

Railway applications — Track — Switches and crossings —

Part 3: Requirements for wheel/rail interaction

ICS 45.080

National foreword

This British Standard is the UK implementation of EN 13232-3:2003+A1:2011. It supersedes BS EN 13232-3:2003, which is withdrawn.

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

The UK participation in its preparation was entrusted to Technical Committee RAE/2, Railway Applications - Track.

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

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Bahnanwendungen - Oberbau - Weichen und Kreuzungen -
Anforderungen an das Zusammenspiel Rad/Schiene

This European Standard was approved by CEN on 13 February 2003 and includes Amendment 1 approved by CEN on 13 September 2011.

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Foreword

This document (EN 13232-3:2003+A1:2011) 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of an identical text or by endorsement, at the latest by April 2012, and conflicting national standards shall be withdrawn at the latest by April 2012.

A1 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 2008/57/EC, see informative Annex ZA, which is an integral part of this document. **A1**

This document includes Amendment 1, approved by CEN on 2011-09-13.

This document supersedes EN 13232-3:2003.

The start and finish of text introduced or altered by amendment is indicated in the text by tags **A1** **A1**.

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 series of European Standards "Railway Applications – Track – Switches and Crossings" covers the design and quality of switches and crossings in flat bottomed rail. The list of parts is as follows:

- *Part 1 : Definitions*
- *Part 2 : Requirements for geometric design*
- *Part 3 : Requirements for wheel/rail interaction*
- *Part 4 : Actuation, locking and detection*
- *Part 5 : Switches*
- *Part 6 : Fixed common and obtuse crossings*
- *Part 7 : Crossings with movable parts*
- *Part 8 : Expansion devices*
- *Part 9 : Layouts*

Part 1 contains terminology used throughout all parts of this series. Parts 2 to 4 contain basic design guides and are applicable to all switch and crossing assemblies. Parts 5 to 8 deal with particular types of equipment, including their tolerances. Part 9 defines the functional and geometric dimensions and tolerances for layout assemblies. These use Parts 1 to 4 as a basis.

The following terms are used within to define the parties involved in using the European Standard as the technical basis for a transaction:

- **Customer** the Operator or User of the equipment, or the Purchaser of the equipment on the User's behalf;

— Supplier the body responsible for the use of the European Standard in response to the Customer's requirements.

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, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

1 Scope

This part of this European Standard specifies:

- characterisation of wheel and track dimensions;
- geometric design principles for wheel guidance;
- design principles for wheel load transfer;
- deciding whether movable crossings are needed.

These are illustrated by their application to turnout components:

- switches;
- crossings;
- check rails.

but the principles apply equally to more complex layouts.

2 Normative references

Not applicable.

3 Presentation

3.1 General

The motion of wheels and transfer of wheel loads is a complex subject, involving the accumulation of extensive data and an understanding of dynamic effects.

By making certain assumptions it is feasible to define rules which are simple yet rigorous enough for design of all types of switches and crossings. Some of these rules assume a 2-axle bogie or vehicle. The need for other special requirements such as those posed by 3-axle or other vehicles must be stated by the Customer.

3.2 Wheel and track dimensions

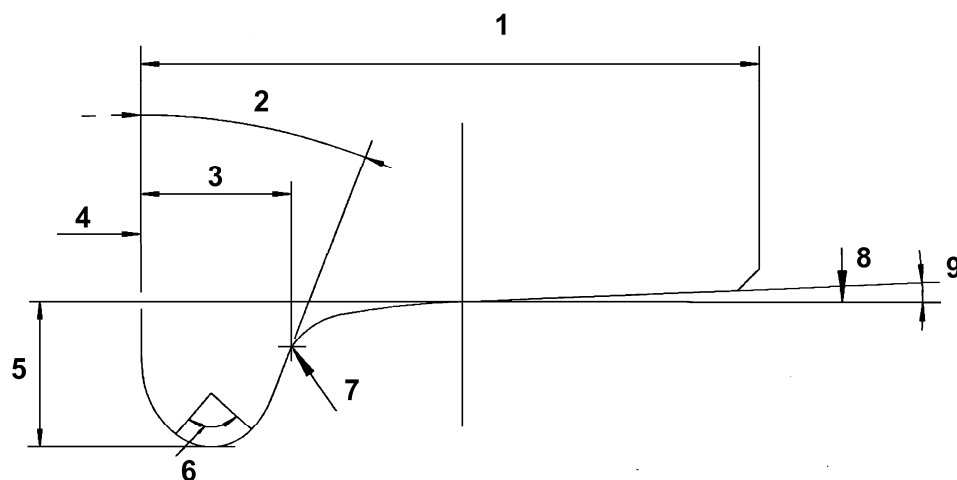
This clause deals with the key dimensions needed for the analysis of the interaction between wheels and the track, either for guidance calculations or load transfer calculations.

Wheel and track dimensions are defined below.

3.3 Wheel profiles

Sufficient dimensions of the cross-section or profile of a wheel are required for switch and crossing design. As a minimum, a dimensioned profile drawing shall be provided by the customer, with the following key dimensions as defined in Figure 1:

- flange width, height and flange angle;
- tyre width and tread angle;
- wheel diameter or radius.



Key

- | | |
|----------------------|------------------|
| 1 Tyre width | 6 Danger zone |
| 2 Flange angle | 7 Contact point |
| 3 Flange width | 8 Wheel diameter |
| 4 Wheel back to back | 9 Tread angle |
| 5 Flange depth | |

Figure 1 — Key wheel dimensions (in addition to profile details)

3.4 Wheelsets

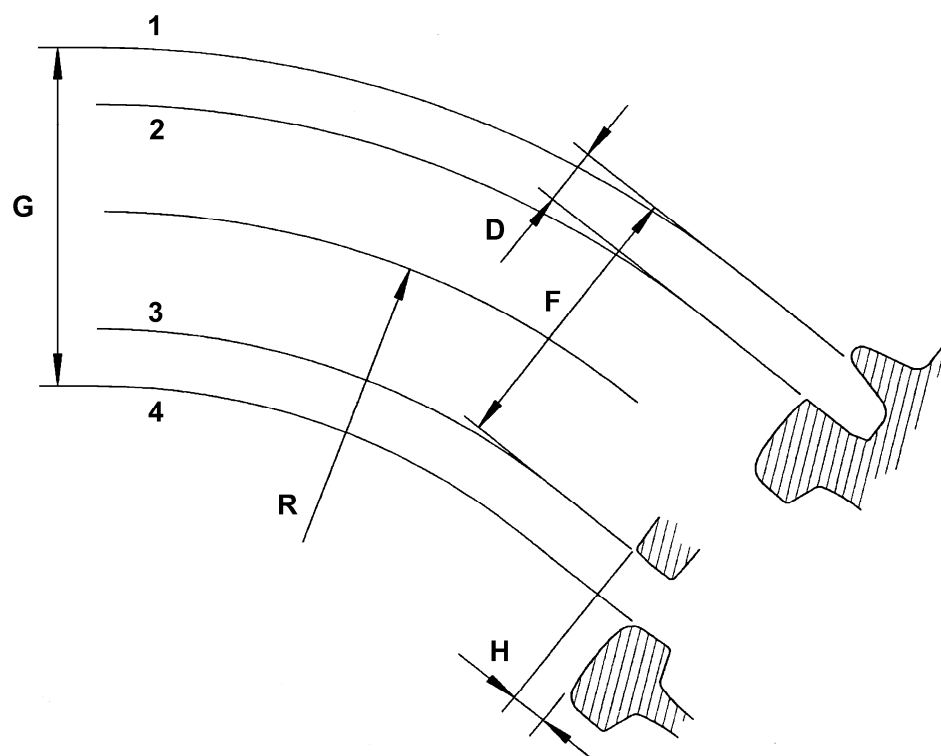
Additional parameters related to the wheelsets are required for calculations for wheelset guidance. The Customer shall provide the following parameter values:

- wheel back-to-back (see Figure 1);
- axle spacing;
- number of axles;
- clearance of middle axles, if applicable;
- bogie spacing and minimum curve radius for vehicles.

3.5 Rail and track

The key parameters related to the track geometry which are used in calculations for wheelset guidance are shown in Figure 2 and listed below:

- centreline radius (R);
- track gauge (G);
- dimension for nose protection (check gauge) (F);
- wing flangeway (D).



Key

- 1 Highside
- 2 Wing
- 3 Check
- 4 Lowside

Figure 2 — Key track dimensions

and the following shall be provided by the Customer:

- maximum permissible check rail height above running table (H).

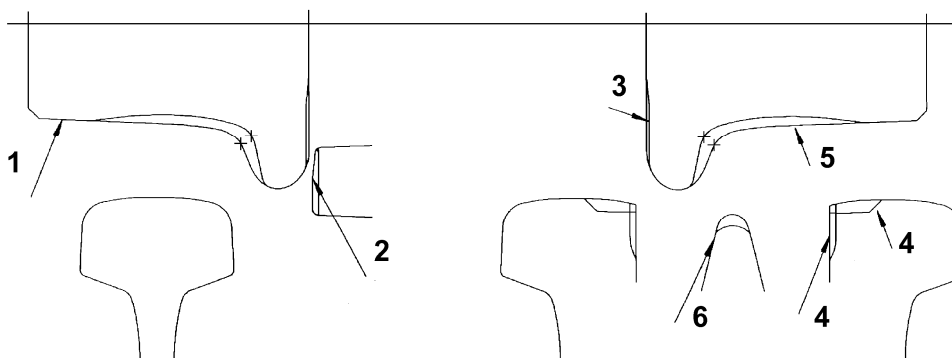
3.6 Tolerances and wear

It is necessary to consider tolerances and wear in order to design correctly. These are alternatively referred to as manufacturing tolerances and service tolerances.

If the Customer provides worn wheel profiles or amounts of wear, then these should be used. Otherwise the assumptions made by the Supplier shall form the basis for design, and these shall be stated. Examples of key areas of wear are:

- back of wheel flanges;
- front of wheel flanges;
- false flanges;
- flange angle.

Locations of typical lateral wheel and track wear are shown in Figure 3. These must be taken into account when designing flangeway gaps. See clause 4.



Key

- | | |
|----------------------------|----------------------|
| 1 False flange | 4 Wing wear |
| 2 Guard or check rail wear | 5 Wheel wear (front) |
| 3 Wheel wear (back) | 6 Vee wear |

Figure 3 — Locations of wheel and rail wear

Vertical wear, examples of which are also illustrated in Figure 3, is more relevant to wheel load transfer. See clause 5.

False flanges are to be avoided as they will increase wear as well as the rate of damage to switches and crossings.

3.7 Contact zone

For switch and crossing design, there are issues which shall be verified during design. These are as follows.

3.7.1 Contact profile

The relative radii of wheel and rail shall be taken into account.

3.7.2 Contact danger zone

The wheel profile supplied by the Customer shall indicate the danger zone for guidance contact, which is that part of the wheel flange which falls on the flange radius and which therefore exceeds the angle for safe guidance. The switch and crossing Supplier shall ensure that guidance contact does not take place within this zone for both new and worn wheels, except where it is agreed that flange-running is a normal operating regime.

The danger zone is illustrated in Figure 1.

3.7.3 Flangeway depth

The depth of the flangeway shall be sufficient to prevent flanges from running on the floor of the flangeway except if otherwise required by the Customer. This shall be verified considering the increased depth of flange of a maximum worn wheel and with the shallow flangeway of a maximum worn running surface of a rail.

4 Guidance principles

The guidance of a wheelset through switches and crossings concerns mainly the lateral or horizontal dimensions of wheel, axle, and track. Note that, in Figures 5, 6 and 7, the wheels are shown in a simplified form as ellipses at the gauge reference plane.

4.1 Guard and check Rails

Guard and check rails are rails which bear on the face of the wheel (usually the back face) to provide guidance without load bearing.

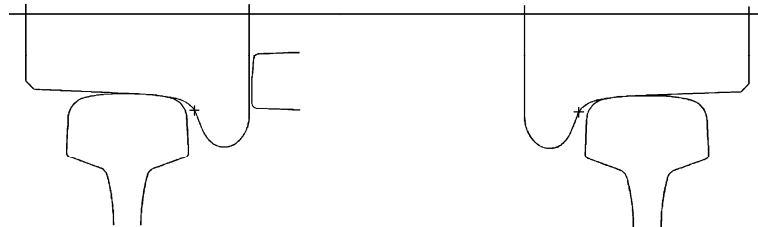


Figure 4a) — Check Rail (normally active)

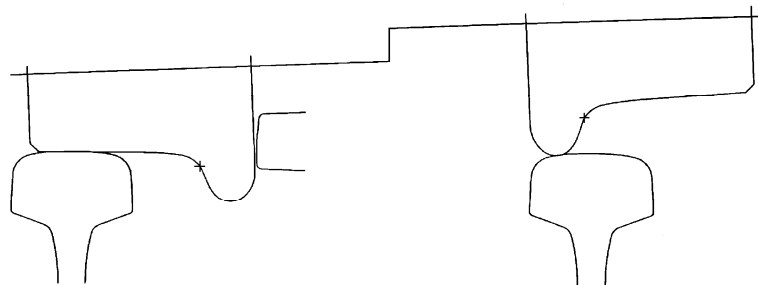


Figure 4b) — Guard Rail (normally passive)

Figure 4 — Active v passive guarding

Operation of guard and check rails depends on whether they are intended to be passive or active. Passive guard rails come into operation after incipient derailment and are intended to rerail wheels once they have begun to climb the opposite running rail.

Active check rails are intended to make contact with the back of the wheel flange under normal conditions of operation in order to protect the opposite running rail. See Figure 4.

4.2 Wheelset guidance

In order to determine wheelset guidance, it is necessary to make an assumption of the way in which the wheelset is constrained to move. The assumption is shown in Figure 5. When the wheelset, bogie or vehicle is superimposed upon the track, it moves along a trajectory which is skewed relative to the track running edges.

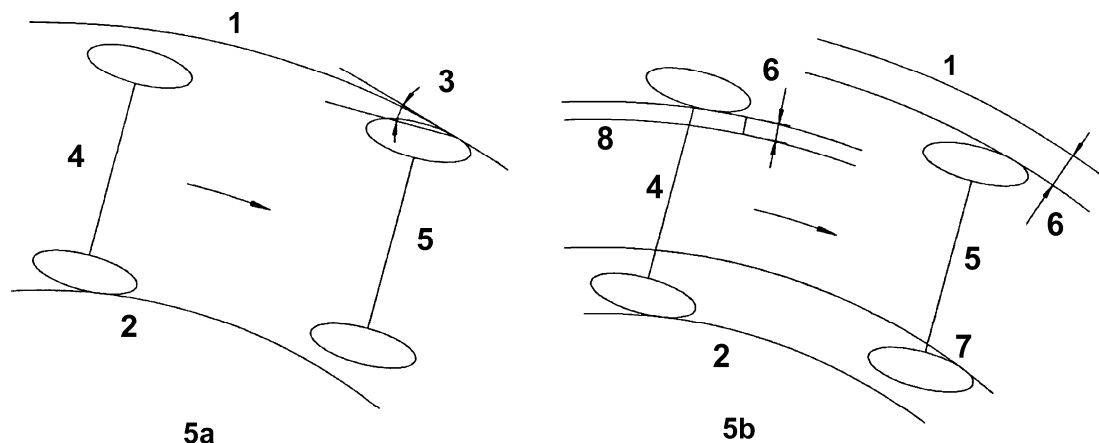


Figure 5a) Unchecked

Figure 5b) Checked

Key

- | | |
|-------------------|----------------|
| 1 Highside | 5 Leading axle |
| 2 Lowside | 6 Clearance |
| 3 Angle of attack | 7 Check |
| 4 Trailing axle | 8 Wing |

Figure 5 — Wheelset trajectory

Given the assumption of the mode of running and the resulting angle of attack, it is possible to determine the adequacy of the flangeway, the effectiveness of protection to the crossing nose, and the support for wheel load transfer.

The assumed trajectory provides for the worst case, or the maximum possible angle of attack, and subjects the leading wheel to the closest contact with a crossing nose, and subjects the trailing wheel to the poorest load transfer.

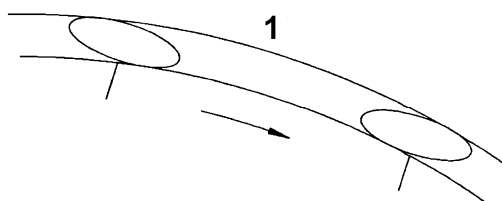
4.2.1 Angle of attack

The greatest angle of attack is achieved when the wheelset is running around a curve. For curves without check rails, the bogie will travel as in Figure 5a, with the high-side wheel of the leading axle in contact with the running edge of the high-side rail and the low-side wheel of the trailing axle in contact with the running edge of the low-side rail.

The angle of attack is usually reduced if the bogie is constrained as in Figure 5b. The leading axle runs with the low-side inner wheel flange against the check rail, and the low-side wheel of the trailing axle is in contact with the running edge of the low-side running rail.

4.2.2 Flangeway

The flangeway shall be wide enough to allow the flanges of the wheels to pass without being trapped or being forced to climb and derail. See Figure 6a which illustrates wheel trapping.



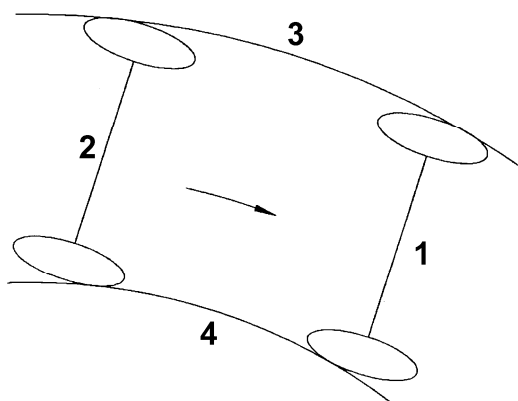
Key

- 1 Highside

Figure 6a) — Minimum flangeway (for wheel trapping)

4.2.3 Gauge widening

Gauge widening may be applied to the lowside rail to prevent trapping of the wheels of a bogie. Refer to Figure 6b which illustrates bogie trapping.



Key

- 1 Leading axle
2 Trailing axle
3 Highside
4 Lowside

Figure 6b) — Minimum gauge (for bogie trapping)

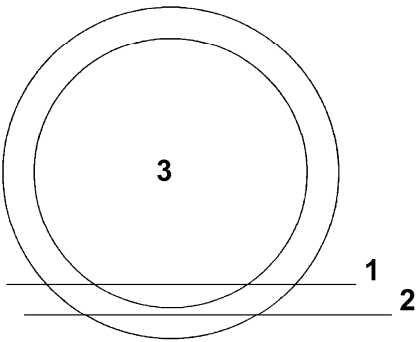
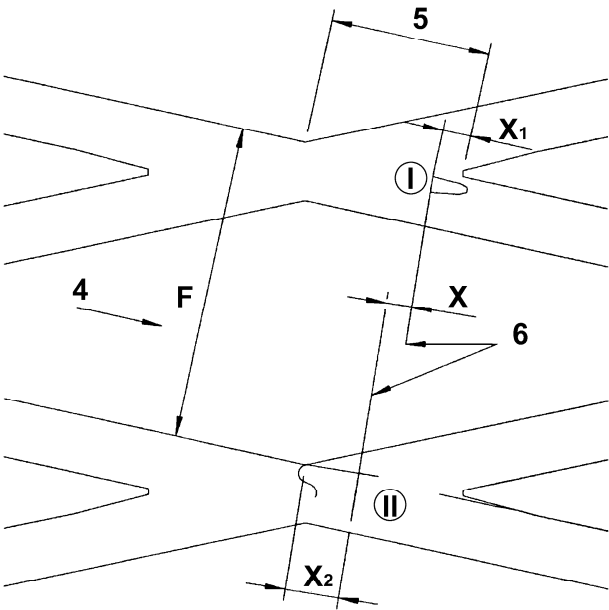
The extent and amount of gauge widening shall be defined by the Customer or calculated by the Supplier based on sufficient details of the Customer's rolling stock.

4.2.4 Check rail and common crossing nose

A minimum parallel length of check rail shall be provided opposite the fixed crossing nose to protect the otherwise unguided zone of the crossing, which consists of the throat flare, crossing gap and side planing. If the parallel length is less than this minimum, it shall be agreed with the Customer.

4.2.5 Obtuse Crossings

A crossing gap L exists between one nose (end of the vee) of the crossing and the knuckle (smallest gap between the wing and the check rail) as shown in Figure 7. Where obtuse crossings are used in pairs such as in diamond crossings or slips, it is necessary to verify the extent of guidance.



X ₁	Centreline to Nose – guidance re-established
X ₂	Centreline to Knuckle where guidance is broken
X	Unguided distance
F	Dimension for nose protection

Key

- 1 Level of II
- 2 Level of I
- 3 Wheel
- 4 Direction
- 5 Crossing gap L
- 6 Wheel axis

Figure 7 — Diamond crossing - Wheel trajectory

Figure 7 shows how a wheelset passes through an obtuse crossing. The value of X is the unguided distance. In the special case of an obtuse crossing a positive value of X , which represents a partly unguided trajectory, is permitted. However the value of X shall, if positive, be agreed between the Customer and the Supplier.

4.3 Transitional guidance

Where there are both unchecked track and checked track sections together there will be zones of transitional guidance in between. To date, however, there is no precise or widespread rule for the choice of flare to be used to gain control of a wheel passing from unchecked to checked track.

Therefore if the Customer has established rules and parameter values then they shall be provided to the Supplier, or the two parties must agree the parameter values.

4.4 Entry flares

The entry flare is the part of the check or guard rail or wing in which the flangeway gap width varies towards the end of the check, guard rail or wing.

A low value of the entry flare, which determines a long check rail, produces perturbations for a longer time than those observed under the same conditions for a shorter check rail with high value for entry flare.

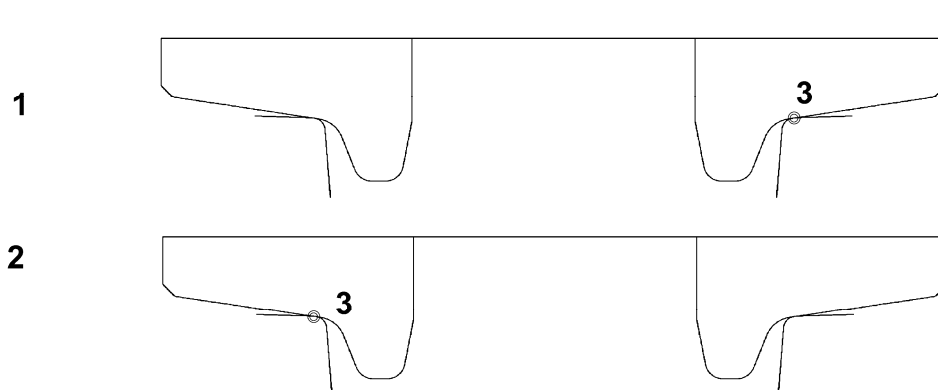
On the other hand, transverse forces increase with the high values of entry flare, but the energy (as the integration of transverse force with distance) is lower for high entry flares than for lower ones.

The entry flare angle shall therefore be agreed between Customer and Supplier.

5 Wheel load transfer

The objective of this section is to provide rules for demonstrating good wheel load transfer, and thereby to avoid areas where a wheel is unsupported or where the support is insufficient.

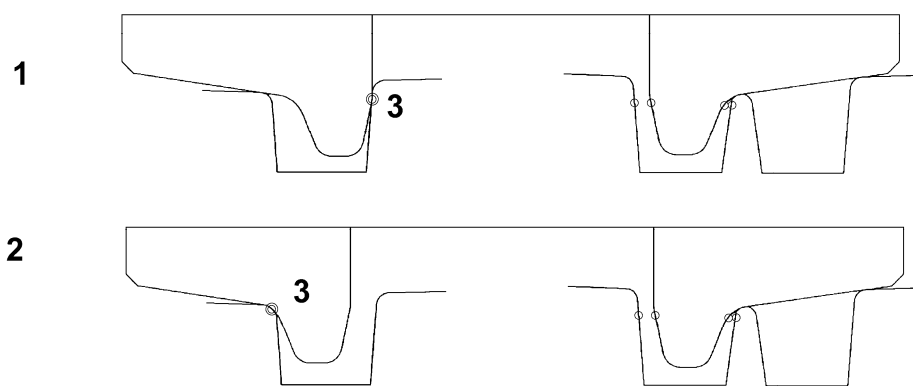
The work on wheelset guidance above defines the positioning of the wheel relative to the track to give the worst case for load transfer. Various contact regimes are shown for illustration only in Figure 8.



Key

- 1 Leading axle
- 2 Trailing axle
- 3 Contact

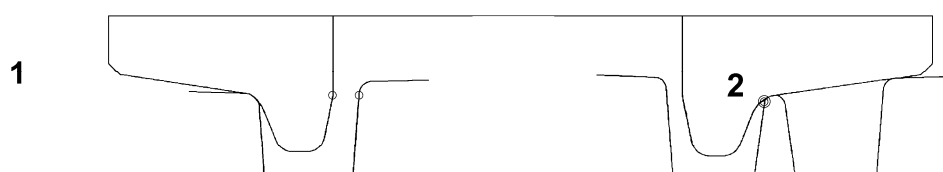
Figure 8a) — Unchecked



Key

- 1 Leading axle
- 2 Trailing axle
- 3 Contact

Figure 8b) — Checked



Key

- 1 Leading axle
- 2 Contact

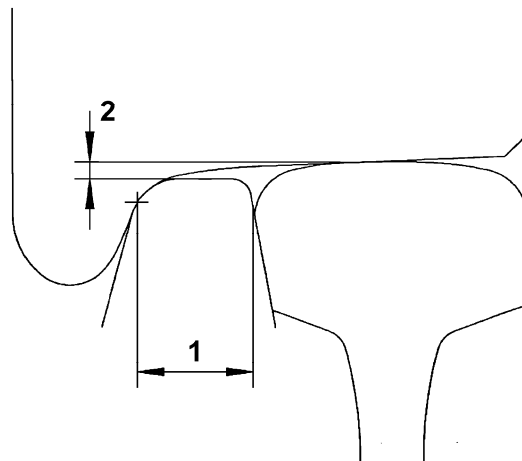
Figure 8c) — Checked Ineffectively

Figure 8 — Contact regimes

5.1 Sufficiency of bearing area

The minimum support shall be dimensioned in such a way that it is able to bear the wheel load under all circumstances.

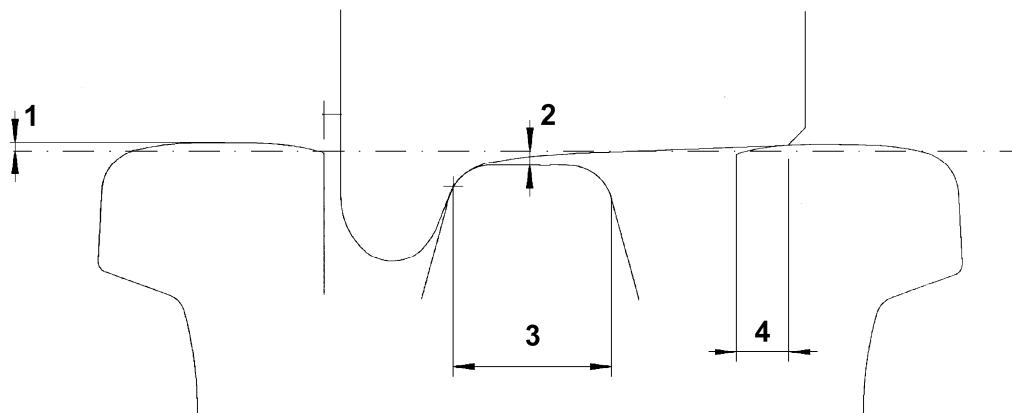
The support is insufficient if the aggregate support width under the wheel is too small in the area over which load transfer occurs. See Figure 9 for bearing area in switches, and Figure 10 for bearing area in crossings. If the support width is too small and cannot be increased, then see clause 6.



Key

- 1 Bearing width
- 2 Switch top machining

Figure 9 — Wheel load transfer in switches



Key

- 1 Crossing wing superelevation
- 2 Crossing vee top machining
- 3 Bearing width
- 4 Bearing width

Figure 10 — Wheel load transfer in crossings

In a crossing the gap is formed between the nose and the throat (smallest gap between the wings) of the crossing. The Supplier shall be responsible for ensuring that when the wheel passes through this gap the wheel load is sufficiently supported by both vee and wing until either is sufficiently wide to carry the wheel load alone.

5.2 Transfer surfaces

The load transfer point or range occurs over the part of the switch or crossing surface which slopes in order to provide as smooth a transfer as possible. This slope is defined by the Supplier and is called:

- in the switches: switch top machining;
- in the crossing: crossing vee top machining and crossing wing superelevation.

5.3 Method of assessment

The method of assessment and acceptance of the load transfer to be used by the Supplier shall be agreed between the Customer and Supplier.

6 Insufficient wheel support or guidance

There are two main areas in which wheel support and guidance may be affected by too large an interruption in their passage. These are where crossing gaps are provided in common and obtuse crossings.

6.1 Common crossings

When sufficient support cannot be satisfactorily achieved using a fixed crossing design then an alternative design may be considered. One such alternative design is the movable crossing wherein the gap is closed, and the wheel is fully supported by the crossing throughout its passage. See clause 6.3.

Another alternative is the flange-running crossing in which the bottom of the flangeway gap is ramped to carry the wheel across the crossing gap.

6.2 Obtuse crossings

Insufficient wheel support is not usually the main problem in obtuse crossings, but rather lack of guidance.

If a satisfactory value of X (see clause 4.2.5) cannot be agreed then a switch diamond may be used. See clause 6.3.

6.3 Movable crossings

If fixed common or obtuse crossings provide insufficient guidance or contact during wheel load transfer, then movable crossings may be used to eliminate the crossing gap. There are several types, of which the following are examples:

- swing nose or movable point;
- movable wing;
- switch diamond.

Other criteria for the selection of movable crossings are:

- reduction of noise and vibration;
- reduction of maintenance;
- improved ride comfort.

Annex ZA (informative)

A1 Relationship between this European Standard and the Essential Requirements of EU Directive 2008/57/EC

This European Standard has been prepared under a mandate given to CEN/CENELEC/ETSI by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the Directive 2008/57/EC¹.

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the clauses of this standard given in Table ZA.1 for HS Infrastructure and in Table ZA.2 for CR Infrastructure confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

¹ This Directive 2008/57/EC adopted on 17th June 2008 is a recast of the previous Directives 96/48/EC 'Interoperability of the trans-European high-speed rail system' and 2001/16/EC 'Interoperability of the trans-European conventional rail system' and revisions thereof by 2004/50/EC 'Corrigendum to Directive 2004/50/EC of the European Parliament and of the Council of 29th April 2004 amending Council Directive 96/48/EC on the interoperability of the trans-European high-speed rail system and Directive 2001/16/EC of the European Parliament and of the Council on the interoperability of the trans-European conventional rail system'.

Table ZA.1 — Correspondence between this European Standard, the HS TSI INF, published in OJEU dated 19th March 2008, and Directive 2008/57/EC

Clause(s)/ sub-clause(s) of this European Standard	Chapter/§/annexes of the TSI	Corresponding text, articles/§/annexes of the Directive 2008/57/EC	Comments
The complete standard is for application	4. Description of the infrastructure domain 4.2.2 Nominal track gauge 4.2.11.b) Rail inclination – Switches and crossings 4.2.12.2 Use of swing noses 4.2.12.3 Geometrical characteristics 4.2.13 Track resistance – vertical and lateral loads 5 Interoperability constituents 5.3.1.1.b) The rail – Railhead profile – Switches and crossings 5.3.4.c) Switches and crossings – Geometrical characteristics Annex A – Table A1 Annex B1 –Table B1	Annex III Essential requirements 1. General requirements 1.1 Safety Clauses 1.1.1 – 1.1.2 and 1.1.3 1.5 Technical compatibility	

Table ZA.2 — Correspondence between this European Standard, the CR TSI INF published in OJEU dated 14th May 2011, and Directive 2008/57/EC

Clause(s)/ sub-clause(s) of this European Standard	Chapter/§/annexes of the TSI	Corresponding text, articles/§/annexes of the Directive 2008/57/EC	Comments
The complete standard is for application	4. Description of the infrastructure subsystem 4.2.5 Track parameters 4.2.5.1 Nominal track gauge 4.2.5.7.2 Rail inclination – Requirements for switches and crossings 4.2.6 Switches and crossings 4.2.6.2 In-service geometry of switches and crossings 4.2.6.3 Maximum unguided length of fixed obtuse crossings. 4.2.7 Track resistance to applied loads 5. Interoperability constituents 5.3.1 Constituents performances and specifications - The rail 6. Assessment of conformity of interoperability constituents and EC verification of the subsystems 6.2.4.7 Assessment of geometry of switches and crossings 6.2.5.2 Assessment of track resistance for switches and crossings Annex B – Table 21	Annex III Essential requirements 1. General requirements 1.1 Safety Clauses 1.1.1 – 1.1.2 and 1.1.3 1.5 Technical compatibility	Rails, fastenings and sleepers used for short length of track for specific purposes, for example in switches and crossings, at expansion devices, transition slabs and special structures, are not to be considered to be interoperability constituents according to § 5.2 (3) of the CR TSI INF

WARNING — Other requirements and other EC Directives may be applicable to the product(s) falling within the scope of this standard. 

Bibliography

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

EN 13232-2, *Railway applications - Track - Switches and crossings - Part 2: Requirements for geometric design.*

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

EN 13260, *Railway applications - Wheelsets and bogies - Wheelsets - Product requirement.*

UIC Leaflet 510-02 OR, *Trailing stock - Conditions concerning the use of wheels of various diameters with running gear of different types.*

UIC Leaflet 716, *Maximum permissible wear profiles for switches.*

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