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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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ICS:

45.060.01	Železniška vozila na splošno	Railway rolling stock in general

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

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

Bahnanwendungen - Parameter der Rad-Schiene Kontaktgeometrie - Definitionen und Berechnungsmethoden

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Contents

Page

European foreword

This document (EN 15302:2021) 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of an identical text or by endorsement, at the latest by April 2022, and conflicting national standards shall be withdrawn at the latest by April 2022.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 15302:2008+A1:2010.

The main changes with respect to the previous edition are listed below:

— Extension of the Scope;

— Introduction of new wheel-rail contact geometry parameters (rolling radii coefficient, nonlinearity parameter);

— Additional methods for evaluation of equivalent conicity;

— Improvement of the description of the reference profiles;

— Additional reference wheel profile C;

— Reference results based on analytical solutions;

— Hints for plausibility checking of measured profiles;

— Revised assessment of the smoothing process;

— New assessment of the complete process.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

Any feedback and questions on this document should be directed to the users’ national standards body. A complete listing of these bodies can be found on the CEN website.

According to the CEN-CENELEC Internal Regulations, the national standards organisations 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, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

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 (Δr-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 ($\Delta\tan\gamma$-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 13231-2:2020, *Railway applications — Track — Acceptance of works — Part 2: Acceptance of reprofiling rails in plain line, switches, crossings and expansion devices*

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 https://www.electropedia.org/

— ISO Online browsing platform: available at https://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 is to be understood as two and one-half and 1 500 as one thousand five hundred.

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 (defined as 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

NOTE Some additional symbols not included in the list above are explained in the section where they are used.

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.

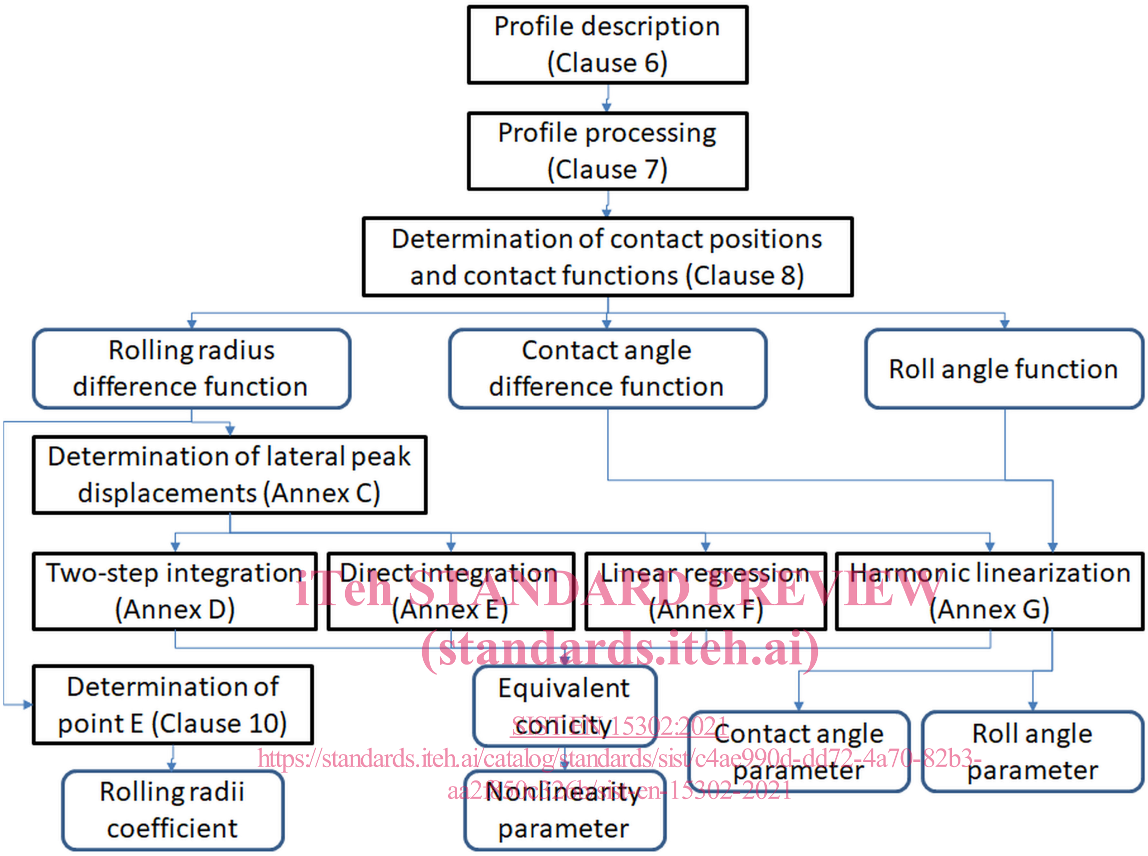


Figure 1 — Process of contact geometry parameter determination

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.

NOTE 2 The bending of the axle under the load generally is relevant. Therefore, the measurements are usually 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 3 In areas with high profile curvature, a lower spacing may be required in order to get an accurate profile shape.

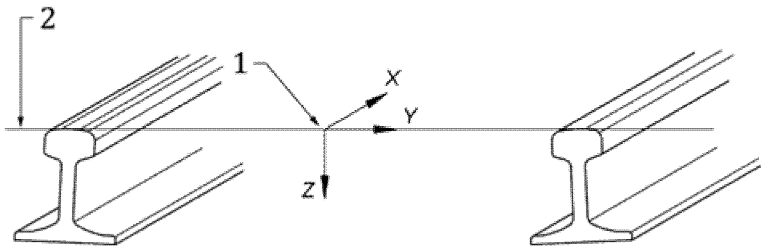
It shall be reported whether the profiles were measured in the loaded or unloaded condition.

NOTE 4 For freight vehicles contact geometry is potentially more significantly influenced by the load. Therefore, if the equivalent conicity is to be used to investigate running behaviour, the contact geometry is sometimes 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 5 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.