
**Železniške naprave - Zgornji ustroj proge - Kakovost tirne geometrije - 6. del:
Karakterizacija kakovosti tirne geometrije**

Railway applications - Track - Track geometry quality - Part 6: Characterisation of track geometry quality

Bahnanwendungen - Oberbau - Qualität der Gleisgeometrie - Teil 6: Charakterisierung der geometrischen Gleisagequalität

Applications ferroviaires - Voie - Qualité géométrique de la voie - Partie 6:
Caractérisation de la qualité géométrique de la voie

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**Railway applications - Track - Track geometry quality - Part 6:
Characterisation of track geometry quality**

Applications ferroviaires - Voie - Qualité géométrique de la
voie - Partie 6: Caractérisation de la qualité géométrique de
la voie

Bahnanwendungen - Oberbau - Qualität der Gleisgeometrie
- Teil 6: Charakterisierung der geometrischen
Gleislagequalität

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Foreword

This document (EN 13848-6:2014) 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of an identical text or by endorsement, at the latest by September 2014, and conflicting national standards shall be withdrawn at the latest by September 2014.

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 by the European Commission and the European Free Trade Association.

This European Standard is one of the series EN 13848 "*Railway applications – Track – Track geometry quality*" as listed below:

- *Part 1: Characterisation of track geometry*
- *Part 2: Measuring systems – Track recording vehicles*
- *Part 3: Measuring systems – Track construction and maintenance machines*
- *Part 4: Measuring systems – Manual and lightweight devices*
- *Part 5: Geometric quality levels – Plain line*
- *Part 6: Characterisation of track geometry quality*

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1 Scope

This European Standard characterizes the quality of track geometry based on parameters defined in EN 13848-1 and specifies the different track geometry classes which should be considered.

This European Standard covers the following topics:

- description of track geometry quality;
- classification of track quality according to track geometry parameters;
- considerations on how this classification can be used;
- this European Standard applies to high-speed and conventional lines of 1 435 mm and wider gauge;
- this European Standard forms an integral part of EN 13848 series.

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 13848-1, *Railway applications - Track - Track geometry quality - Part 1: Characterisation of track geometry*

3 Terms, definitions, symbols and abbreviations

3.1 Terms and definitions

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

3.1.1

re-colouring

algorithm which modifies the spectral content of a signal aimed to compensate or apply the characteristics of a specific measuring system

Note 1 to entry: The re-colouring is used in EN 13848 series to convert a chord measurement signal into a *D1* or *D2* measurement signal.

3.1.2

track quality class (TQC)

characterization of track geometry quality as a function of speed and expressed as a range of TQIs

3.1.3

track quality index (TQI)

value that characterises track geometry quality of a track section based on parameters and measuring methods compliant with EN 13848 series

3.2 Symbols and abbreviations

For the purposes of this document, the following symbols and abbreviations apply.

Table 1 — Symbols and abbreviations

Symbol	Designation	Unit
<i>AL</i>	Alignment	mm
<i>ATQI</i>	Alternative Track Quality Index	
<i>CL</i>	Cross level	mm
<i>CoSD</i>	Combined standard deviation	mm
<i>D1</i>	Wavelength range $3\text{ m} < \lambda \leq 25\text{ m}$	m
<i>D2</i>	Wavelength range $25\text{ m} < \lambda \leq 70\text{ m}$	m
<i>D3</i>	Wavelength range $70\text{ m} < \lambda \leq 150\text{ m}$ for longitudinal level Wavelength range $70\text{ m} < \lambda \leq 200\text{ m}$ for alignment	m
λ	Wavelength	m
<i>G</i>	Track gauge	mm
<i>LL</i>	Longitudinal level	mm
<i>MBS</i>	Multi Body System	
<i>NTQI</i>	National Track Quality Index	
<i>PMA</i>	Point Mass Acceleration (method)	
<i>PSD</i>	Power Spectral Density	$\text{m}^2/(\text{s}^3\text{m})$
<i>SD</i>	Standard deviation	mm
<i>SD_{LL}</i>	Standard deviation longitudinal level	mm
<i>SD_{AL}</i>	Standard deviation alignment	mm
<i>TQI</i>	Track Quality Index	
<i>TQI_{ref}</i>	Reference Track Quality Index	
<i>TQC</i>	Track Quality Class	
<i>V</i>	Speed	km/h
<i>VRA</i>	Vehicle Response Analysis (method)	

NOTE In this European Standard, *AL* stands for “alignment” and is not to be confused with *AL* standing for “alert limit” as defined in EN 13848–5:2008+A1:2010.

4 Basic principles

4.1 Introduction

It is necessary to standardize the way that track geometry quality is assessed in order to permit safe and cost-effective railway traffic by focusing on the functional requirements of both track and vehicle.

Basic parameters for track geometry quality assessment

As track geometry measurement, vehicles present their outputs in accordance with the parameters specified in EN 13848-1, any standardized assessment method shall be based on these parameters.

4.2 Transparency

Any algorithm for track geometry quality assessment complying with this standard shall be fully documented, reproducible and available in the public domain.

4.3 Complexity

Track geometry quality should be assessed by as few *TQ/s* as possible and the algorithm should be understandable by the user.

4.4 Track-vehicle interaction

Track quality assessment should reflect the principles of track-vehicle interaction. For example, the track geometry defects of the same amplitude but different wavelengths lead to different vehicle responses and the required wavelength range will be different depending on the track-vehicle interaction parameters to be assessed.

5 Assessment of track geometry quality: state-of-the-art

5.1 General

Track geometry quality can be characterized by various *TQ/s* according to the level of aggregation they are used for. The *TQ/s* described in the following sub-clauses are used by at least one of the European Railway Networks. They represent the current state-of-the-art of description of track geometry quality.

5.2 Standard deviation (*SD*)

The standard deviation is one of the most commonly used *TQ/s* by European Railway Networks. It represents the dispersion of a signal over a given track section, in relation to the mean value of this signal over the considered section.

$$SD = \sqrt{\frac{\sum_{i=1}^N (x_i - \bar{x})^2}{N-1}}$$

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where

N is the number of values in the sample;

x_i is the current value of a signal;

\bar{x} is the mean value of a signal;

SD is the standard deviation.

NOTE 1 Standard deviation is linked to the energy of the signal in a given wavelength range $[\lambda 1, \lambda 2]$ according to the following relationship: $SD^2 = 2 \int_{\lambda 1}^{\lambda 2} S_{xx}(\nu) d\nu$, where S_{xx} is the *PSD* described in 5.6 below.

SD is commonly calculated for the following parameters:

- Longitudinal level $D1$;
- Alignment $D1$.

It is also calculated for other parameters such as:

- Twist;
- Track gauge;
- Cross level;

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- Longitudinal level $D2$;
- Alignment $D2$.

For longitudinal level and alignment it is recommended to calculate SD separately for each rail. It may also be calculated differently (for example: mean of both rails, worst or best of either rail or outer rail in curves).

Length of track section used for standard deviation has influence on the result. If comparable results are expected, only one length should be used. Commonly, for maintenance reasons standard deviation is calculated over a length of 200 m. It may be calculated either at fixed distances without overlap or with overlap, as a sliding standard deviation. Calculation of standard deviation is also done over longer distances such as 1 km, an entire line or an entire network.

NOTE 2 Distinction between specific track sections, such as plain lines, stations and switches and crossings, can also be made.

When calculating SD for twist, track gauge and cross level attention should be paid on the possible influence of the quasi-static part of the signals.

5.3 Isolated defects

Isolated defects may present a derailment risk; however counting the number of isolated defects exceeding a specified threshold such as intervention limit and alert limit on a given fixed length of track can be representative of the track geometry quality. This method is used by several European Railway Networks.

The number of isolated defects per unit of track length is commonly counted for the following parameters:

- Longitudinal level $D1$;
- Alignment $D1$;
- Twist;
- Track gauge;
- Cross level.

It can be also counted for the following parameters:

- Longitudinal level $D2$;
- Alignment $D2$.

Commonly, the number of isolated defects is counted over 1 km or more. It may also be counted over 100 m or 200 m of track.

If required, distinction between specific track sections can be made, such as plain lines, stations and switches and crossings.

Alternatively a calculation can be made to specify what percentage of a line exceeds a certain threshold level.

5.4 Combination of various parameters**5.4.1 Combined standard deviation (CoSD)**

Assessment of the overall track geometry quality of a track section (200 m, 1 000 m...) can be done by a combination of weighted standard deviations of individual geometric parameters. An example of such a TQI is given below.

$$CoSD = \sqrt{w_{\overline{AL}} \cdot SD_{\overline{AL}}^2 + w_G \cdot SD_G^2 + w_{CL} \cdot SD_{CL}^2 + w_{\overline{LL}} \cdot SD_{\overline{LL}}^2}$$

where

SD standard deviation of the individual geometry parameters;

w weighting factor of the individual geometry parameters;

with the indices:

\overline{AL} alignment, average of left and right rails;

G track gauge;

CL cross level;

\overline{LL} longitudinal level, average of left and right rails.

It is up to the Infrastructure Manager to determine the weighting factors, e.g. for tamping purposes the weighting factor w_G should be zero.

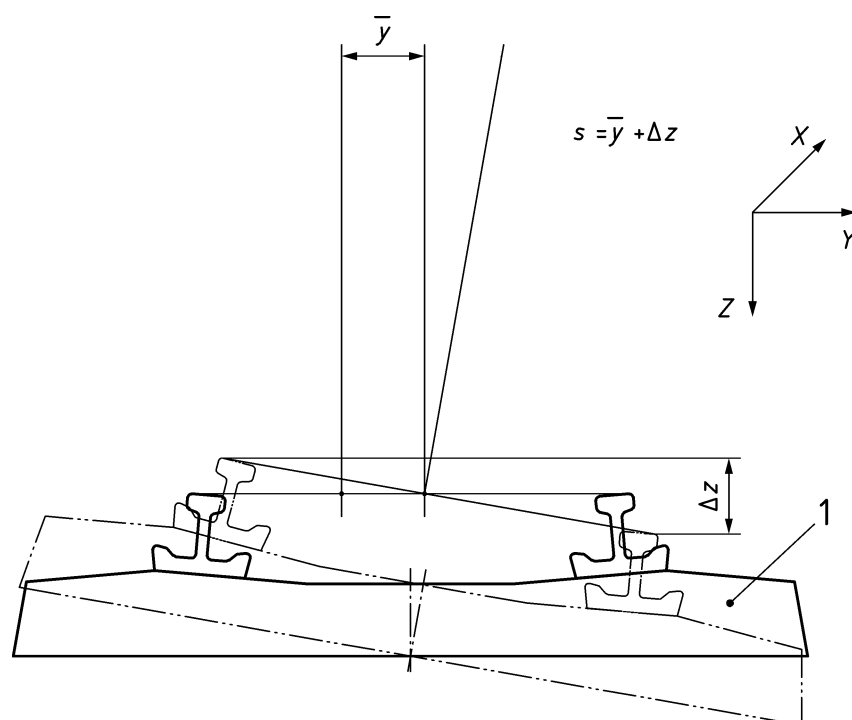
Another method might be to transform the standard deviations of geometry parameters or their combinations into a dimensionless number that can be used without distinction of line category, speed range and track geometry parameter.

5.4.2 Standard deviation of the combinations of parameters

Standard deviation for a combination of track geometry parameters can be evaluated. This is based on the observation that the level of the combined signals may better reflect the vehicle behaviour than the individual signals.

For example, a standard deviation, over a sliding 200 m length of track, can be evaluated for the sum of alignment and cross level in $D1$ as follows:

- the alignments of left and right rails are combined into one signal, in curves by choosing the outer rail and on tangent track by either averaging or choosing one of the two rails;
- cross level and alignment signals are combined together by using a sign convention so that an alignment defect to the right is added with the same sign to a cross level defect where right rail is lower than the left rail. Figure 1 shows an example of the combination of cross level Δz and alignment \overline{y} where the signs are both positive;
- the standard deviation of the combined signals is calculated over a sliding 200 m length of track.

**Key**

1

reference position

$$\bar{y} = (AL_{\text{right}} + AL_{\text{left}}) / 2$$

combination of alignment

$$\Delta z = z_{\text{right}} - z_{\text{left}}$$

cross level

s

sum of cross level and alignment

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Figure 1 — Combination of alignment and cross level**5.4.3 Point mass acceleration method (PMA)**

The PMA method is based on the following principles:

- The PMA model considers an unsprung virtual vehicle. It is assumed to be a point mass, thus only the motion of the centre of gravity is investigated. This point mass is guided in a certain distance over the track centre line.
- The point mass is moved at a constant speed corresponding to the maximum allowed speed over the measured track section.
- Due to the geometrical imperfection of the track, which is described by the longitudinal level and alignment of both rails, the point mass incurs accelerations a_y and a_z in the horizontal and vertical directions.
- The vectorial summation of these accelerations is used to characterize the track geometry quality.

Theoretical background information as well as features of the PMA method are given in Annex A.

5.5 Methods based on vehicle response**5.5.1 Use of theoretical model**

Vehicle response analysis (VRA) can be used to make objective, quantified statements about the relationship between the track geometry quality and the vehicle's responses at various speeds. It takes into consideration factors such as successions of isolated defects that might generate resonance, combinations of defects at the same location and local track design (e.g. curvature and cant).