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Railway applications – Track – Track alignment design parameters – Track gauges 1 435 mm and wider

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Denna standard ersätter SS-EN 13803-1:2010, utgåva 1 och SS-EN 13803-2:2006+A1:2009, utgåva 1.

The European Standard EN 13803:2017 has the status of a Swedish Standard. This document contains the official version of EN 13803:2017.

This standard supersedes the Swedish Standard SS-EN 13803-1:2010, edition 1 and SS-EN 13803-2:2006+A1:2009, edition 1.

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 13803

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English Version

Railway applications - Track - Track alignment design parameters - Track gauges 1 435 mm and wider

Applications ferroviaires - Voie - Paramètres de conception du tracé de la voie - Écartement 1 435 mm et plus large

Bahnanwendungen - Oberbau - Trassierungsparameter - Spurweiten 1 435 mm und größer

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European foreword

This document (EN 13803:2017) 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of an identical text or by endorsement, at the latest by October 2017, and conflicting national standards shall be withdrawn at the latest by October 2017.

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

For relationship with EU Directive 2008/57/EC, 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, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

The purpose of this European Standard is to specify rules and limits for track alignment design parameters, including alignments within switches and crossings. Several of these limits are functions of speed. Alternatively, for a given track alignment, it specifies rules and limits that determine permissible speed.

This European Standard applies to nominal track gauges 1 435 mm and wider with speeds up to 360 km/h. Normative Annex A describes the conversion rules which shall be applied for tracks with nominal gauges wider than 1 435 mm. Normative Annex B is applied for nominal track gauges 1 520 mm, 1 524 mm and 1 668 mm.

This European Standard is also applicable where track alignment takes into account vehicles that have been approved for high cant deficiencies (including tilting trains).

More restrictive requirements of Technical specifications for interoperability relating to the 'infrastructure' subsystem of the rail system in the European Union (TSI INF) and other (national, company, etc.) rules will apply.

This European Standard need not be applicable to lines, or dedicated parts of railway infrastructure that are not interoperable with railway vehicles tested and approved according to EN 14363.

2 Normative references

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

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

EN 14363, *Railway applications - Testing and Simulation for the acceptance of running characteristics of railway vehicles - Running Behaviour and stationary tests*

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 ISO 80000-3, *Quantities and units - Part 3: Space and time (ISO 80000-3)*

3 Terms and definitions

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

3.1
track gauge
distance between the corresponding running edges of the two rails

3.2
nominal track gauge
single value which identifies the track gauge but may differ from the design track gauge, e.g. the most widely used track gauge in Europe that has a nominal value of 1 435 mm although this is not the design track gauge normally specified

3.3
limit
design value not to be exceeded

Note 1 to entry: These values ensure maintenance costs of the track are kept at a reasonable level, except where particular conditions of poor track stability can occur, without compromising passenger comfort. However, the actual design values for new lines should normally have substantial margins to the limits.

Note 2 to entry: For certain parameters, this European Standard specifies both a normal limit and an exceptional limit. The exceptional limits represent the least restrictive limits applied by any European railway, and are intended for use only under special circumstances and can require an associated maintenance regime.

3.4
alignment element
segment of the track with either vertical direction, horizontal direction or cant obeying a unique mathematical description as a function of chainage

Note 1 to entry: Unless otherwise stated, the appertaining track alignment design parameters are defined for the track centre line and the longitudinal distance for the track centre line is defined in a projection in a horizontal plane.

3.5
chainage
longitudinal distance along the horizontal projection of the track centre line

3.6
curvature
derivative of the horizontal direction of the track centre line with respect to chainage

Note 1 to entry: In the direction of the chainage, curvature is positive in a right-hand curve and negative on a left-hand curve. The magnitude of the curvature corresponds to the inverse of the horizontal radius.

3.7
circular curve
curved alignment element of constant curvature

3.8
transition curve
alignment element where curvature changes with respect to chainage

Note 1 to entry: The clothoid (sometimes approximated as a 3rd degree polynomial, “cubic parabola”) is normally used for transition curves, giving a linear variation of curvature. In some cases, curvature is smoothed at the ends of the transition.

Note 2 to entry: It is possible to use other forms of transition curve, which show a nonlinear variation of curvature. Informative Annex C gives a detailed account of certain alternative types of transitions that may be used in track alignment design.

Note 3 to entry: Normally, a transition curve is not used for the vertical alignment.

3.9
compound curve
sequence of curved alignment elements, including two or more circular curves in the same direction

Note 1 to entry: The compound curve can include transition curves between the circular curves and/or the circular curves and the straight tracks.

3.10
reverse curve
sequence of curved alignment elements, containing alignment elements which curve in the opposite directions

Note 1 to entry: A sequence of curved alignment elements can be both a compound curve and a reverse curve.

3.11
cant
amount by which one running rail is raised above the other running rail, in a track cross section

3.12
equilibrium cant
cant at a particular speed at which the vehicle will have a resultant force perpendicular to the running plane

3.13
cant deficiency
difference between applied cant and a higher equilibrium cant

Note 1 to entry: When there is cant deficiency, there will be an unbalanced lateral force in the running plane. The resultant force will move towards the outer rail of the curve.

3.14
cant excess
difference between applied cant and a lower equilibrium cant

Note 1 to entry: When there is cant excess, there will be an unbalanced lateral force in the running plane. The resultant force will move towards the inner rail of the curve.

Note 2 to entry: Cant on a straight track results in cant excess, generating a lateral force towards the low rail.

3.15
cant transition
alignment element where cant changes with respect to chainage

Note 1 to entry: Normally, a cant transition coincides with a transition curve.

Note 2 to entry: Cant transitions giving a linear variation of cant are usually used. In some cases, cant is smoothed at the ends of the transition.

Note 3 to entry: It is possible to use other forms of cant transition, which show a nonlinear variation of cant. Informative Annex C gives a detailed account of certain alternative types of transitions that may be used in track alignment design.

3.16
cant gradient
absolute value of the derivative (with respect to chainage) of cant

3.17
rate of change of cant
absolute value of the time derivative of cant

3.18
rate of change of cant deficiency
absolute value of the time derivative of cant deficiency (and/or cant excess)

3.19
track distance
lateral distance between two tracks, measured at the horizontal projection of the track centre lines

Note 1 to entry: Other standards can define track distance as the sloping length parallel to a canted track plane.

4 Symbols and abbreviations

No.	Symbol	Designation	Unit
1	dD/ds	cant gradient	mm/m
2	dD/dt	rate of change of cant	mm/s
3	dI/dt	rate of change of cant deficiency (and/or cant excess)	mm/s
4	D	cant	mm
5	D_{EQ}	equilibrium cant	mm
6	E	cant excess	mm
7	g	acceleration due to gravity according to EN ISO 80000-3	m/s^2
8	I	cant deficiency	mm
9	L_c	length between two abrupt changes of curvature	m
10	L_D	length of cant transition	m
11	L_g	length of constant gradient	m
12	L_K	length of transition curve	m
13	L_i	length of alignment elements between two linear cant transitions	m
14	L_s	length between two abrupt changes of cant deficiency	m
15	L_v	length of vertical radius	m
16	p	gradient	-
17	q_E	factor for calculation of equilibrium cant: 11,8	mm·m·(h/km)^2
18	q_N	factor for calculation of length of cant transition or transition curve with non-constant gradient of cant and curvature, respectively	-
19	q_R	factor for calculation of vertical radius	m·h^2/km^2
20	q_s	factor for calculation of lengths between abrupt changes of cant deficiency	-
21	q_V	factor for conversion of the units for vehicle speed: 3,6	(km/h)/(m/s)
22	R	radius of horizontal curve	m
23	R_{v}	radius of vertical curve	m
24	s	longitudinal distance	m
25	t	time	s
26	V	speed	km/h
27	CE, lim	limit applicable at fixed crossings and expansion devices (index)	-
28	lim	general limit (index)	-
29	R, lim	limit applicable at small radius curves (index)	-
30	u, lim	upper limit for a parameter which also have a lower limit (index)	-

5 General

5.1 Background

This European Standard specifies rules and limits for track alignment design. These limits assume that standards for acceptance of vehicle, track construction and maintenance are fulfilled (construction and in-service tolerances are not specified in this standard). Engineering requirements specific to the mechanical behaviour of switch and crossing components and subsystems are to be found in the relevant standards. Certain design considerations for switches and crossings layouts are presented in informative annexes.

This European Standard is not a design manual. The limits are not intended to be imposed as usual design values. However, design values shall be within the limits stated in this European Standard.

Limits in this European Standard are based on practical experience of European railways. Limits are applied where it is necessary to compromise between train performance, comfort levels, maintenance of the vehicle and track, and construction costs.

Unnecessary use of design values close to limits should be avoided, substantial margins to them should be provided. There are often conflicts between the desire for margins to one parameter and another, these should be distributed over all design parameters, possibly by applying a margin with respect to speed.

For certain parameters, this European Standard also specifies exceptional limits less restrictive than normal limits, which represent the least restrictive limits applied by any European railway. Such limits are intended for use only under special circumstances and can require an associated maintenance regime. In particular, use of exceptional limits (instead of normal limits) for several parameters at the same location shall be avoided. Informative Annex D describes the constraints and risks associated with the use of design values in the range between a limit and corresponding exceptional limit.

Operational limits for speed and cant deficiency shall be applied to specific vehicles according to their approval parameters.

Due to lack of experience among the European railways, no limits are specified for higher speeds than 360 km/h.

The limits are defined for normal service operations. If and when running trials are conducted, for example to ascertain the vehicle dynamic behaviour (by continually monitoring of the vehicle responses), exceeding the limits (particularly in terms of cant deficiency) should be permitted and it is up to the infrastructure manager to decide any appropriate arrangement. In this context, safety margins are generally reinforced by taking additional steps such as ballast consolidation, monitoring of track geometric quality, etc.

5.2 Alignment characteristics

The alignment defines the geometrical position of the track. It is divided into horizontal alignment and vertical alignment.

The horizontal alignment is the projection of the track centre line on a horizontal plane. The horizontal alignment consists of a sequence of alignment elements, each obeying a unique mathematical description as a function of longitudinal distance along the horizontal projection (chainage). The elements for horizontal alignment are connected at tangent points, where two connected elements have the same coordinates and the same directions. Elements for horizontal alignment are specified in Table 1.

Table 1 — Elements for horizontal alignment

Alignment element	Characteristics
Straight line	No horizontal curvature
Circular curve	Constant horizontal curvature
Transition curve, Clothoid type	Horizontal curvature varies linearly with chainage
Transition curves, other types [a]	Horizontal curvature varies nonlinearly with chainage
[a] Informative Annex C gives a detailed account of certain alternative types of transition curves that may be used in track alignment design	

Most modern switches have a tangential geometry, where the diverging track starts with an alignment that is tangential with the through track. However, switch designs may start with an abrupt change of horizontal direction at the beginning of the switch. Possible design criteria for the alignment before the switch, taking the entry angle in account, are described in informative Annex E.

When a turnout is placed on a track gradient other than zero, a vertical curve and/or cant, the horizontal geometry of the diverging track will deviate slightly from the element types in Table 1.

The vertical alignment defines the level of the track as a function of chainage (the longitudinal position along the horizontal projection of the track centre line). The elements for vertical alignment are connected at tangent points, where two connected elements have the same level and the same track gradient p (with certain exceptions). Elements for vertical alignment are specified in Table 2.

Table 2 — Elements for vertical alignment

Alignment element	Characteristics
Constant gradient	No vertical curvature
Vertical curve, parabola	Derivative of gradient with respect to chainage is constant
Vertical curve, circular	Derivative of vertical angle with respect to sloping length along the track is constant

NOTE A vertical curve in track that starts or ends in canted switches and crossings can be of a higher order polynomial than a parabola.

The applied cant D in the track is the difference in level of two running rails. Cant can be applied by raising one rail above the level of the vertical profile and keeping the other rail on the same level as the vertical profile, or by a pre-defined relationship raising one rail and lowering the other rail. The cant can be considered as a sequence of elements connected at tangent points where two elements have the same magnitude of applied cant. (At a tangent point with cant, the same rail is the high rail before and after the tangent point.) Elements for cant are specified in Table 3.

Table 3 — Elements for cant

Alignment element	Characteristics
Constant cant	Cant is constant along the entire element
Cant transition, linear	Cant varies linearly with chainage
Cant transition, nonlinear [a]	Cant varies nonlinearly with chainage
[a] Informative Annex C gives a detailed account of certain alternative types of cant transitions that may be used in track alignment design.	

Cant transitions should normally coincide with transition curves, but exceptions are possible.

The geometrical consequences of placing a turnout on track gradients, vertical curves and/or applying cant in a turnout are described in informative Annex F.

The alignment of a ballasted track is normally maintained by Track Construction and Maintenance Machines. The maintenance with such machines is simplified if there is no more than one tangent point within the measuring chord of the machine (typically 10 m to 20 m).

All limits and exceptional limits in Clause 6 apply, hence the permissible range for one parameter, for example horizontal radius *R*, can be further restricted due to the chosen values of other parameters. For example, at a certain location in an alignment sequence, the permissible range for horizontal radius *R* can be limited due to applied cant *D*, limit for cant deficiency *I* and/or characteristics of adjacent elements. Informative Annex G presents certain applications of the limits.

6 Limits for 1 435 mm gauge

6.1 Radius of horizontal curve *R*

In this European Standard, radius is positive on both right-hand and left-hand curves.

Speed independent lower limit for horizontal radii R_{lim} is specified in Table 4.

Table 4 — Lower limit for horizontal curves R_{lim}

Normal limit [a]	Exceptional limit [a]
150 m	
[a] Further requirements for the radius along platforms are defined in TSI INF.	

NOTE Not all vehicles are designed and approved for horizontal radii smaller than 150 m (for example, see EN 15273–2).

There is no upper limit for horizontal radius in this European Standard. However, local standards can have such an upper limit, related to capabilities of the alignment software to handle very large numbers or to other practical aspects.

6.2 Cant *D*

In this European Standard, cant on a horizontal curve is positive if the outer rail is higher than the inner rail.

NOTE 1 Negative cant is unavoidable at switches and crossings on a canted main line where the turnout is curving in the opposite direction to the main line and, in certain cases, on the plain line immediately adjoining a canted turnout. Negative cant can also be used on temporary tracks.

Upper limits for cant D_{lim}, independent of horizontal radius *R*, are specified in Table 5.

Table 5 — Upper limits for cant D_{lim}

	Normal limits	**Exceptional limits**
General [a]	160 mm	180 mm [b]
Switches and crossings [a]	120 mm	160 mm

[a] Further requirements for the cant along platforms are defined in TSI INF.

[b] Cant exceeding 160 mm can cause freight load displacement and deterioration of passenger comfort when a train stops or runs with low speed (high value of cant excess). On-track machines and vehicles with special loads with a high centre of gravity can become unstable. Therefore, an associated maintenance regime and other measures may be necessary (for example exclude certain types of freight traffic, avoid trains regularly stopping on such a curve, etc.).

Upper limit for cant $D_{R,\text{lim}}$, as a function of horizontal radius R, is specified in Table 6.

Table 6 — Upper limit for cant $D_{R,\text{lim}}$ as a function of horizontal radius R

Normal limit [a]	**Exceptional limit** [a]
$D_{R,\text{lim}} = \frac{R - 50\text{ m}}{1{,}5\text{ m / mm}}$	

[a] This limit may be relaxed provided that measures are taken to ensure safety, see EN 13848–5 or in the case of the diverging track of a turnout with an element of least 10 m length with constant cant on both sides of the curve with small radius.

NOTE 2 High cant on small-radius curves increases the risk of derailing when vehicles are running at low speed. Under these conditions, vertical wheel forces applied to the outer rail are much reduced, especially where track twist (see EN 13848–1 and EN 13848–5) causes additional force reductions.

NOTE 3 Track twist limits are defined in EN 13848–5 as a function of applied cant. Using high cant values will impose lower twist values or other measures to ensure safety.

6.3 Cant deficiency *I*

For given values of local radius R and cant D, and speed V, the cant deficiency I is defined according to Formula (1):

$$I = D_{\text{EQ}} - D = q_{\text{E}} \frac{V^2}{R} - D \qquad (1)$$

where

D_{EQ} is equilibrium cant (mm) and

q_{E} = 11,8 mm·m·h²/km².

NOTE 1 With negative cant, the cant deficiency will be higher than equilibrium cant.

General upper limits for cant deficiency I_{lim} are specified in Table 7.

Table 7 — Upper limits for cant deficiency I_{lim}

	Normal limits [a]	**Exceptional limits** [a]
Non-tilting trains		
$V \leq 220$ km/h	153 mm	180 mm [b]
220 km/h < $V \leq 300$ km/h	153 mm [b]	
300 km/h < $V \leq 360$ km/h	100 mm [b]	
Tilting trains		
80 km/h ≤ $V \leq 260$ km/h [c]	275 mm	300 mm

[a] It is common practice to apply different limits for cant deficiency to different categories of trains. It is assumed that every vehicle has been tested and approved according to the procedures in EN 14363 in conditions covering its own range of operating cant deficiency (denoted I_{adm} in EN 14363). Examples of local limits are shown in informative Annex H.

[b] Trains complying with EN 14363, equipped with a cant deficiency compensation system other than tilt, may be permitted by the Infrastructure Manager to run with higher cant deficiency values.

[c] Currently, there are no lines in Europe used or planned where maximum speed for tilting trains exceeds 260 km/h.

NOTE 2 For a given vehicle, increased cant deficiency generates increasing forces between the wheel and the rail; see informative Annex I.

NOTE 3 Depending on the characteristics of specific features in track, such as bridges carrying direct-laid ballastless track, tracks with jointed rails, sections of line exposed to very strong cross winds, etc., it can be necessary to restrict the permissible cant deficiency. Rules in respect of these restrictions cannot be formulated beforehand since they will be dictated by the design of these features.

NOTE 4 High values of cant deficiency are related to passenger (dis)comfort, see informative Annex J.

For tracks with crossings in the outer rail and for expansion devices, there are more restrictive upper limits $I_{CE,\mathrm{lim}}$, dependent on speed V, specified in Table 8.