conditions, this effect is calculated as follows:

$$\Delta b_{\delta D} = \frac{h_p}{L} [D_1 - D_2]_{>0} \quad (26)$$

[A1] Track 1 is the outer (a) track of the curve and track 2, the inner (i) track of the curve **[A1]**. The cant shall always be regarded in the same direction (see Figure 5).



Key

- V1 track 1 (outer curve)
- V2 track 2 (inner curve)

Figure 5 — The distance between centres in the case of a cant difference

9.2.3 Allowances to take into account random phenomena

The effects to be covered are explained in 5.2.2.

The effects on the two tracks simultaneously shall be considered. However, it shall be noted that the phenomena of the two tracks are independent of each other which means an arithmetic sum of the allowance of each track taken separately can be thought excessive.

Allowances shall be defined to take account of random phenomena when determining the distance between centres. The different phenomena are grouped according to their character:

- the verification limit distance between centres only takes into account the widening and certain allowances ensuring safety when traffic crosses during control with the parameters recorded at the site. The grouping of these parameters is called M_{EA1} ;
- the installation limit distance between centres takes into account the distance between centres and all the displacements and wear that might appear during two maintenance periods by means of an allowance M_{EA2} . Keeping this distance between centres ensures that clearances for the different maintenance and verification operations are maintained;
- the nominal installation distance between centres, besides allowances M_{EA1} and M_{EA2} , also takes into account an additional allowance determined in 5.4, called M_{EA3} . Maintaining this space between centres ensures easier track construction and maintenance.

The allowance M_{EA1} corresponds to Σ_{EA1} .

The sum of the allowances M_{EA1} and M_{EA2} is determined by Σ_{EA2} .

The sum of the allowances M_{EA1} and M_{EA3} is determined by Σ_{EA3} .

9.2.4 Determination

The effects described in 9.2.1 depend on the local situation of each track (cant, curve radius and track gauge) and shall be taken into account by adding the two semi-widths of the reference profile. The random effects, explained in 7.2.2.5, will be taken into account by a single allowance Σ_{EAj} . The distance between centres shall cover the arithmetic sum of these effects:

$$EA \geq (b_{CR} + S_{i/a} + qs_{i/a})_{voie1} + (b_{CR} + S_{i/a} + qs_{i/a})_{voie2} + \Delta b_{\delta D} + \Sigma_{EAj} \quad (27)$$

In order to optimize the allowance calculations, a more refined formula which incorporates quasi-static phenomena into the track allowance for random phenomena is presented in Annex A.

9.2.4.1 Determination of allowance Σ_{EAj}

Depending on the use given to the limit distance between centres to be determined, allowance Σ_{EAj} will take into account a different part of the effects accordingly.

The effective value of Σ_{EAj} may be chosen:

- either as a fixed value, determined on the basis of the experience the infrastructure manager has on his network;
- or as a value calculated on the basis of the maintenance tolerances with the following calculation method.

The phenomena to be taken into account depend on the calculation methodology and type of distance between centres considered.

9.2.4.2 Calculation methodology

9.2.4.2.1 For the static gauge

For the static gauge, there is no general rule governing the calculation methodology for the limit distance between centres.

Very often, the limit distance between centres is determined as the sum of the nominal gauge semi-widths.

Where a corresponding kinematic gauge exists, the limit distance between centres can be calculated with the kinematic method.

9.2.4.2.2 For the kinematic gauge

When determining the limit distance between centres, it shall be considered that it is very unlikely that all the phenomena will attain extreme values simultaneously. This is why the arithmetic sum of the allowances is not acceptable. It can be shown that an acceptable degree of certainty can be obtained whilst following the general formula below:

$$\Sigma_{EA} = k \sqrt{\left[(\Delta b_{T_1})^2 + (\Delta b_{T_2})^2 + \dots (\Delta b_{T_n})^2 \right]_{voie1} + \left[(\Delta b_{T_1})^2 + (\Delta b_{T_2})^2 + \dots (\Delta b_{T_n})^2 \right]_{voie2}} \quad (28)$$

where T_j is the allowance of the various phenomena to be considered. Parameters that are not independent shall be considered together, i.e. in an arithmetic sum. It shall be noted that the same phenomena on the two tracks are to be considered as independent.

Coefficient k determines the degree of safety ($k \geq 1$).

An example of the calculation and the values recommended for the tolerances are given in Annex A and Annex B.

9.2.4.2.3 For the dynamic gauge

No standardized method yet exists for calculation of the limit distance between centres for the dynamic gauge

The kinematic gauge calculation principle can be easily transposed.

9.3 Determination of the nominal distance between track centres

9.3.1 General

All the allowances mentioned in the calculation of the limit distance between centres above are covered by the nominal distance between centres. The nominal distance between centres presents additional allowances. These allowances are to be chosen by the infrastructure manager on the basis of the phenomena he wants to cover:

- an allowance to increase the safety level;
- an additional maintenance allowance;
- an allowance to cover aerodynamic phenomena;
- an allowance to facilitate the installation of switches and crossings;
- an allowance to permit the running of special consignments;
- a reserve for future layout or gauge modifications;
- allowances to obtain a non-variable distance between centres that is easily manageable for the maintenance and verification services where actual allowances are generous.

Additional allowances for the safety of persons outside the scope of this standard and shall be defined by the authority responsible.

9.3.2 Determination

Generally, the value of the nominal distance between centres is constant; it is defined for ranges of selected radii in order to facilitate track design, laying and maintenance.

However, there is no methodology common to all networks for determining the nominal distance between centres because it results from different allowances, to be considered or not, according to the requirements of each infrastructure manager. The nominal distance between centres will therefore be determined at the same time as the nominal gauge, following a feasibility study based on the objective set and the resulting economic and technical consequences.

One way of obtaining a bigger safety allowance with the aim only of facilitating the management of the distance between centres is to add together all the random allowances mentioned in the case of the limit distance between centres in an arithmetic sum instead of a root mean square sum. It shall be noted that this methodology is generally accepted but rarely used on the different networks.

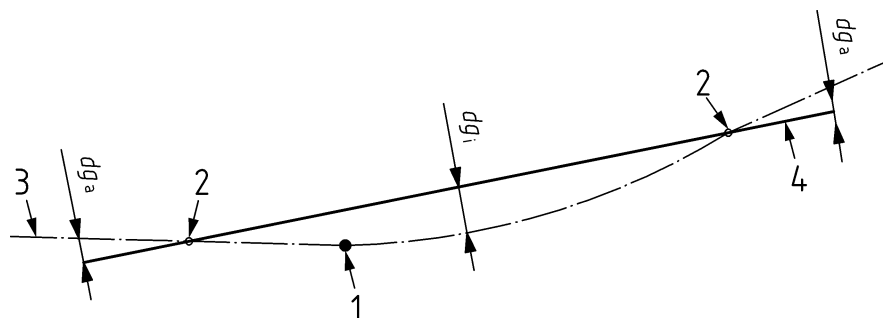
10 Elements of variable layout

10.1 General

10.1.1 Calculation principle

The abovementioned rules provide enough information to determine the space to be reserved for rail traffic on a straight track and in the body of a curve. In transition zones, it is noted that a vehicle occupies a progressively varying space according to the characteristics of two elements of the layout concerned. This

transition zone depends on not just its layout characteristics, but also on the length of the vehicles operating on the tracks concerned. See Figure 6.



Key

- 1 start of curve (curve tangent point)
- 2 centreline of bogies or axles
- 3 track centreline
- 4 centreline of the vehicle

Figure 6 — Effects of transitions

The rules for additional overthrows and for the quasi-static effect take no account of the position of the end point on the body. When a vehicle enters a curve, the various effects begin to act as soon as the first axle comes into the curve. The centre of gravity and the points defining the location reached by the vehicle are before the start of the transition. The rules to be applied to determine the gauge variations when crossing a layout transition zone are explained below.

10.1.2 Characteristics of a layout transition

A layout transition often consists of a variation in the curve radius on the one hand, and a variation of cant, or of cant deficiency, on the other. The first can be constructed in either a progressive or abrupt manner. The second is always determined by means of a transition cant ramp requiring a minimum distance (see also EN 13803-1).

The curve and gradient transitions are generally merged although they can be separate.

The vertical transition curves generally do not have any progressive curve transition (see EN 13803-1). The same phenomena occur only for plane curves.

Due to the fact that switches and crossings are very specific layout elements, they are dealt with separately.

10.1.3 Gauge variations

Gauge variations depend on the gauge type. As a general rule, the gauge elements of variable width are:

- the overthrows;
- the quasi-static effect.

It shall be noted that the overthrows depend only on the curve radius and local track gauge. When the gauge is considered relative to the nearest rail, the track gauge part is taken into account automatically and therefore can be disregarded.

On the inside of the curve, the quasi-static effect depends only on the cant and the transition step. It shall be noted that the characteristic point of the vehicle that determines the maximum point reached by the vehicle is located in the middle of the body.

On the outside of the curve, the quasi-static effect varies according to the cant deficiency which depends both on the locally applied cant, the curve radius and the speed. On this side, the maximum point reached by the vehicle is located at the ends of the body.

Similar phenomena occur in the vertical direction. They are not dealt with in detail in the following.

10.2 Layout transition

10.2.1 Sudden change of curvature

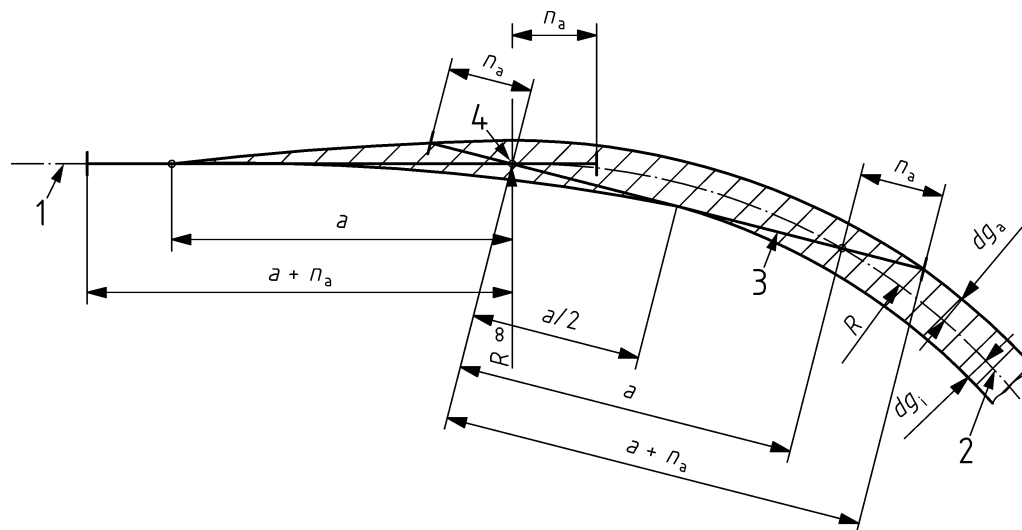
10.2.1.1 Variation of additional overthrows

When a vehicle is located at the beginning of a curve, the front of it already has an overthrow relative to the track centreline before the first bogie or wheelset has re-entered the curve.

As soon as the first bogie or wheelset enters the curve, the rear of the vehicle begins to have an overthrow. This means that the outside additional overthrows are to be partially taken into account from a distance $(n_a + a)$ from the layout transition. The geometric overthrow appears fully when the vehicle is located entirely in the curve, therefore when the rear of the vehicle is at a distance n_a from the start of the curve. A smooth change is created between these two extreme situations.

A similar situation arises on the inside of the curve. As the critical points are located between the two bogies, the change in the additional overthrows begins at a distance a from the start of the transition zone to end at a distance $a/2$ in the curve.

The change in the additional overthrows occurs over a distance dependant on the vehicle wheelbase a and overhang n_a . As the vehicle length is unknown, the maximum allowable length shall be determined. The detail of this change is determined by running all the reference vehicles through the transition zone.



Key

- 1 element of straight layout
- 2 element of curved layout of radius R
- 3 reference vehicle
- 4 transition point

Figure 7 — Effects of a sudden change of curvature

10.2.1.2 Quasi-static effect transition

The change of curvature in the transition zone changes the quasi-static effect at the same time as the cant change step.

The quasi-static effect shall be checked at the centre of gravity of the body, normally located in its midpoint. The curvature to be taken into account is the “average” value between the bogie centres or wheelsets. The ultimate point reached by the vehicle is between the bogie centres for structures on the inside of the curve and at the body ends for structures on the outside of the curve.

Generally, the rolling stock takes into account part of the roll. In the case of a transition from a straight track to a curve, the phenomenon seldom occurs before the layout transition.

10.2.1.3 Simplifications

The calculation of the space occupied by the reference vehicles depends largely on the characteristics of the transition. The calculation shall consequently be repeated for each transition zone. However, the start and end point is always the same as shown above. To simplify matters, the additional overthrows can be changed linearly between the two points

10.2.2 Smooth transition of curvature

Smooth transitions of curvature only apply when the speeds are high enough (see EN 13803-1).

The principles are exactly the same although the results change slightly:

- the starting point is the same as in the previous case; a distance $(n_a + a)$ before the start of the transition on the outside of the curve and a distance “ a ” from the same point on the inside of the curve;
- the end point of the transition zone is located at the same distance as in the previous case but relative to the end of the transition curve; at (na) beyond this point on the outside of the curve and at the distance $(a/2)$ after this same point on the inside of the curve;
- the changes occur more progressively because the curve radius also changes progressively.

Similar simplifications can be introduced. It is often thought that the transition zone is linear along its length but displaced towards the straight alignment.