SIST

SLOVENSKI STANDARD
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Železniške naprave - Geometrijski parametri stika kolo-tirnica - Definicije in metode vrednotenja

Railway Applications - Wheel-rail contact geometry parameters - Definitions and methods for evaluation

Bahnanwendungen - Parameter der Rad-Schiene-Berührgeometrie - Definitionen und Auswertemethoden

Applications ferroviaires - Paramètres géométriques du contact roue-rail - Définitions et méthodes de détermination

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English Version

Railway Applications - Wheel-rail contact geometry parameters - Definitions and methods for evaluation

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Bahnanwendungen - Parameter der Rad-Schiene-Berührgeometrie - Definitionen und Auswertemethoden

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Contents

Page

European foreword

This document (prEN 15302:2018) 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 will supersede EN 15302:2008+A1:2010.

This document has been prepared under a standardization request 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.

Introduction

This document is based on the UIC Code 519 OR submitted to CEN by the International Union of Railways (UIC) and which has been revised by CEN/TC 256/WG 10 “Vehicle/Track Interaction”.

The wheel-rail contact geometry is fundamental for explaining the dynamic running behaviour of a railway vehicle, as well as the quasi-static behaviour in curves. Among the parameters which influence the dynamic behaviour of a rail vehicle, the equivalent conicity plays an essential role since it allows for the satisfactory characterization of the wheel-rail contact geometry on tangent track and on very large-radius curves. A wheelset describes a waveform while running on a track. Klingel’s theory, valid for massless wheelsets with conical profiles, states that the waveform is sinusoidal and its wavelength depends on the cone angle of the wheel profile.

Real wheel profiles are not pure cones, but have changing cone angles across the tread, leading to a nonlinear dependency of the rolling radius difference on the lateral movement of the wheelset on the track. The wavelength of the wheelset movement according to the nonlinear kinematic equations of motion may be calculated by solving numerically this formula or by specific methods for linearization of the rolling radius difference function. Equivalent conicity is evaluated by comparison of this wavelength with the equivalent wavelength of a conical wheelset according to Klingel's formula or by calculating the conicity from the linearized rolling radius difference function.

It is important to have a clear specification for the evaluation of wheel-rail contact geometry parameters, which are used in European and national standards and documents (legal and technical).

The objective is to ensure that the results for the determined parameters are consistent. However it is possible to use different evaluation procedures to those given in this document, provided that the procedure used leads to the determination of wheel-rail contact parameters in accordance with the calculation results using the reference profiles specified in Annex I. A validation process is given in this document to be used in order to determine whether or not an evaluation procedure can achieve the specified reference results.

Technical background will be given in a Technical Report published after the publication of this document.

1 Scope

This document establishes definitions and evaluation methods for wheel-rail contact geometry parameters influencing the vehicle running dynamic behaviour:

- the rolling radius difference between the two wheels of a wheelset (Δ*r*-function) which serves as a basis for all further calculations;
- the equivalent conicity function from which are derived:
  - a single equivalent conicity value for a specified amplitude which is relevant for the assessment of vehicle running stability on straight track and in very large radius curves according to EN 14363;
  - the nonlinearity parameter which characterizes the shape of this function and is related to the vehicle behaviour particularly in the speed range close to the running stability limit;
- the rolling radii coefficient which is used to describe the theoretical radial steering capability of a wheelset in a curved track.

Additional information is given about the relationship between the contact angles of the two wheels of a wheelset (Δtan*γ*-function) and about the roll angle parameter.

NOTE Out of the presented parameters only those related to the contact angle are relevant for independently rotating wheels of wheel pairs.

Descriptions of possible calculation methods are included in this document. Test case calculations are provided to achieve comparable results and to check the proper implementation of the described algorithms.

To validate alternative methods not described in this document acceptance criteria are given for the equivalent conicity function. This includes reference profiles, profile combinations, tolerances and reference results with tolerance limits.

This document also includes minimum requirements for the measurement of wheel and rail profiles as well as of the parameters needed for the transformation into a common coordinate system of right- and left-hand profiles.

This document does not define limits for the wheel-rail contact geometry parameters and gives no tolerances for the rail profile and the wheel profile to achieve acceptable results.

For the application of this document some general recommendations are given.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 13231-3:2012, *Railway applications — Track — Acceptance of works — Part 3: Acceptance of reprofiling rails in track*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

NOTE This document uses the standard European notation for numeric values with “comma” (,) as the decimal point and “space” ( ) as the thousands delimiter. Thus for example 2,5 mm is to be understood as 2.5 mm and 1 500 mm as 1500 mm.

3.1
equivalent conicity
tangent of the cone angle of a wheelset with coned wheels whose kinematic movement has the same wavelength as the given wheelset for a certain amplitude of the lateral wheelset movement

3.2
nonlinearity parameter
local slope of the equivalent conicity function between two specified wheelset displacement amplitudes

3.3
radial steering index
ratio between the curve radius negotiable without longitudinal creepage and the actual curve radius of the track section to describe the radial steering capability of a wheelset in a track section

3.4
rolling radii coefficient
relationship describing the capability of a wheel-rail contact geometry to provide the rolling radii difference needed for a wheelset to negotiate an actual curve without longitudinal creepage and flange contact

Note 1 to entry: This parameter is related to the radial steering index.

3.5
uncertainty
refer to the definition of expanded uncertainty with a coverage factor equal to 2 as defined in ISO/IEC Guide 98-3:2008-09 (JCGM/WG1/100)

Note 1 to entry: The uncertainty as defined corresponds to a confidence level of about 95 % of a normal distribution.

3.6
reproducibility
degree of agreement between the values of successive measurements of the same parameter made under varying conditions using the same measurement and interpretation methods

4 Symbols and abbreviations

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

$2b_A$ nominal contact point spacing (1 500 mm for standard gauge)

D_0 tread datum position; location on the wheel tread, 70 mm (for standard gauge) from the internal face of the wheel

x displacement of the wheelset in the longitudinal direction of the track

y displacement of the wheelset in the lateral direction of the track (at top of rail level)

Ψ	angle of the wheelset movement in the *x*-*y*-plane
ds	curve length of the path corresponding to the angle $d\Psi$
V	speed of forward movement of the vehicle
R_{WS}	local radius of the wheelset path
r	mean rolling-radius of both wheels
r_0	radius of the wheels when the wheelset is centred on the track
r_1	rolling-radius of the right-hand wheel
r_2	rolling-radius of the left-hand wheel
Δr	difference of the rolling-radius between right-hand and left-hand wheels
y_{em}	lateral displacement where $\Delta r = 0$
y_{emin}	minimum value of lateral displacements
y_{emax}	maximum value of lateral displacements
$\hat{y}$	amplitude of the wave
λ	wavelength of the wheelset movement
γ	contact angle; angle between the tangent at the wheel-rail contact point and the track plane
$\Delta\tan\gamma$	difference of the tangents of the contact angles between right-hand and left-hand wheels
$\tan\gamma_e$	equivalent conicity
N_P	nonlinearity parameter
Δr_E	rolling radius difference available for kinematic rolling (rolling without slip)
R_E	minimum curve radius for kinematic rolling
q_E	radial steering index
ρ_E	rolling radii coefficient
ε_e	contact angle parameter
φ	roll angle of the wheelset around the longitudinal axis
σ_e	roll angle parameter
σ_{err}	standard deviation of random profile errors

5 Overview of the process for determining contact parameters

Figure 1 gives an overview of the process for determining the contact parameters described in this document. The figure also shows the clauses of this standard where more information on particular steps of the process is given, including possible options.

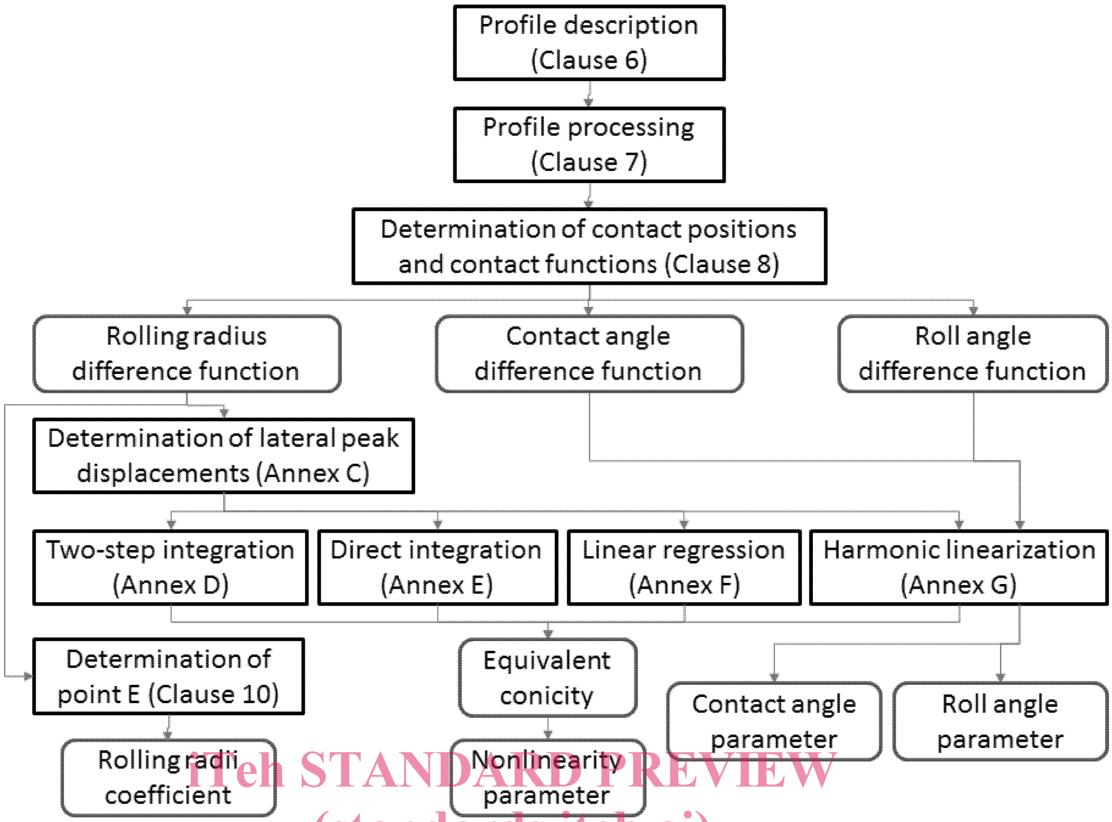


Figure 1 — Process of contact geometry parameter determination

6 Description of wheel and rail profiles

6.1 General

The determination of wheel-rail contact geometry parameters requires knowledge of the shapes of the wheel and rail profiles to be assessed as well as their relative position including

— wheel back-to-back distance,

— wheel diameters, if relevant,

— track gauge,

— profile orientation in relation to the track plane (rail inclination, wheel inclination due to axle bending).

NOTE 1 If there is significant difference in wheel diameter (more than 2 mm) the resulting roll effect may need to be included if not covered by the measuring system.

The bending of the axle under the load generally cannot be ignored. Therefore the measurements should be made for representative load conditions near to the contact point.

In case of measuring systems which are not able to include the wheel inclination due to axle bending, the orientation may be determined by other methods such as static calculations. In some cases it may be possible to use already known bending angles representative for the vehicle considered.

When the profiles are determined by measurement, special-purpose devices can be used, such as wheel and rail profile measuring devices or automatic measuring systems carried aboard special railbound vehicles for rail profiles or ground based systems for wheel profiles.

The measurement devices shall be able to provide the profile coordinates with a maximum 0,5 mm spacing along the arc of the profile.

NOTE 2 In areas with high profile curvature, a lower spacing may be required in order to get an accurate profile shape.

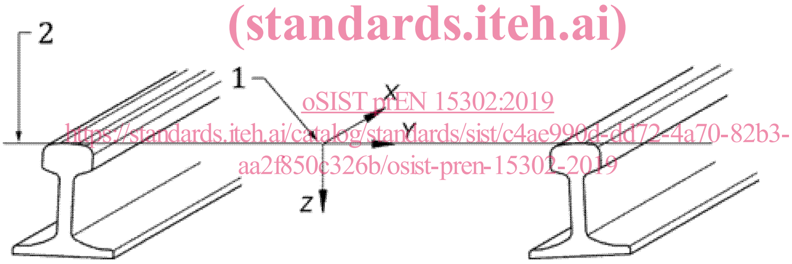
It shall be reported whether the profiles were measured in the loaded or unloaded condition.

For freight vehicles contact geometry may be more significantly influenced by the load. If the equivalent conicity is to be used to investigate running behaviour, the contact geometry may be considered in empty and laden condition.

When theoretical profiles are used the inclination shall be considered.

Independent of the source of the profiles (theoretical or measured), the two rails of the railway track shall be referred to a track-related coordinate system oriented such that the x-axis is longitudinal to the track, the y-axis tangential to the upper surface of the rail heads and the z-axis perpendicular to both axes, see Figure 2. The two wheels of the wheelset shall be referred to a single coordinate system with axes oriented in analogous directions.

NOTE 3 The relative position and orientation of the two profiles is relevant. Therefore, the use of a measuring system with a single profile measuring head without reference between the two sides can lead to large uncertainties of the calculated contact parameters.



Key

1 Track-related coordinate system

2 Top of rail level

Figure 2 — Track-related coordinate system (consistent with EN 13848-1)

It is recommended to provide the input data (theoretical or measured) related to the following coordinate systems.

For the rails the origin of the coordinate system is defined so that y = 0 at the middle of the measured track gauge and z = 0 at the top of the rails.

For the wheels the origin of the coordinate system is defined so that y = 0 at the middle of the wheel back to back distance and z = 0 at D_0 for both wheels. Any significant wheel diameter difference shall be included as an offset in the rolling radius difference function, see 8.2.

The wheel and rail profiles shall be characterized such that

— for the rail, the profile is defined not only on the top but also on the inner side (gauge face) at least down to 14 mm below the top of the rail,

— for the wheel, the profile is defined not only on the wheel tread but also on the outer part and in the area of the wheel flange root down to at least 10 mm below D_0,

— any significant radius difference between the two wheels of a wheelset (measured at the tread datum positions of the profiles) is taken into account.

The numerical resolution of the profile data shall be consistent with the evaluation process (smoothing and calculation). If profile data are given with low numerical resolution, the shape may become step-like with repeated samples of identical amplitude and jumps which are much larger than in reality. This will lead to unrealistic results for the contact parameters. It is therefore recommended to provide profile data with a high numerical resolution, e.g. with $1 \cdot 10^{-3}$ mm. This is clearly beyond the precision of the measurement system, but prevents problems in the calculation of contact geometry parameters.

For the following steps in the procedure the profile coordinates shall be provided sorted along the arc, in order to give a continuous profile.

6.2 Uncertainty of the measuring systems

The uncertainty of the measuring system shall be quantified as a combination of the uncertainties of the following parameters:

a) coordinates of a single profile;

b) relative position of left and right profile (vertical and lateral distance, rotation around longitudinal axis).

These uncertainties shall be determined in laboratory tests and be provided by the supplier of the measuring system. One possible test for rail profile measurements is described in EN 13231-3:2012, Annex A. If it is not practical to check the measuring system in the laboratory, an in-field cross-check with a reference measuring instrument is required.

If the profiles and the relative position parameters are not measured with the same system then the interface between the systems shall be included in the uncertainty analysis (for example the influence of different spacing of data points, adjustment of the different measuring systems, …).

In order to limit the uncertainty of the calculated contact parameters, measurement uncertainties of the relative position parameters shall not exceed the following values:

— difference of wheel radii (measured at the tread datum positions of the profiles): 0,2 mm;

— wheel back-to-back distance: 0,5 mm;

— track gauge: 0,5 mm.

NOTE 1 Tolerances for the diameter difference between wheels on the same axle are specified in EN 15313 for new and re-profiled wheelsets.

NOTE 2 For the assessment of equivalent conicity the sum of the tolerances of wheel back-to-back distance and track gauge is the relevant parameter.

7 Plausibility check and processing of measured wheel and rail profiles

For the measurement of wheel and rail profiles a lot of measuring instruments with different measuring principles and differing sensitivity to measuring conditions are available. Before using measured profiles for contact geometry parameter calculations, the following pre-processing steps, which may be additional to the already implemented checks in the measuring systems, shall be carried out: