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Železniške naprave - Zgornji ustroj - Kakovost tirne geometrije - 6. del: Karakteristike 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 Gleislagequalität

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

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Foreword

This document (prEN 13848-6:2012) has been prepared by Technical Committee CEN/TC 256 "Railway applications", the secretariat of which is held by DIN.

This document is currently submitted to the CEN Enquiry.

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(s).

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*

1 Scope

This European Standard characterises the quality of track geometry based on parameters defined in EN 13848-1 and specifies the different track geometry classes which have to 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 Standard applies to high-speed and conventional lines of 1 435 mm and wider gauge railways provided that the vehicles operated on those lines comply with EN 14363 and other vehicle safety standards.

This 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+A1:2008, *Railway applications – Track – Track geometry quality – Part 1: Characterisation of track geometry*

EN 14363, *Railway applications – Testing for the acceptance of running characteristics of railway vehicles – Testing of running behaviour and stationary tests*

3 Terms and definitions

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

3.1
track quality index (TQI)
value that characterizes track geometry quality of a track section based on parameters and measuring methods compliant with EN 13848 series

3.2
track quality class (TQC)
characterisation of track geometry quality as a function of speed and expressed as a range of TQIs

3.3
re-colouring
algorithm which converts one signal into a different signal. It is used in EN 13848 series to convert a chord measurement signal into a *D*1 or *D*2 measurement signal

4 Symbols and abbreviations

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

Table 1 — Symbols and abbreviations

Symbol	Designation	Unit
AL	Alignment	mm
ATQI	Alternative Track Quality Index	
CoSD	Combined standard deviation	mm

Symbol	Designation	Unit
*D*1	Wavelength range 3 m < $\lambda \leq$ 25 m	m
*D*2	Wavelength range 25 m < $\lambda \leq$ 70 m	m
*D*3	Wavelength range 70 m < $\lambda \leq$ 150 m for longitudinal level Wavelength range 70 m < $\lambda \leq$ 200 m for alignment	m
λ	Wavelength	m
LL	Longitudinal Level	mm
NTQI	National Track Quality Index	
PMA	Point Mass Acceleration (method)	
PSD	Power Spectral Density	
SD	Standard deviation	mm
TQI	Track Quality Index	
TQI_{ref}	Reference Track Quality Index	
TQC	Track Quality Class	
V	Speed	km/h
VRA	Vehicle Response Analysis (method)	

NOTE In this Standard, *AL* stands for “alignment” and is not to be confused with *AL* standing for “alert limit” as defined in EN 13848-5.

5 Basic principles

5.1 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.

5.2 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.

5.3 Transparency

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

5.4 Complexity

Track geometry quality should be assessed by as few TQIs as possible and the algorithm should be understandable by the user.

5.5 Track-vehicle interaction

Track quality assessment should reflect the principles of track-vehicle interaction, e.g. the fact that track geometry defects of the same amplitude but different wavelengths lead to different vehicle responses.

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

6.1 General

Track geometry quality can be characterised by various TQIs according to the level of aggregation they are used for. The TQIs described in the following subclauses 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.

6.2 Standard deviation (SD)

The standard deviation is one of the most commonly used TQIs 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.

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

where:

— N is the number of samples

— x_i is the current value of a signal

— $\overline{x}$ is the mean value of a signal

— SD is the standard deviation

NOTE Standard deviation is linked to the energy of the signal in a given wavelength range [λ1, λ2] according the following relationship $SD^2 = 2\int_{\lambda 1}^{\lambda 2} S_{xx}(\nu)\mathrm{d}\nu$, where S_{xx} is the PSD described in sub-clause 6.6 below.

SD is commonly calculated for the following parameters:

— Longitudinal level *D*1;

— Alignment *D*1.

It is also calculated for other parameters such as:

— Twist;

— Track gauge;

— Cross level;

— Longitudinal level *D*2;

— Alignment *D*2.

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).

Commonly, standard deviation is calculated over a length of 100 m or 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 Distinction between specific track sections, such as plain lines, stations and switches and crossings, can also be made.

6.3 Isolated defects

Isolated defects are mainly related to safety; 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 *D*1;

— Alignment *D*1;

— Twist;

— Track gauge;

— Cross level.

It is also counted for the following parameters:

— Longitudinal level *D*2;

— Alignment *D*2.

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.

6.4 Combination of various parameters

6.4.1 Combined standard deviation (CoSD)

Assessment of the overall track geometry quality of a track section (200 m, 1000 m ...) can be done by a combination of weighted standard deviations of individual geometric parameters. An example of such a TQI is given below.

$$CoSD = \sqrt{w_{\overline{AL}}.SD_{\overline{AL}}^{2} + w_{G}.SD_{G}^{2} + w_{CL}.SD_{CL}^{2} + w_{\overline{LL}}.SD_{\overline{LL}}^{2}}$$

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 and TQI limits, e.g. for tamping purposes the weighting factor w_G is 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.

6.4.2 Standard deviation of the combinations of parameters

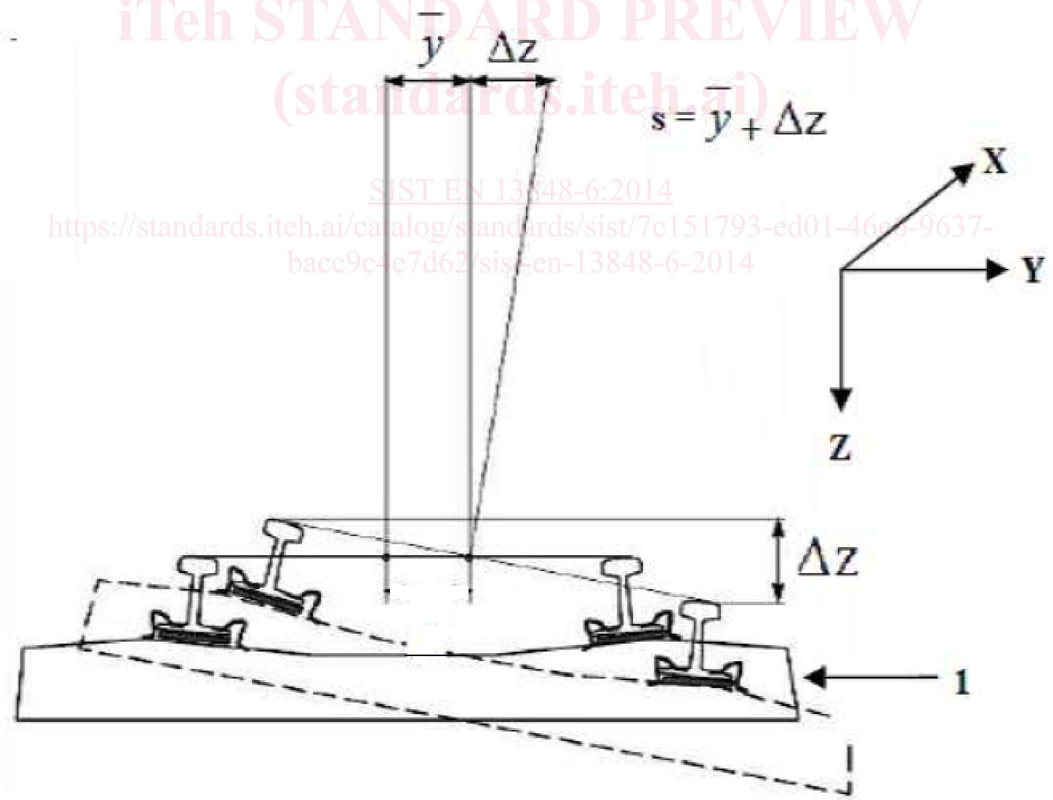
Standard deviation for a combination of track geometry parameters can be evaluated. This is based on the observation that the level of the combined signals may better reflect the vehicle behaviour than the individual signals.

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 *D*1 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

$\overline{y}$ = $(AL_{right} + AL_{left})/2$: combination of alignment

$\Delta z = z_{right} - z_{left}$: cross level

Figure 1 — Combination of alignment and cross level

6.4.3 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 for 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.

6.5 Using vehicle response

6.5.1 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).

The VRA method is based on the following principles:

- Calculation of vehicle response to the track geometry measured according to EN 13848-1, the vehicle response being represented by the wheel-rail forces and by accelerations of the vehicle running gear and car body;
- Consideration of different vehicle types and speeds, taking into account the worst response of all vehicles considered at every measuring point;
- The output can be referred back to single parameters like longitudinal level, twist and alignment;
- The assessment criteria are based on the limit values given by EN 14363.

An example of a VRA method, as well as features of such methods, are given in Annex B.

6.5.2 Use of direct measurement

Although not generally used for TQIs calculation, direct measurements of vehicle response can help in assessing interaction between running vehicle and track, with respect to safety as well as ride quality.

Usually the accelerations of bogie and car body are measured in both lateral and vertical directions, but measurement of wheel–rail forces, such as lateral and vertical forces (Y and Q), can also be made.

Inspection runs are usually made on high speed lines, but they can also be of interest on conventional lines.

The following principles should be respected when using direct measurement:

- The vehicles used for these evaluations are representative of the rolling stock used on the assessed lines;
- The runs are made at the maximum speed of the line, with a tolerance of ±10 %;
- The measurements are made at the parts of the vehicle where the highest response is expected, e.g. the leading bogie or wheelset;