

Railway applications — Gauges

Part 3: Structure gauges

ICS 45.020

National foreword

This British Standard is the UK implementation of EN 15273-3:2009.

The UK participation in its preparation was entrusted by Technical Committee RAE/1, Railway applications, to Subcommittee RAE/001/-/12, Railway applications – Gauging.

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

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.

This part of BS EN 15273 includes a number of gauges specifically intended for use in Great Britain. However, current UK 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), adopted in 2007, and the Conventional Rail Infrastructure Technical Specification for Interoperability (CR INF TSI), expected to be adopted in 2011. 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.

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

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

Amendments/corrigenda issued since publication

Date	Comments

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 May 2010

© BSI 2010

ISBN 978 0 580 55705 7

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 15273-3

December 2009

ICS 45.020

English Version

Railway applications - Gauges - Part 3: Structure gauges

Applications ferroviaires - Gabarits - Partie 3: Gabarit des obstacles

Bahnanwendungen - Begrenzungslinien - Teil 3: Lichtraumprofile

This European Standard was approved by CEN on 3 October 2009.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN Management Centre or to any CEN member.

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

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.



EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: Avenue Marnix 17, B-1000 Brussels

© 2009 CEN All rights of exploitation in any form and by any means reserved worldwide for CEN national Members.

Ref. No. EN 15273-3:2009: E

Contents

Page

Foreword.....	7
Introduction	8
1 Scope	9
2 Normative references	9
3 Terms and definitions	9
4 Symbols, abbreviations and subscripts.....	12
4.1 Symbols and abbreviations	12
4.2 Subscripts	17
4.3 Notations	18
5 General information on all the gauging methods.....	18
5.1 The reference profile and its associated rules	18
5.2 Transverse widening	18
5.2.1 Gauge variations depending on the local situation	18
5.2.2 Random transverse phenomena	19
5.3 Superelevation and lowering perpendicular to the running surface.....	20
5.3.1 Introduction	20
5.3.2 Vertical superelevation or lowering for longitudinal profile transition curves	20
5.3.3 Vertical effect of the roll	21
5.3.4 Uplift.....	22
5.3.5 Vertical random phenomena	22
5.4 Additional allowances	22
5.5 Gauge types	23
5.5.1 Gauge methodologies	23
5.5.2 Structure gauge types.....	23
5.5.3 Uniform gauge.....	24
5.6 Gauge choice	24
5.6.1 Gauge and methodology choice	24
5.6.2 Structure gauge choice.....	25
5.6.3 Taking account of the allowances	25
5.6.4 Gauge catalogue.....	25
6 Rules for determination of the static gauge	26
6.1 General.....	26
6.2 Associated rules	26
6.3 Determination of the sum of allowances Σ	27
6.3.1 Transverse allowances	27
6.3.2 Vertical allowances for random phenomena	28
7 Rules for determination of the kinematic gauge	29
7.1 General.....	29
7.2 Associated rules	29
7.3 Transverse allowances for random phenomena	30
7.3.1 Phenomena considered	30
7.3.2 Determination of the sum of transverse allowances Σ_j	30
7.4 Vertical allowances for random phenomena	31
7.4.1 Phenomena considered	31
7.4.2 Determination of the sum of vertical allowances Σ_v	31
8 Rules for determination of the dynamic gauge	31
8.1 General.....	31

8.2	Associated rules.....	32
8.3	Transverse allowances for random phenomena.....	32
8.3.1	Phenomena considered	32
8.3.2	Determination of the sum of allowances Σ_j	32
8.4	Vertical allowances for random phenomena	33
8.4.1	Phenomena considered	33
8.4.2	Determination of the sum of vertical allowances Σ_v	33
9	Distance between track centres.....	34
9.1	General	34
9.2	Determination of the limit distance between track centres	34
9.2.1	Introduction.....	34
9.2.2	Effect of cant difference $\Delta b_{\delta D}$	35
9.2.3	Allowances to take into account random phenomena	36
9.2.4	Determination	37
9.3	Determination of the nominal distance between track centres	38
9.3.1	Introduction.....	38
9.3.2	Determination	38
10	Elements of variable layout.....	39
10.1	Introduction.....	39
10.1.1	Calculation principle	39
10.1.2	Characteristics of a layout transition	39
10.1.3	Gauge variations	40
10.2	Layout transition	40
10.2.1	Sudden change of curvature.....	40
10.2.2	Smooth transition of curvature.....	41
10.3	Crossing of a turnout	42
10.3.1	Introduction.....	42
10.3.2	Additional overthrow variations	43
10.3.3	Quasi-static effect variations	44
10.3.4	Result.....	44
11	Determination of the pantograph free passage gauge.....	45
11.1	General	45
11.1.1	Space to be cleared for electrified lines.....	45
11.1.2	Particularities	45
11.1.3	Basic principles	45
11.2	Determination of the pantograph free passage mechanical gauge (in the case of the kinematic gauge)	46
11.2.1	Determination of the mechanical gauge width.....	46
11.2.2	Determination of the maximum height h_{eff} of the mechanical gauge	49
11.3	Pantograph electrical gauge (in the case of the kinematic gauge).....	49
11.3.1	Introduction.....	49
11.3.2	Pantograph electrical gauge width.....	49
11.3.3	Electrical gauge height	50
11.3.4	Insulating distance	50
11.4	Determination of the pantograph gauge in the case of the dynamic gauge	50
12	Overhead contact wire	51
13	Rules for installation of platform edges.....	52
13.1	General	52
13.2	Gaps b_{lac} and h_{lac}	53
13.3	Installation dimensions.....	55
13.3.1	Installation relative to the running surface.....	55
13.3.2	Installation relative to the horizontal (x_q, y_q)	55
13.3.3	Installation tolerances.....	56
13.4	Verification and tolerances.....	56
14	Tilting trains	56
14.1	General	56

14.2	Transition curve.....	57
14.3	Degraded modes.....	58
15	Rules for ferries	58
16	Track accessories.....	58
16.1	Introduction	58
16.2	Contact ramps.....	59
16.3	Active check rails.....	59
16.4	Planking of level crossings	59
16.5	Electric third rail.....	59
16.6	Rail brakes.....	59
17	Verification and maintenance of the gauge	60
17.1	Structure gauge	60
17.2	Distance between centres.....	60
18	Guide for determination of a new gauge from an existing infrastructure	60
Annex A	(normative) Calculation methodology for structure gauge allowances	61
A.1	Introduction	61
A.2	Formulation in the case of the static or kinematic gauge	61
A.2.1	For the installation nominal gauge	61
A.2.2	For the installation limit gauge.....	62
A.2.3	Limit gauge.....	64
A.2.4	For the installation nominal distance between centres.....	64
A.2.5	For the installation limit distance between centres	65
A.2.6	For the limit distance between centres	65
A.2.7	For the pantograph gauge	65
A.3	Formulation in the case of the dynamic gauge	66
A.3.1	General.....	66
A.3.2	For the installation nominal gauge	66
A.3.3	For the installation limit gauge.....	66
A.3.4	Limit gauge.....	67
A.3.5	For the installation nominal distance between centres.....	68
A.3.6	For the installation limit distance between centres	68
A.3.7	For the limit distance between centres	69
A.3.8	For the pantograph gauge	69
Annex B	(informative) Recommended values for calculation of the structure gauge and calculation examples.....	70
B.1	Recommendations for coefficients.....	70
B.2	Examples of kinematic calculation	71
B.2.1	Limit gauge and installation limit gauge	71
B.2.2	Nominal, installation limit and limit distances between centres	72
B.2.3	Pantograph gauge	73
Annex C	(normative) International gauges G1, GA, GB and GC	80
C.1	General.....	80
C.1.1	Application	80
C.1.2	Gauge types	80
C.1.3	Parameters and common rules	80
C.1.4	Calculation of distance between centres	81
C.1.5	Pantograph free passage gauge	81
C.1.6	Gauge parts	81
C.2	Gauge for the upper parts ($h > 400$ mm).....	82
C.2.1	Gauge G1	82
C.2.2	Gauges GA and GB.....	83
C.2.3	Gauge GC	84
C.3	Lower parts ($h \leq 0,400$ m).....	85
C.3.1	Lower parts of G1C2 – generally applicable	85
C.3.2	Lower parts of G1C1 – Tracks for rail brake equipment.....	87
C.3.3	Lower parts for "rolling" roads – G1C3.....	91

C.3.4	Pantograph free passage gauge	93
Annex D	(normative) Gauges for multilateral and national agreements	94
D.1	Introduction	94
D.2	Kinematic gauges derived from international gauges	94
D.2.1	Gauge G2	94
D.2.2	Gauges GB1 and GB2	96
D.3	Static gauges derived from international gauges	99
D.3.1	Gauge G1	99
D.3.2	Gauge G2	102
D.3.3	Gauges GA, GB and GC	104
D.4	National application gauge	106
D.4.1	Belgian gauges BE1, BE2 and BE3	106
D.4.2	French gauges FR-3.3	109
D.4.3	Portuguese gauges PTb, PTb+ and PTc	111
D.4.4	Finnish gauge FIN1	117
D.4.5	Swedish gauges SEa and SEc	120
D.4.6	German gauge DE1	123
D.4.7	German gauge DE2	124
D.4.8	German gauge DE3	126
D.4.9	Czech gauge Z-GČD	128
D.4.10	UK gauge UK1	129
D.4.11	UK gauge UK1 [D]	132
D.4.12	UK gauge W6a	133
Annex E	(informative) Calculation example for determination of the gauge at a turnout	136
E.1	Introduction	136
E.2	Methodology	137
E.3	Widening in the curve	137
E.3.1	Widening of the main line	137
E.3.2	Widening in the turnout route	139
E.4	The quasi-static effect	140
E.5	Gauge width at a turnout	141
Annex F	(normative) Determination of reference vehicle characteristics	144
F.1	Introduction	144
F.2	Methodology	144
F.3	Calculation example	145
F.3.1	Introduction	145
F.3.2	Vehicle no.1 (on the inside of the curve)	145
F.3.3	Vehicle no.2 (on the outside of the curve)	145
F.3.4	Vehicle no.3 (on the inside of the curve)	146
F.3.5	Vehicle no.4 (on the outside of the curve)	146
F.3.6	Summary	146
F.3.7	International gauge reference vehicles	146
Annex G	(normative) Uniform gauge	149
G.1	Introduction	149
G.2	GU1	149
G.2.1	General	149
G.2.2	Determination of the gauge	149
G.2.3	Equivalent kinematic gauge	151
G.3	GU2	151
G.3.1	General	151
G.3.2	Determination of the gauge	152
G.4	GUC	153
G.4.1	General	153
G.4.2	Determination of the gauge	154
Annex H	(informative) Gauge maintenance guideline	156
H.1	Introduction	156
H.2	Choice of gauge	156

H.3	Installation rules	156
H.3.1	Guidelines for installation of equipment along the track	156
H.3.2	Guidelines for the installation of tracks alongside structures	157
H.3.3	Guidelines for the installation of temporary structures	157
H.4	Managing and checking of structures	157
H.4.1	Management principles	157
H.4.2	Management of critical situations	157
H.4.3	Practical aspects for measuring the structures	158
H.5	Effect of track maintenance	158
H.6	Personnel training	158
Annex I	(informative) A-deviations	159
Annex ZA	(informative) Relationship between this European Standard and the Essential Requirements of the 2008/57/EC	161
Bibliography		170

Foreword

This document (EN 15273-3:2009) 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 June 2010, and conflicting national standards shall be withdrawn at the latest by June 2010.

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

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

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, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

This document is the third of a series of three parts of 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 as a function of 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 and taking account of the specific constraints to operate within it.

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 gauge as a one-to-one agreement 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.

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 not requiring the interoperability of the rolling stock on other networks.

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.

2 Normative references

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

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

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

EN 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.

The structure gauge is defined on the basis of the reference profile by applying the associated rules.

There are three types of structure gauge.

3.2 structure limit gauge
space not to be encroached upon at any time and fixes the limit for normal operation. It is used to ensure that structures allow free passage

Consequently, no structure is allowed to penetrate this space at any time.

3.3 structure installation limit gauge
space not to be encroached upon taking into account a maintenance allowance. It is to be used to define the structure installation limit

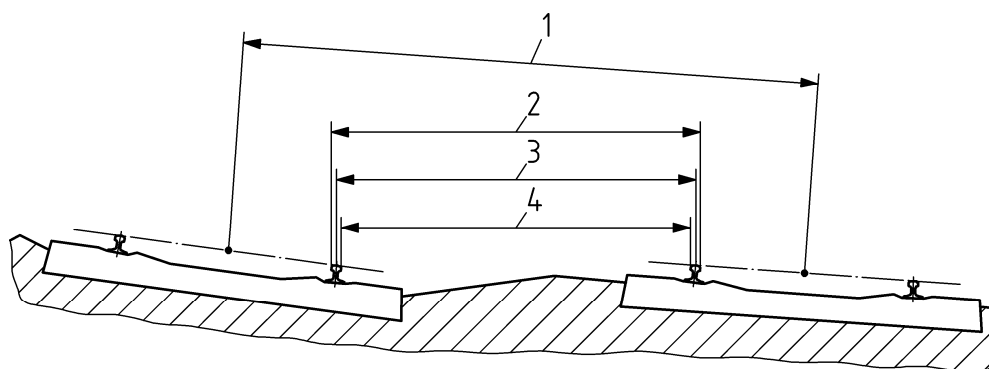
Consequently, no structure shall be installed if free passage is desired following normal maintenance operations.

3.4 structure installation nominal gauge
space to be cleared for all structures to permit train operation and track maintenance, including adequate allowances. This space may include allowances for special consignments and other conditions

3.5 distance between track centres
distance between the centre points of the two tracks concerned, measured parallel to the running surface of the track used, called the reference track, which is the track with the least cant

NOTE 1 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 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
- 2 space between centres measured between the running edges
- 3 space between centres measured between the rail centrelines
- 4 space between centres measured between the outside edges of the rails

Figure 1 — Distance between track centres

3.6

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. This distance varies as a function of the local track parameters (e.g. cant, curve radius, etc.)

3.7

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. This distance varies as a function of the local track parameters (e.g. cant, curve radius, etc.). It takes into account maintenance allowances

3.8

installation nominal distance between centres

distance between centres that generally has a suitable allowance to permit ease of design, laying, monitoring and maintenance, the operation of special transport or any other aspect. Outside the small radius zones, the nominal distance between centres is often invariable (determined with fixed parameters)

4 Symbols, abbreviations and subscripts

4.1 Symbols and abbreviations

Table 1 — Symbols and abbreviations

Symbol	Designation	Unit	Symbol number
a	Distance between end axles of vehicles not fitted with bogies or between bogie centres	m	1.001
b	Semi-width or distance parallel to the running surface, relative to the track centreline or of the vehicle	m	1.007
b'	Semi-width of the pantograph gauge	m	3.001
b'_q	Actual installation distance of the platforms, measured from the rail running edge	m	1.008
b_{RP}	Semi-width of the reference profile	m	3.002
b_{elec}	Electrical insulation distance	m	3.003
b_{gap}	Standard width of the gap between the platform and the step	m	1.019
$b_{structure}$	Distance parallel to the running surface between the structure and the track centreline	m	3.004
b_q	Semi-width of the platform installation	m	1.021
Δb	Variation in semi-width b	m	3.005
b_{veh}	Semi-width of the vehicle	m	1.030
b_w	Semi-width of the pantograph head	m	1.033
C_0	(Reference) roll centre	m	3.006
c_w	Semi-width of the pantograph head insulating horn	m	3.007
dg	Geometric overthrow	m	3.008
dg_a	Geometric overthrow of the vehicle on the outside of the curve	m	1.038
dg_i	Geometric overthrow of the vehicle on the inside of the curve	m	1.041
D	Cant	m	1.044
D_0	Fixed cant value taken into account by agreement between the vehicle and the infrastructure	m	1.045
D'_0	Reference cant taken into account by the vehicle for the pantograph gauge	m	3.009
D'_L and D''_L	Limit cant values used in calculation of the total allowances	m	3.010
$D_{max,0}$	Standard maximum cant to allow for enlargement of the kinematic gauge	m	1.050

Table 1 (continued)

Symbol	Designation	Unit	Symbol number
δD	Cant difference (between two tracks)	m	3.011
e_p	Offset of the pantograph due to the vehicle characteristics	m	1.067
e_{pi}	Offset of the pantograph due to the vehicle characteristics, inside of the curve	m	3.012
e_{pa}	Offset of the pantograph due to the vehicle characteristics, outside of the curve	m	3.013
e_{po}	Offset of the pantograph at the upper verification point	m	1.068
e_{pu}	Offset of the pantograph at the lower verification point	m	1.071
e_v	Lowering of track components	m	1.073
EA	Distance between track centres	m	3.014
f_s	Allowance to take into account raising of the contact wire	m	1.079
f_{dyn}	Allowance to take into account dynamic movement of the contact wire	m	3.015
f_{wa}	Allowance to take into account the overrun by the pantograph head of the contact surface because of pantograph contact strip wear	m	1.083
f_{ws}	Allowance to take into account the overrun by the pantograph head of the contact surface because of pantograph skewing	m	1.084
h	Height in relation to the running surface	m	1.088
h'	Reference height in the calculation of the pantograph gauge	m	3.016
h_o'	Maximum verification height of the pantograph gauge in a raised position	m	1.089
h_u'	Minimum verification height of the pantograph gauge in a raised position	m	1.090
h_{Co}	Value of h_c used for the agreement between the vehicle and the infrastructure	m	1.092
h'_{Co}	(Reference) roll centre height for the pantograph gauge	m	3.017

Table 1 (continued)

Symbol	Designation	Unit	Symbol number
h_{RP}	Height of the reference profile	m	1.093
h_{eff}	Effective height of the raised pantograph	m	1.094
$h_{eff,elec}$	Effective height of the raised pantograph plus the electrical insulation	m	1.095
h_f	Height of the contact wire	m	1.096
$h_{min,RP}$	Minimum height of the lateral surface of the reference profile (at platform level)	m	1.101
h_{ec}	Height of the platform edge coping	m	1.102
$h_{structure}$	Height of the structure above the running surface	m	3.018
h_P	Height of point P	m	3.019
h_q	Height of the platform above the running surface	m	1.103
Δh	Height variation h	m	3.020
I	Cant deficiency	m	1.107
I'_C	Maximum local cant deficiency to be considered for classic trains	m	1.108
I'_P	Maximum local cant deficiency to be considered for tilting trains	m	1.109
I_C	Maximum cant deficiency used by the infrastructure manager for his routes	m	1.110
I_L	Limit cant deficiency used in the kinematic calculation	m	3.021
I_0	Fixed cant deficiency value taken into account by agreement between the vehicle and the infrastructure with regard to the kinematic gauge	m	1.116
I'_0	Reference cant deficiency taken into account by the vehicle for the pantograph gauge	m	3.022
I_P	Cant deficiency of tilting body vehicles	m	1.117
k, k'	Security coefficient to take into account track irregularities		1.123
K	Amplification coefficient for calculation of allowances		3.023
ℓ	Track gauge, distance between the rail running edges	m	1.126
ℓ_{nom}	Nominal track gauge	m	1.129
L	Standard distance between the centrelines of the rails of the same track	m	1.134
M_j	(Horizontal) safety allowance for the structure gauge, covering certain random phenomena ($j = 1, 2$ or 3)	m	3.024
M_{EAj}	Safety allowance for the distance between centres, covering certain random phenomena. ($j = 1, 2$ or 3)	m	3.025

Table 1 (continued)

Symbol	Designation	Unit	Symbol number
n_a	n for the sections outside the axles or bogie centres	m	1.158
P	Upper point of the reference profile lateral face which is the determining factor for the distance between centres		3.026
q	Transverse clearance between wheelset and bogie frame, or wheelset and body for vehicles not fitted with bogies	m	1.172
Q	End lateral point of the reference profile upper face		3.027
q_s	Quasi-static effect	m	3.028
q_{s_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	1.174
q_{s_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	1.175
$q_{s'_i}$	Quasi-static effect for the pantograph gauge on the inside of the curve	m	3.029
$q_{s'_a}$	Quasi-static effect for the pantograph gauge on the outside of the curve	m	3.030
R	Horizontal curve radius	m	1.178
R_v	Vertical transition radius in longitudinal section	m	1.185
s_0	Flexibility coefficient taken into account in the agreement between the vehicle and the infrastructure		1.188
s'_0	Flexibility coefficient taken into account in the agreement between the vehicle and the infrastructure for the pantograph gauge		1.189
S	Allowed additional overthrow	m	1.192
S_a	Allowed additional overthrow on the outside of the curve	m	1.197
S_i	Allowed additional overthrow on the inside of the curve	m	1.204
T_{load}	Angle of dissymmetry, considered as in η_{or} for poor load distribution	°	1.212
T_D	Track crosslevel errors between two maintenance periods	m	1.213
T_N	Track vertical tolerance	m	1.214
T_{osc}	Crosslevel track irregularities causing random oscillations	m	1.215
T_{susp}	Angle of dissymmetry, considered as in η_{or} for poor suspension adjustment	°	1.217
T_{track}	Transverse displacement of the track between two periods of maintenance	m	1.218
V_c	Maximum speed of classic vehicles	km/h	3.031

Table 1 (continued)

Symbol	Designation	Unit	Symbol number
V_P	Maximum speed of tilting vehicles	km/h	3.032
V'_c	Local speed of classic vehicles	km/h	1.221
V'_P	Local speed of tilting vehicles	km/h	1.222
w	Transverse clearance between bogie and body	m	1.228
x_{qi}	Transverse clearance between bogie and body towards the inside of the curve varying as a function of the track curve radius	m	1.231
x_{qa}	Horizontal coordinate of the platform edge on the outside of the curve	m	3.033
x	Distance taken into account from the point of origin O for the calculation of e_v	m	1.233
y	Vertical coordinate	m	3.034
y_{qi}	Vertical coordinate of the platform edge on the inside of the curve	m	3.035
y	Part of the quasi-static roll taken into account by the vehicle	m	1.234
z_0	Fixed value available to the vehicle on the outside of the static reference profile to allow quasi-static roll of the vehicle	m	1.237
α	Additional angle of roll of the body due to the clearance to the side bearers	°	1.242
α_Q	Maximum angle of rotation around the roll centre for the upper parts	°	3.036
α''	Angle made by the gangway between the platform and the ferry	°	1.245
γ	Entry angle of turnouts	radian	1.246
$\delta_{q,a}$	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	1.256
Σ_j	Sum of the (horizontal) safety allowances for the structure gauge covering certain random phenomena ($j = 1, 2$ or 3)	m	3.037
Σ'_j	Sum of the allowances used in the calculation of the kinematic limit ($j = 1, 2$ or 3)	m	3.038
Σ''_j	Sum of the allowances used in the calculation of the dynamic limit ($j = 1, 2$ or 3)	m	3.039
Σ_{EAj}	Sum of the safety allowances for the distance between centres covering certain random phenomena ($j = 1, 2$ or 3)	m	3.040
Σ_V	Sum of the values of the allowances taken into account by the infrastructure in the vertical direction	m	1.278
η_0	Angle of dissymmetry of a vehicle due to construction tolerances, to suspension adjustment and to unequal load distributions	°	1.281

Table 1 (continued)

Symbol	Designation	Unit	Symbol number
η_{0r}	Reference angle η_0 taken into account in the agreement	°	1.283
θ	Angle resulting from the suspension adjustment tolerances	radian	1.284
τ	Pantograph construction and installation tolerance	m	1.286

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 vehicle and the infrastructure

Subscript st: refers to the static calculation rules. The subscript is often omitted when the context makes it clear that it is a question of the static parameter

Subscript kin: refers to the kinematic calculation rules. The subscript is often omitted when the context makes it clear that it is a question of the kinematic parameter

Subscript dyn: refers to the dynamic calculation rules. The subscript is often omitted when the context makes it clear that it is a question of the dynamic parameter

Subscript act: refers to the actual local value, i. e. measured on the track

Subscript RP: refers to the reference profile

Subscript gap: 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 gauge

Subscript max: refers to the maximum value that may appear as a function of 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

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 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 structure gauge or the structure gauge (on straight track or other).

Generally added to this profile is widening as a function of 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 EN 15273-1 for more detailed explanations).

Horizontal 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 Introduction

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 given in EN 15273-1. The specific formulae to be applied for the gauge used 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 type of gauge, the vehicle already takes part of this into account not exceeding the values of I_0 and D_0 . The infrastructure only takes into account the additional value.

The general formulations are given in EN 15273-1. 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 vehicle.

5.2.2 Random transverse phenomena

Random phenomena to be considered depend on the gauge used.

The following phenomena are considered as the responsibility of the Infrastructure Manager.

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

Irregularities of ballasted track 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:

$$\frac{S_0}{L} T_{osc} (h - h_{c0})_{>0} \quad (1)$$

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 vehicle.

5.2.2.2 Track displacement (T_{track})

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_{track} 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 neglected.

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 gauge profile rotates around the track centreline at an angle corresponding to the maximum variation:

$$S_0 \cdot \frac{T_D}{L} \cdot (h - h_{c0})_{>0} \quad (2)$$

Due to the flexibility of the suspension, the vehicle will tend to rotate around the roll centre.

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

- 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:

- poor 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_{load} .

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 :

$$T_{\text{dis}} = T_{\text{load}} + T_{\text{susp}} \quad (4)$$

5.3 Superelevation and lowering perpendicular to the running surface

5.3.1 Introduction

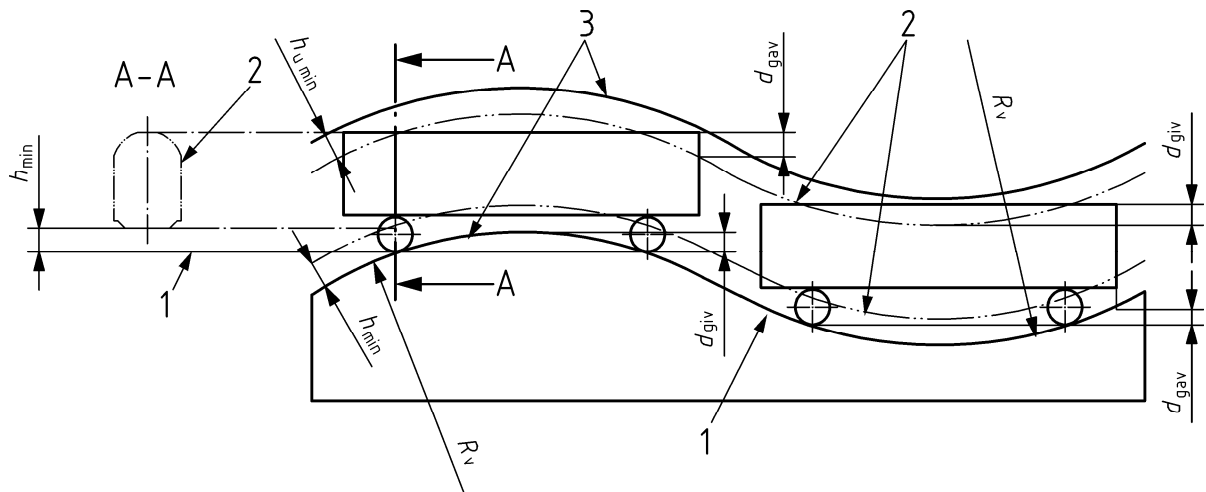
In most cases, the vehicle takes into account vertical displacements (including tolerances) unless specified otherwise. The following vertical displacements shall only be considered by the infrastructure manager.

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 given in EN 15273-1. The specific formulae to be applied for the gauge used are given in the annex. 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 gauges 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.

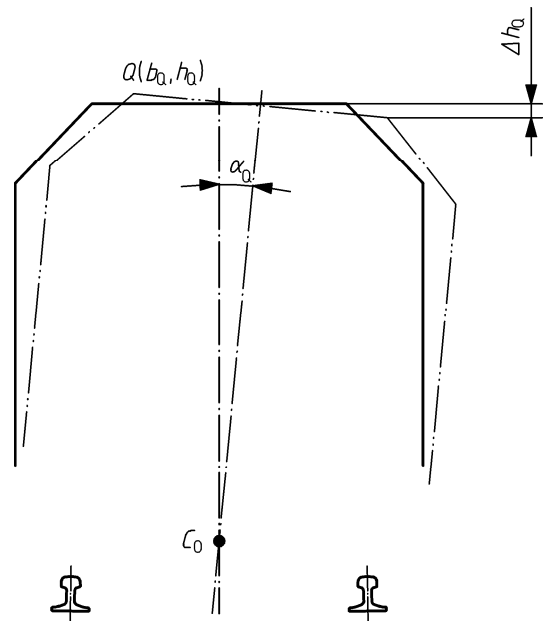


Figure 3 — Vertical effect of the roll

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 due to track tolerances T_{osc} (see 5.2.2.1);
- dissymmetry η_0 (see 5.2.2.4).

The superelevation is determined by the following formula:

$$\Delta h_Q = b_Q \cdot \alpha_Q \sqrt{\left(\frac{b_Q}{h_Q - h_{C0}} \right)^2 + 1} \quad (5)$$

where

α_Q is the rotation of the gauge due to the quasi-static effect

h_Q, b_Q : are the coordinates of the point considered Q .

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 .

5.3.3.2 Lower parts

The same principle can be used for the lower parts but it is taken into account by the vehicle.

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 (e.g. 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 vehicle 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 EN 15273-1. 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 limit gauge** only takes into account widening and certain allowances that ensure safety of operations during control with the parameters measured on site. This group of allowances is called M_1 ;
- the **structure installation limit gauge** takes into account the structure 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;
- the **structure installation nominal gauge** takes into account not only allowances M_1 and M_2 , but also 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.

Allowance M_1 corresponds to Σ_1 .

The sum of allowances M_1 and M_2 is determined by Σ_2 .

The sum of 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 vehicle.

5.6 Gauge choice

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, it is necessary to clear the nominal gauge and in the case of major reconstruction of installations, it is advised clearing it. 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 limit gauge may need to be defined when he 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 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 various networks.

5.6.4 Gauge catalogue

Technical interoperability conditions are defined in EN 15273-1. The application of international or reduced interoperability gauges depends on international regulations or bilateral or multilateral agreements even. The gauge choice is fixed by each network.

A distinction is made between:

- gauges "interoperable internationally". They are listed in Annex C;

- and other gauges for bilateral or multilateral agreements or national applications. They are listed in Annex D.

6 Rules for determination of the static gauge

6.1 General

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 vehicle 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 the situation of the local track (cant, curve radius and rail 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.

NOTE In this clause, the subscript "s" is omitted from all the parameters in order to improve the legibility.

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:

$$b_{\text{structure}} \geq b_{RP} + S_{i/a} + qs_{i/a} + \Sigma_j \quad (6)$$

where

- b_{RP} is the semi-width of the static reference profile;
- $S_{i/a}$ are the additional overthrows (see 5.2.1.2) ;
- $qs_{i/a}$ is the quasi-static effect with the following general formulation:

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

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

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

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

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

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

$$h_{\text{structure}} \geq h_{RP} + \Delta h_{R_V} + \Delta h_{\text{susp}} + \Delta h_Q + \Sigma_V \quad (11)$$

where

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

where

$$\alpha_Q = \frac{s_0}{L} \cdot \max(D, I) \quad (12)$$

- an additional allowance Σ_V for the random phenomena.

6.3 Determination of the sum of allowances Σ

6.3.1 Transverse allowances

6.3.1.1 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 vehicle. 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_{track} 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.

6.3.1.2 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 ($k \geq 1$).

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.

6.3.2 Vertical allowances for random phenomena

6.3.2.1 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 parts);
- track vertical tolerance T_N ;
- vertical tolerances;
- additional allowances.

6.3.2.2 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:

$$\Sigma_v = k \sqrt{\sum_{j'} \Delta h_{T_j}^2}, \quad (14)$$

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.

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

7 Rules for determination of the kinematic gauge

7.1 General

The reference profile is determined for a flat straight track, of nominal rail gauge without cant. 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.

NOTE In this clause, the subscript "kin" is omitted from all the parameters in order to improve the legibility.

7.2 Associated rules

The position of the structure shall cover the sum:

$$b_{\text{structure}} \geq b_{RP} + S_{i/a} + qs_{i/a} + \Sigma_j \quad (15)$$

where:

- b_{RP} is the semi-width of the kinematic reference profile;
- $S_{i/a}$ are the additional overthrows (see 5.2.1.2);
- $qs_{i/a}$ is the quasi-static effect with the following general formulation:

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

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

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

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

$$h_{\text{structure}} \geq h_{RP} + \Delta h_{R_v} + \Delta h_Q + \Sigma_v \quad (18)$$

where

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

where

$$\alpha_Q = \frac{s_0}{L} \cdot \max(D, I) \quad (19)$$

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 vehicle. 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_{track} 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:

$$\Sigma_j = k \sqrt{\sum_{j'} \Delta b_{T_{j'}}^2} \quad (20)$$

where $T_{j'}$ is the allowance of the various phenomena to be considered (see 7.2). 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.

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 parts);
- track vertical tolerance 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:

$$\Sigma_V = k \sqrt{\sum_{j'} \Delta h_{T_j}^2} \quad (21)$$

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 ($k \geq 1$).

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.

8 Rules for determination of the dynamic gauge

8.1 General

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.

NOTE In this clause, the subscript "dyn" is omitted from all the parameters in order to improve the legibility.

8.2 Associated rules

The position of the structure shall cover the sum:

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

where

- b_{RP} 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.

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

$$h_{\text{structure}} \geq h_{RP} + \Delta h_{R_v} + \Sigma_v \quad (23)$$

where

- h_{RP} 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 listed in 1.4.2. The various phenomena are grouped according to their character.

M_1 includes the effects of certain random phenomena due to actual movements of the vehicles. This allowance determines the limit of the point reached by the vehicle. 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_{track} 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 vehicle).

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:

$$\Sigma_j = k \sqrt{\sum_{j'} \Delta b_{T_j}^2} \quad (24)$$

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 ($k \geq 1$).

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.

8.4 Vertical allowances for random phenomena

8.4.1 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 parts);
- 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:

$$\Sigma_v = k \sqrt{\sum_{j'} \Delta h_{T_j}^2} \quad (25)$$

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 traffic on adjacent tracks at the same time 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 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 Introduction

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 or in EN 15273-1 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: $qS_{i/a}$ (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.

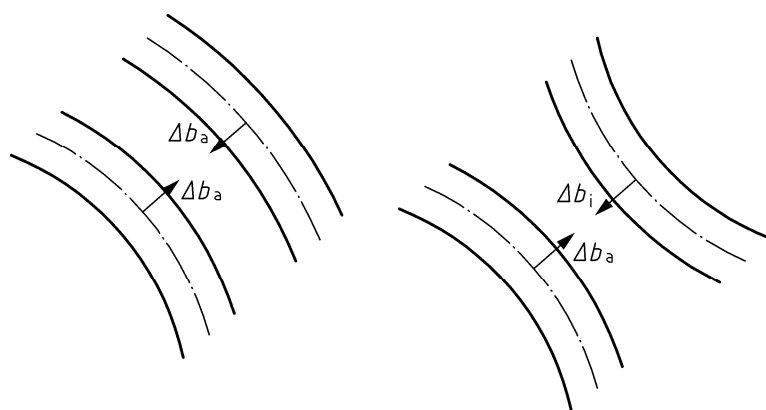


Figure 4 — Distances between centres

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

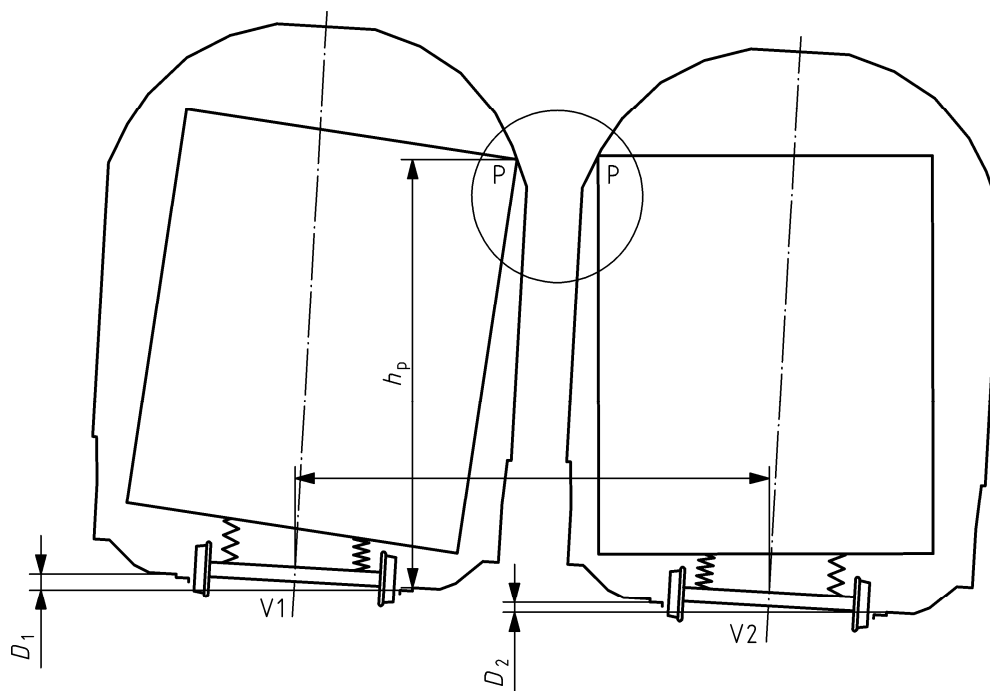
When the two tracks considered have a different cant or transverse crosslevel, the two gauges tend to get closer to each other or further away at the top of the vertical part. This has major consequences on the distance between centres measured at the running surface.

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:

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

Track 1 is the left-hand track and track 2 the right-hand track. The cant shall always be regarded in the same direction (see Figure 5).



Key

V1: track 1

V2: track 2

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 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 installation nominal distance between centres, in addition to the allowances M_{EA1} and M_{EA2} , also takes into account the 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 allowances M_{EA1} and M_{EA2} is determined by Σ_{EA2} .

The sum of allowances M_{EA1} to 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 rail 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:

$$EA \geq (b_{RP} + S_{i/a} + qS_{i/a})_{track1} + (b_{RP} + S_{i/a} + qS_{i/a})_{track2} + \Delta b_{\delta D} + \Sigma_{EAj} \quad (27)$$

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} can 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:

$$\Sigma_{EA} = k \sqrt{\left(\sum_j \Delta b_{T_j}^2 \right)_{track1} + \left(\sum_j \Delta b_{T_j}^2 \right)_{track2}} \quad (28)$$

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 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.

9.2.4.2.3 For the dynamic gauge

No standardized method yet exists for calculation 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 Introduction

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 has additional allowances that 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 turnouts;
- 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.

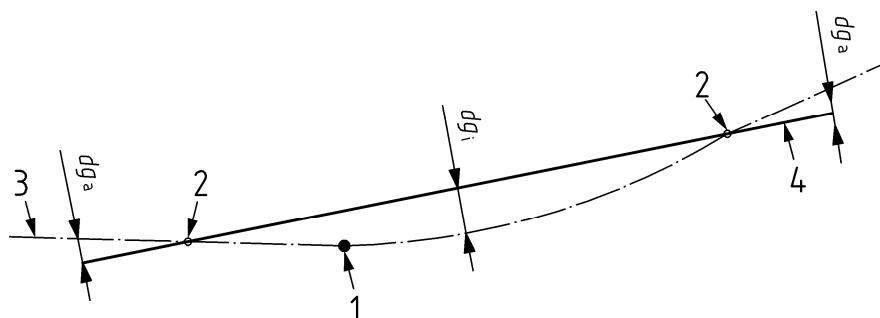
One way of obtaining a bigger safety allowance with the aim only of facilitating the management of the distance between centres is to add together all the random allowances mentioned in the case of the limit distance between centres in an arithmetic sum instead of a root mean square sum. It shall be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

10 Elements of variable layout

10.1 Introduction

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 as a function of 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 vehicle centreline

Figure 6 — Transition effects

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 curve radius can vary smoothly or suddenly, while the change of cant is always determined by a cant gradient that requires a minimum distance (see also ENV 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 ENV 13803-1). The same phenomena occur only for plane curves.

Due to the fact that turnouts 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 rail 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 is a function of 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

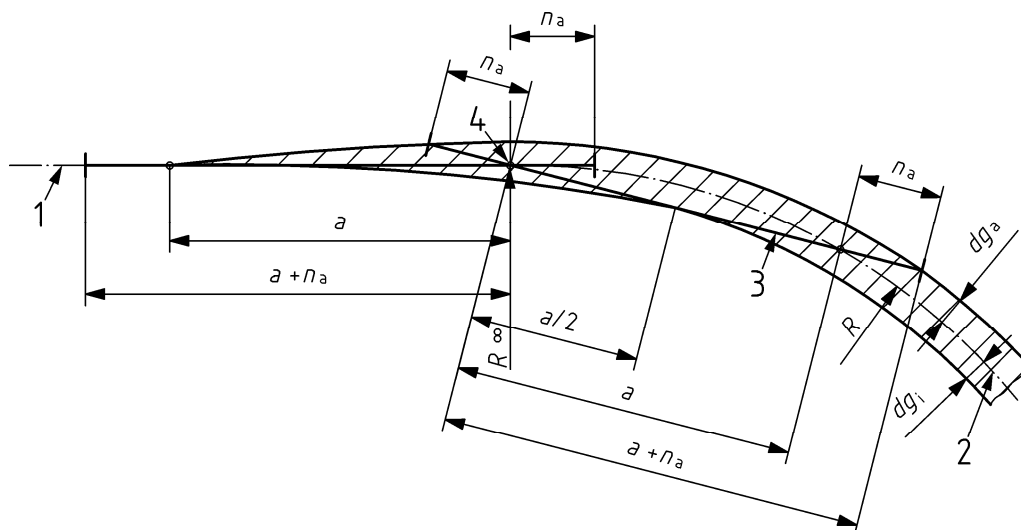
10.2.1.1 Variation of additional overthrows

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 axle has re-entered the curve.

As soon as the first bogie or axle 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 that is a function of the vehicle wheelbase a and overhang na . 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 (beginning of curve)

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 axles. 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 vehicle 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

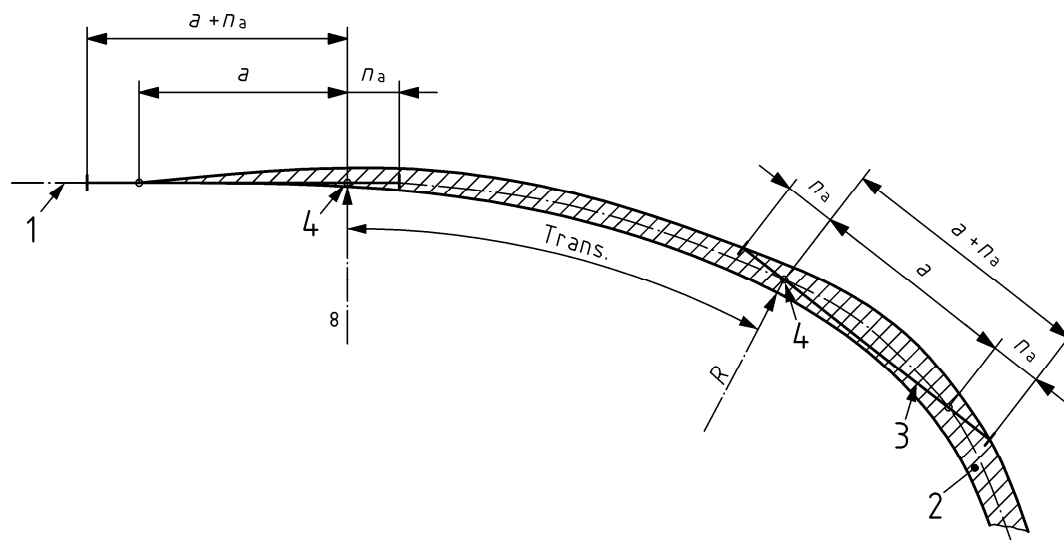
10.2.2 Smooth transition of curvature

Smooth transitions of curvature only apply when the speeds are high enough (see ENV 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 point curve; at (n_a) 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 smoothly because the curve radius also changes smoothly.

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



Key

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

Trans transition

Figure 8 — Effects of a smooth transition

10.3 Crossing of a turnout

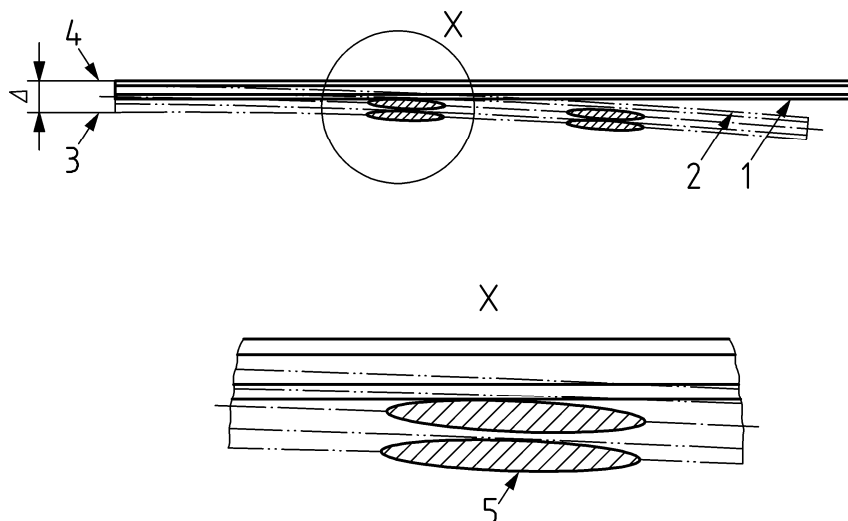
10.3.1 Introduction

The turnout generally comprises a straight main track and a curved turnout route. In order to be able to install structures correctly, account shall be taken of the traffic on both the tracks. The space to be cleared for the turnout route requires particular consideration.

The layout of a turnout is very specific:

- the switch entry angle diverts the vehicle at the beginning of the turnout. This switch entry angle is present even in the case of a turnout with a curve exit (see EN 13232-1). This angle forces the axle and the vehicle to leave the theoretical curve exit towards the outside of the curve (see figure);
- the curve radius may vary widely along the turnout with parts of the curve less than the vehicle length. These layout elements are not always straight.

NOTE This effect is greater in turnouts with a small radius.



Key

- 1 actual layout
- 2 theoretical layout (tangent)
- 3 vehicle in theoretical position
- 4 vehicle in actual position
- 5 wheel flange
- 4 additional overthrow due to the switch entry angle

Figure 9 — Principle of the switch entry angle effect

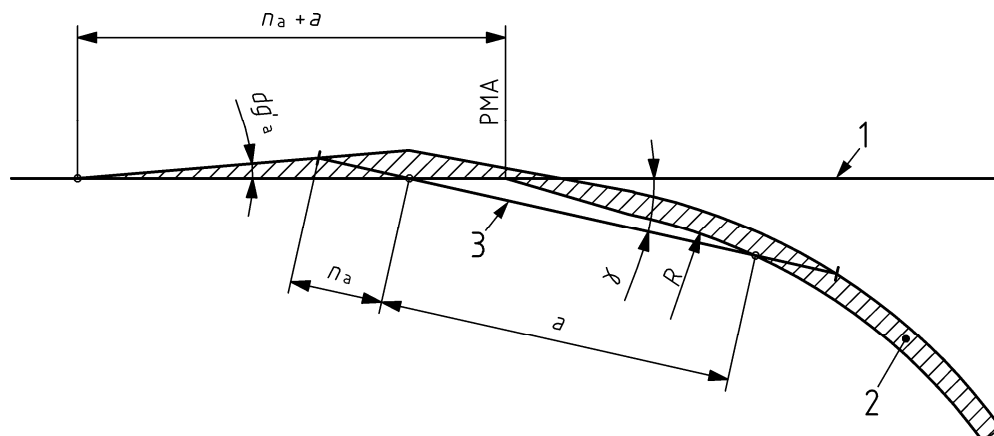
A turnout cannot be considered as a normal curvature transition.

10.3.2 Additional overthrow variations

Because of the switch entry angle, at the mathematical switch toe of the turnout, the vehicle is travelling in the opposite direction of the turnout route relative to the theoretical layout. In order to take account of this phenomenon, the displacements of the reference vehicles shall be examined by simulation case by case and use the space envelope occupied by the reference vehicles.

Connection to the origin of the turnout can be simplified in the same way as for the transition curves.

NOTE It may be noted that the widening at the origin of the turnout can be greater than in the body of the curve.



Key

- 1 straight track layout
- 2 turnout route layout
- 3 reference vehicle

PMA Mathematical Switch Toe

γ switch entry angle of the turnout

dg'_a geometric overthrow of the turnout

Figure 10 — Geometric overthrow of the turnout

10.3.3 Quasi-static effect variations

As the layout of a turnout can be variable, the theoretical quasi-static effect varies continuously in principle. In addition, the switch entry angle generated an instantaneous impact that corresponds locally to a very high cant deficiency.

Very short parts of the layout often exist in the turnouts, in which the curve radius is very large.

To examine the quasi-static effect, all these elements can be disregarded because of the distribution of these impacts and the inertia of the body. The value of the quasi-static effect is normally limited to the cant and cant deficiency design value.

10.3.4 Result

As the turnout crossing speed is constant, it is possible to examine the turnout once to cover all cases. The result of this is shown in the following figure.

Annex E gives a calculation example for a given turnout.

11 Determination of the pantograph free passage gauge

11.1 General

11.1.1 Space to be cleared for electrified lines

In the case of electrified lines with overhead contact wires, an additional space shall be cleared for:

- the installation of the overhead line;
- the free passage of the pantograph.

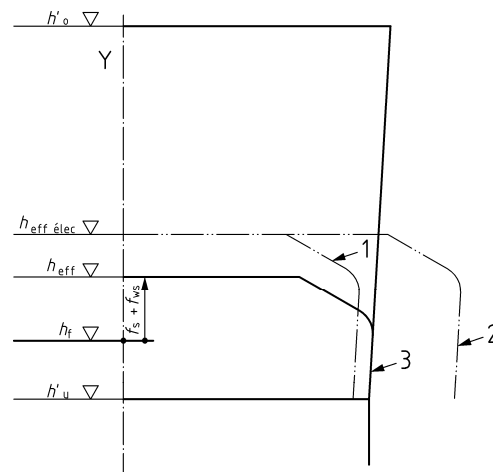
The first depends on the design of the line and, therefore, does not come within the scope of this standard. The second point is covered in detail below.

11.1.2 Particularities

The pantograph gauge differs from the structure gauge in the following points:

- the pantograph is (partially) live and therefore there shall be an electrical insulating clearance depending on the nature of the structure (insulated or not);
- the presence of an insulated horn shall be taken into account, if appropriate. Therefore, a double reference profile shall be defined to take into account the mechanical and electrical interference simultaneously;
- in the collection phase, the pantograph is in permanent contact with the contact wire and therefore its height is variable. The same is true for the pantograph gauge.

11.1.3 Basic principles



Key

- Y track centreline
- 1 electrical gauge (with insulated horn)
- 2 electrical gauge (with non-insulated horn)
- 3 mechanical gauge

Figure 11 — Mechanical and electrical pantograph gauge

The pantograph gauge requirements are met only if the electrical and mechanical gauge requirements are met simultaneously:

- the structures that are live and at the same potential as the overhead line shall remain outside the mechanical gauge;
- the insulated structures shall also remain outside the mechanical gauge;
- non-insulated structures (earthed or at a different potential from the overhead line current) shall remain outside the electrical and mechanical gauges.

Figure 11 represents the electrical and mechanical pantograph gauge. For the electrical gauge, the figure illustrates the case with and without insulated horns.

NOTE The insulating clearance depends on the voltage and regulation applied according to the networks concerned. Therefore, the electrical gauge is likely to vary between networks. The definition of the electrical insulating clearances does not come within the scope of this standard.

11.2 Determination of the pantograph free passage mechanical gauge (in the case of the kinematic gauge)

11.2.1 Determination of the mechanical gauge width

11.2.1.1 Introduction

The pantograph gauge width is determined essentially by that of the pantograph considered and its displacements. In the transverse displacements, phenomena similar to those in the structure gauge are found in addition to specific phenomena.

As the pantograph in the collection position follows the contact wire, the pantograph height depends on that of the contact wire. Therefore, the pantograph gauge is to be examined at the various heights it may assume. The extreme situations are examined at the following heights:

- the upper verification height h'_o ;
- the lower verification height h'_u .

Between these two heights, it can be considered that the gauge width varies in a linear way, which defines a space commonly called the "pantograph chimney".

The various parameters are shown in Figure 12.

11.2.1.2 Semi-width b_w of the pantograph head

The semi-width b_w of the pantograph head depends of the type of pantograph used. EN 50367 defines the dimensions of some pantographs used in Europe.

It is the task of the infrastructure manager to determine the pantograph types to be taken into consideration to determine the pantograph gauge depending on the type of electrification used

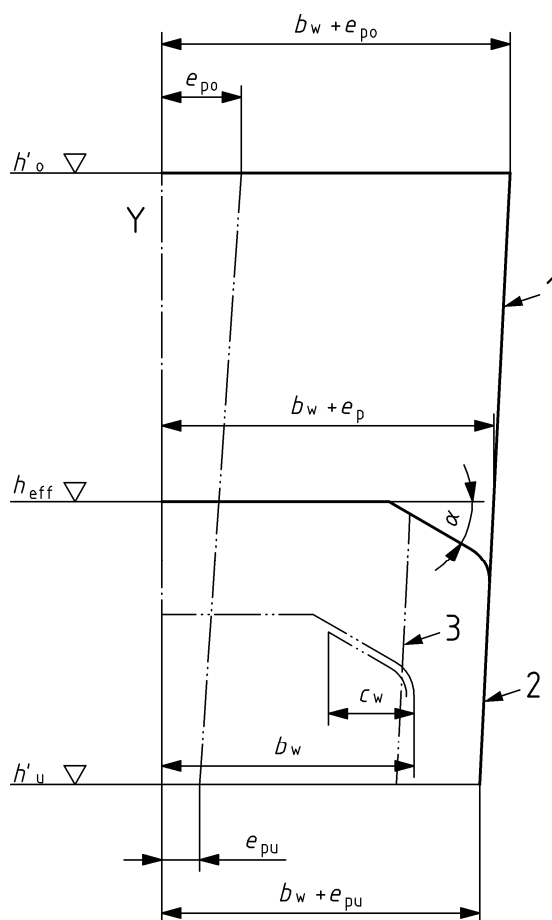
NOTE It should be noted that the authorization to run with a given pantograph type does not depend only on the pantograph type, but also on the vehicle it is mounted on

11.2.1.3 Offset of the pantograph e_p

The pantograph is not always installed in the centreline of the traction unit bogie centres. The offset depends mainly on the following phenomena:

- the clearance between the axle boxes and body/bogies $q + w$;
- the amount of body roll taken into account by the vehicle (depending on s_0' , I_0' and D_0');
- the pantograph mounting tolerance on the roof θ ;
- the transverse flexibility of the pantograph mounting device on the roof τ ;
- the height under consideration h' .

The infrastructure manager defines the offset limit values e_{po} and e_{pu} for the two verification heights h'_o and h'_u . The value at an intermediate height is obtained by a linear interpolation.



Key

- Y track centreline
- 1 pantograph chimney
- 2 mechanical profile
- 3 electrical profile

Figure 12 — Free passage gauge

11.2.1.4 Additional overthrows S

The pantograph gauge has specific additional overthrows.

11.2.1.5 Quasi-static effect

As the pantograph is installed on the roof, the quasi-static effect plays an important role in the calculation of the pantograph gauge. This effect is calculated on the basis of the specific flexibility s_0' , cant D'_0 and reference cant deficiency I'_0 :

$$qs'_i = \frac{s_0'}{L} [D - D'_0]_{>0} (h - h'_{c0}) \text{ inside of the curve} \quad (29)$$

$$qs'_a = \frac{s_0'}{L} [I - I'_0]_{>0} (h - h'_{c0}) \text{ outside of the curve} \quad (30)$$

11.2.1.6 Allowances

According to the gauge definition, the following phenomena shall be covered (see also 5.2.2 or EN 15273-1):

- loading dissymmetry;
- oscillations generated by track irregularities;
- the transverse displacement of the track between two successive maintenance periods;
- the cant variation occurring between two successive maintenance periods;
- allowances M_j and allowance sums Σ_j are defined in 5.2.3 and 5.2.4.

The calculation methodology is in principle the same as that of the structure gauge. Since a pantograph incident is assessed as less severe, a lower safety level is generally accepted. Annex A and Annex B describe a calculation method with recommended values.

11.2.1.7 Calculation methodology

The pantograph gauge width is determined by the sum of the abovementioned parameters. In the case of a line run by various pantographs, the maximum width used shall be considered. Therefore:

for the lower verification point with $h = h_u$:

$$b'_{ui/a,mec} = (b_w + e_{pu} + S'_{i/a} + qs'_{i/a} + \Sigma_j)_{\max} \quad (31)$$

for the upper verification point with $h = h_o$:

$$b'_{oi/a,mec} = (b_w + e_{po} + S'_{i/a} + qs'_{i/a} + \Sigma_j)_{\max} \quad (32)$$

for an intermediate height h , the width is determined by interpolation:

$$b'_h = b'_u + \frac{h - h_u}{h_o - h_u} (b'_o - b'_u) \quad (33)$$