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Railway applications - Track - Track alignment design parameters - Track gauges 1435 mm and wider - Part 2: Switches and crossings and comparable alignment design situations with abrupt changes of curvature

Bahnanwendungen - Oberbau - Linienführung in Gleisen - Spurweiten 1 435 mm und größer - Teil 2: Weichen und Kreuzungen sowie vergleichbare Trassierungselemente mit unvermitteltem Krümmungswechsel
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ICS:

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93.100	Gradnja železnic	Construction of railways

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Railway applications - Track - Track alignment design
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Switches and crossings and comparable alignment design
situations with abrupt changes of curvature

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Spurweiten 1 435 mm und größer - Teil 2: Weichen und
Kreuzungen sowie vergleichbare Trassierungselemente mit
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Foreword

This document (EN 13803-2:2006) 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of an identical text or by endorsement, at the latest by June 2007, and conflicting national standards shall be withdrawn at the latest by June 2007.

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 the following EU Directives:

- Council Directive 96/48/EC of 23 July 1996 on the interoperability of the European high-speed network¹
- European Parliament and Council Directive 2004/17/EC of 31 March 2004 coordinating the procurement procedures of entities operating in the water, energy, transport and postal services sectors²
- Council Directive 91/440/EEC of 29 July 1991 on the development of the Community's railways³

For relationship with EU Directive 96/48/EC, see informative Annex ZA, which is an integral part of this document.

EN 13803 "Railway applications – Track – Track alignment design parameters – Track gauges 1435 mm and wider" consists of the following parts:

- Part 1: Plain line [SIST EN 13803-2:2007
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- Part 2: Switches and crossings and comparable alignment design situations with abrupt changes of curvature

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Romania, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

¹ Official Journal of the European Communities N° L 235 of 1996-09-17

² Official Journal of the European Communities N° L 134 of 2004-04-30

³ Official Journal of the European Communities N° L 237 of 1991-08-24

1 Scope

This European Standard specifies the rules and values for the track alignment design parameters used to determine the maximum operating speeds over tracks with abrupt changes in curvature and, consequently, abrupt changes of cant deficiency. Such conditions occur in the following situations:

- in the diverging tracks in switch and crossing layouts;
- when it is not practical to design an alignment with transition curves;
- if the length of a transition curve is less than the minimum required for plain line track.

Engineering requirements specific to the mechanical behaviour of switch and crossing components and subsystems are to be found in the relevant standards.

This European Standard presupposes that the homologation of the operating vehicles will be valid and specified for conditions corresponding to the limiting values specified in this European Standard.

This European Standard is applicable to abrupt changes in curvature in switch and crossing layouts and plain lines with track gauges of 1435 mm and wider. Annex C is applicable to track gauges wider than 1435 mm.

This European Standard specifies the requirements for preventing buffer locking.

The limiting values specified in this European Standard, when applied at the switch toe, are for switches with tangential geometry (as defined in EN 13232-1).

This European Standard need not be applicable to certain urban and suburban lines.

This European Standard is not applicable to track alignment requirements for tilting body vehicles. However, Annex H draws the designer's attention to the consequences and the restrictions imposed when tilting vehicles are operated over switch and crossing layouts and alignments without transition curves.

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 13232-1:2003, *Railway applications – Track – Switches and crossings – Part 1: Definitions*

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

ENV 13803-1:2002, *Railway applications – Track alignment design parameters – Track gauges 1435 mm and wider – Part 1: Plain line*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 13232-1:2003 and ENV 13803-1:2002 and the following apply.

3.1

abrupt change of cant deficiency ΔI

abrupt change of the cant deficiency and/or cant excess due to an abrupt change in curvature

3.2 rate of change of cant deficiency at an abrupt change in curvature as function of time $\Delta I/\Delta t$
 value used in the theoretical model of the principle of the virtual transition calculation (see Annex E). The value of Δt is the time required to travel over the length of the virtual transition at the specified speed

3.3 distance between bogie centres L_b
 distance between the bogie centres of the characteristic vehicle used to calculate $\Delta I/\Delta t$ (see Annex E). The characteristic vehicle is usually the passenger vehicle with the shortest distance between bogie centres operating over a route

3.4 total length of the intermediate element(s) between two abrupt changes of curvature L_s
 total length of the straight and/or curved element(s) between two abrupt changes of curvature (see Clause 8)

3.5 parameter of clothoid A
 parameter describing the linear change of curvature as function of the length (see 9.2.2.2)

3.6 high speed lines
 (see Directive 96/48/EC)

3.7 conventional lines
 other than high speed lines

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4 Symbols and abbreviations

The symbols and abbreviations specified in EN 13803-1 are also applicable to this European Standard. Additional symbols and abbreviations are as follows

Table 1 — Symbols and abbreviations

No.	Symbol	Designation	Unit
101	A	parameter of clothoid	m
102	C	factor for calculation of equilibrium cant	mm·m·h ² /km ²
103	I_i	cant deficiency of the alignment element i ; $i = 1, 2$	mm
104	I_{max}	maximum value of cant deficiency within the length of the diverging track	mm
105	ΔI	abrupt change of the cant deficiency and/or cant excess due to an abrupt change in curvature	mm
106	$\Delta I/\Delta t$	rate of change of cant deficiency at an abrupt change in curvature as function of time	mm/s
107	ΔI_c	abrupt change of cant deficiency on the crossing side of a turnout with curves of variable curvature in diverging track	mm
108	ΔI_i	abrupt change of the cant deficiency and/or cant excess due to an abrupt change in curvature at tangent point i	mm
109	ΔI_s	abrupt change of cant deficiency on the switch side of a turnout with curves of variable curvature in diverging track	mm
110	L_b	distance between bogie centres of the characteristic vehicle	m

No.	Symbol	Designation	Unit
111	L_s	total length of intermediate element(s) between two abrupt changes of curvature	m
112	n	inverse turnout angle	-
113	q_A	factor for calculation of rate of change of cant deficiency	$\text{mm}\cdot\text{m}^2\cdot\text{h}^3/(\text{s}\cdot\text{km}^3)$
114	q_S	factor for calculation of minimum length of intermediate element(s) between two abrupt changes of curvature	$\text{m}\cdot\text{h}/\text{km}$
115	q_V	factor for conversion of the units for vehicle speed	$\text{km}\cdot\text{s}/(\text{h}\cdot\text{m})$
116	R_0	radius of the diverging track of the switch and crossing unit in the version for straight track	m
117	R_i	radius of the alignment element i within one track; $i = 1, 2$	m
118	R_{id}	equivalent radius for reverse curves (see 8.4)	m
119	R_j	radius of track j within one switch and crossing unit; $j = I, II$	m
120	R_s	effective radius at a toe of a non-tangential switch	m
121	t_i	tangent length i	m
122	v	versine	m

5 General requirements

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The track alignment designer is free to specify the most appropriate values for the various parameters at the specified operating speeds, when considering safety, geographical, engineering, historical, and economic constraints. These values and parameters shall be specified in the contract documents.

The designer shall endeavour not to exceed the recommended limiting values specified in this European Standard and avoid unnecessary use of the maximum (or minimum) limiting values. Annex G describes the constraints and risks associated with the use of maximum (or minimum) limiting values.

Whenever necessary, the track alignment designer shall take into account national standards when these are more restrictive.

The most important requirements for the installation of switch and crossing layouts are specified in Annex B. These requirements have an influence on the design of the alignment elements for both tracks in switch and crossing layouts and, consequently, they influence the maximum operating speeds and life cycle costs. The designer should, as far as it is practicable, comply with these requirements.

Existing installations, which do not conform to this European Standard, should be modified as soon as possible if safety requirements (for example abrupt change of cant deficiency, length of element(s) between abrupt changes of curvature and the safety related parameters listed in ENV 13803-1) are compromised. Other non-conforming installations should, if possible, be modified during the next track renewal.

The railway authority or the manufacturer shall specify the limits (e.g. requirement for the switch entry angle) for non-tangential switches (see also EN 13232-9). Annex F describes a method for calculating the maximum permissible speed at the toe of a non-tangential switch.

6 Principles for the assessment of abrupt changes of cant deficiency at abrupt changes in curvature

6.1 General

The main principle described in 6.2 is based on in-service experiences in terms of safety and passenger comfort.

Some European railway authorities use the principle of the virtual transition described in Annex E (informative).

There are in current use various types of turnouts that have curves of variable curvature combined with circular curves or straights in the diverging track. The different geometrical layouts used in these types of turnout are described in 9.2.2. The curves of variable curvature used in these turnouts are normally of the Clothoid form.

Annex D describes a theoretical calculation method that can be used to compare the effects of a succession of different alignment elements with vehicles of different characteristics.

6.2 Principle based on limiting values of abrupt change of cant deficiency (ΔI)

This principle is based on limiting the abrupt change in cant deficiency between an abutting curve and straight, or between the abutting arcs of a compound or reverse curve. The relationship between cant deficiency, speed, radius, and cant is expressed by the equation:

$$I_i = C \cdot \frac{V^2}{R_i} - D_i \quad [\text{mm}]$$

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where

$$C = 11,8 \text{ mm} \cdot \text{m} \cdot \text{h}^2 / \text{km}^2 \text{ and } i = 1, 2$$

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For curves with cant excess, the equation $I = -E$ shall be used.

Between two abutting curves (i.e. two arcs without an intermediate element) the abrupt change in cant deficiency is $\Delta I = |I_2 \pm I_1|$. For a reverse curve it is $\Delta I = |I_2 + I_1|$ and for a compound curve it is $\Delta I = |I_2 - I_1|$. The limiting values are specified in 7.1.

The limiting lengths of intermediate element(s) between two abrupt changes of curvature are specified in 8.2. The value of abrupt change in cant deficiency to be taken into account when there is no intermediate element between curves, or the intermediate element is of substandard length, is specified in 8.3.2.

7 Circular curves without transition curves

7.1 Limiting values based on the principle of abrupt change of cant deficiency ΔI_{lim}

7.1.1 General

This principle of abrupt change of cant deficiency is described in 6.2.

The maximum permissible speed over an abrupt change in curvature between a curve without cant and a straight shall be based on the limiting values for abrupt change of cant deficiency (ΔI_{lim}) specified in 7.1.2 and 7.1.3.

$$\Delta I = C \cdot \frac{V^2}{R} \leq \Delta I_{\text{lim}} \quad [\text{mm}]$$

where

$$C = 11,8 \text{ mm} \cdot \text{m} \cdot \text{h}^2 / \text{km}^2$$

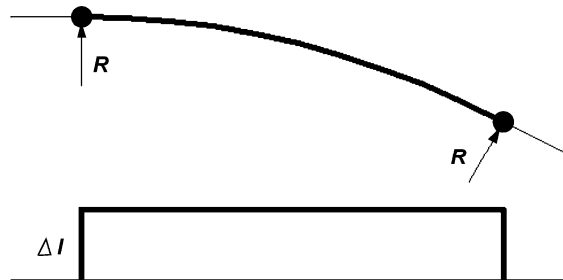


Figure 1 — Combination of circular curve and straight without cant

NOTE When designs are based on the principle of limiting values for abrupt change of cant deficiency (ΔI_{lim}), in accordance with 6.2, it is not necessary to conform to the limiting values for the rate of change of abrupt change of cant deficiency ($\Delta I / \Delta t$), specified for the principle of the virtual transition as described in the informative Annex E.

7.1.2 Switch and crossing layouts SIST EN 13803-2:2007

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The limiting values for an abrupt change of cant deficiency in the tracks of a switch and crossing layout shall be as specified in Table 2.

Table 2a — Limiting values of abrupt change of cant deficiency (ΔI_{lim}) – High-speed lines

Speed V (km/h)	$V \leq 70$	$70 < V \leq 170$	$170 < V \leq 230$
Recommended limiting values ΔI_{lim} (mm)	100	80	60
Maximum limiting values ΔI_{lim} (mm)	120	105	85

Table 2b — Limiting values of abrupt change of cant deficiency (ΔI_{lim}) – Conventional lines

Speed V (km/h)	$V \leq 100$	$100 < V \leq 170$	$170 < V \leq 220$	$220 < V \leq 230$
Recommended limiting values ΔI_{lim} (mm)	100	$133 - 0,33 V$		60
Maximum limiting values ΔI_{lim} (mm)	120	$141 - 0,21 V$	$161 - 0,33 V$	

NOTE A tolerance of 10 mm on the maximum limiting values is permitted for existing turnouts laid on lines to be upgraded for high-speed.

7.1.3 Plain line

Plain line alignments with abrupt changes of cant deficiency shall only be used when the scope for designing the alignment is severely restricted. Such restrictions occur in stations, at small deviations in alignment within a limited length, or in compound curves when there is only a small variation in the radii of abutting curves.

The recommended limiting values for abrupt change of cant deficiency on plain line shall be as specified in Table 3.

Table 3 — Recommended limiting values of abrupt change of cant deficiency (Δ_{lim})

Speed V (km/h)	$V \leq 70$	$70 < V \leq 170$	$170 < V \leq 230$
Recommended limiting values Δ_{lim} (mm)	50	40	30

The use of higher values of abrupt change of cant deficiency should, if possible, be avoided. If the use of higher values is unavoidable, for example in close conjunction to switch and crossing layouts, the limiting values shall not exceed those specified in 7.1.2.

7.2 Limiting values based on the principle of the virtual transition

Some European railway authorities use the principle of the virtual transition (see Annex E). The limits applicable for this principle are given in E.3.

7.3 Minimum radius of horizontal curves

On all tracks (including the diverging tracks in switch and crossing layouts) where different railway vehicles operate, the designed minimum radius for any curve shall not be less than 150 m. In the case of a reverse curve, or curves in opposite directions with short intermediate elements, the alignment design shall conform to 8.4.

8 Combinations of horizontal curves

8.1 General

Horizontal curves can be combined to form a reverse curve, curves in the opposite directions with an intermediate element, a compound curve, and curves in the same direction with an intermediate element. These types of situations are shown in Figure 2. The track elements may have constant curvature (as in Figure 2), but may also be transition curves (for a turnout placed on a transition curve and/or a turnout with variable curvature). In some cases the intermediate element may be a transition curve of sub-standard length, i.e. a transition curve that does not conform to the requirements of ENV 13803-1. In practice, such situations occur in:

- the diverging tracks in switch and crossing layouts;
- plain tracks abutting switch and crossing layouts;
- plain tracks where it is impractical to provide full transition curves (typically stations and sidings);
- plain track alignments with large radii curves;

- compound curves where there is only a small difference in the radii between abutting curves;
- plain tracks with a small deviation in direction or distance between track centre lines.

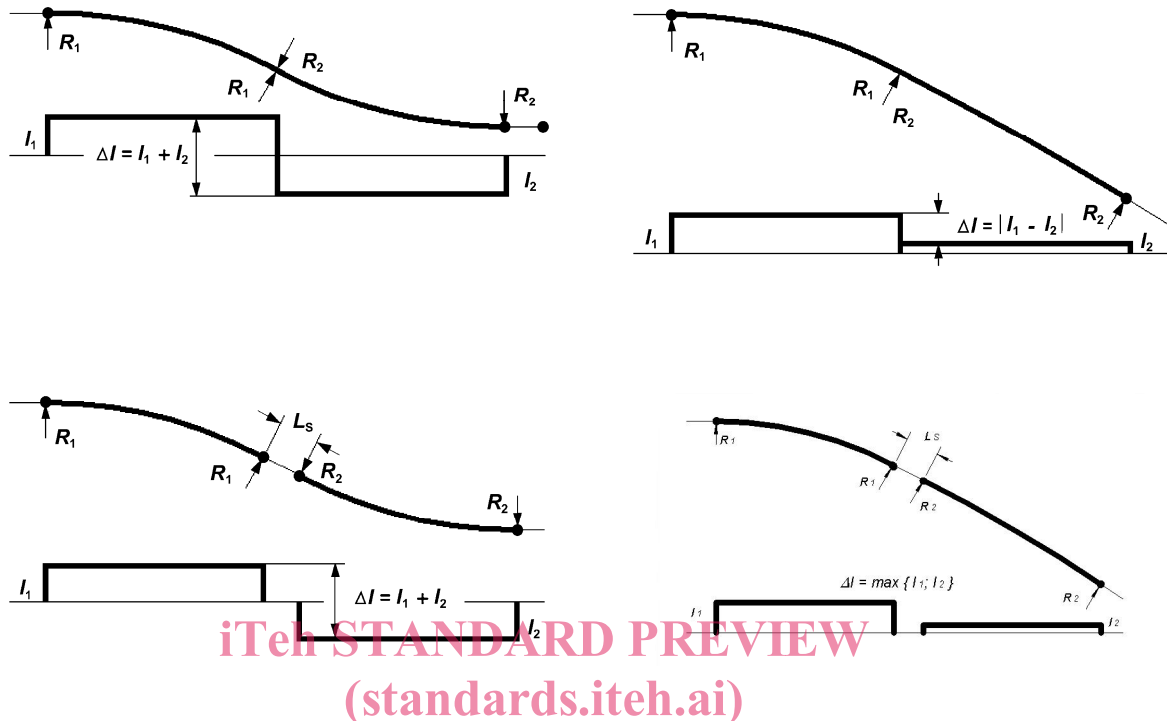


Figure 2 — Combinations of alignment elements

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- the limiting length of the intermediate element(s) between two abrupt changes of curvature (L_{slim});
- the abrupt change of cant deficiency (Δl) applicable for the each combination of alignment elements;
- the requirements for preventing buffer locking.

8.2 Limiting length of intermediate element(s) between two abrupt changes of curvature (L_{slim})

A tangent point with an abrupt change of curvature generates disturbed vehicle dynamics. Therefore, there should be a minimum length to the next tangent point with an abrupt change of curvature.

The limiting length of intermediate element(s) between two abrupt changes of curvature is defined as:

$$L_{slim} = q_{slim} \cdot V \quad [\text{m}]$$

where

q_{slim} is a factor (m·h/km) defined in Table 4

V is the maximum train speed (km/h)