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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

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by the European Committee for Standardization (CEN) (as EN 15302:2021) and was adopted, with corrections and additions by Technical Committee ISO/TC 269, *Railway applications*.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

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 railway vehicle, the equivalent conicity plays an essential role, since it allows a satisfactory characterization of the wheel-rail contact geometry on straight track and in very large radius curves. A wheelset describes a waveform while running on a track. Klingel's theory, valid for massless and rigid wheelsets with conical profiles and pure rolling on rigid rails, 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 can be calculated by solving this formula numerically 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 international 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.

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

1 Scope

This document establishes definitions and evaluation methods for the following 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;

  — 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-hand 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

There are no normative references in this document.

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:

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

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

NOTE This document uses the standard ISO 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 on knife edge rails has the same wavelength as the given wheelset on the given track for a certain amplitude of the lateral wheelset movement

3.2
nonlinearity parameter
local slope of the *equivalent conicity* (3.1) function between two specified wheelset displacement amplitudes

3.3
radial steering index
ratio between the curve radius negotiable without longitudinal creepage or flange contact 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 radius difference needed for a wheelset to negotiate an actual curve without longitudinal creepage or flange contact

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

3.5
uncertainty
expanded uncertainty quantity defining an interval about the result of a measurement that may be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand

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

[SOURCE: ISO/IEC Guide 98-3:2008 [1], 2.3.5]

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

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

$2b_A$	nominal contact point spacing (nominal wheel back-to-back distance plus 2 times tread datum offset, see Figure 4)
D_0	tread datum position; location on the wheel tread where the nominal wheel radius is measured, usually in the range 60 mm to 80 mm from the internal face of the wheel (see Figure 3 and Figure 4)
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	yaw angle, i.e. angle (relative to the longitudinal direction of the track) of the wheelset movement in the x-y-plane

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ds	curve length of the path corresponding to the angle $d\psi$
dt	time increment
V	speed of forward movement of the vehicle
R_{WS}	local radius of the wheelset path
r_0	mean radius of both wheels measured at D_0
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_{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
B	slope of the regression of the Δr function
N_P	nonlinearity parameter
Δr_E	rolling radius difference available for kinematic rolling (rolling without creepage)
R	mean curve radius
R_a	curve radius of outer rail
R_i	curve radius of inner rail
V	vehicle speed
r_a	radius at outer wheel contact point
r_i	radius at inner wheel contact point
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 clauses where they are used.

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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 document where more information on particular steps of the process is given, including possible options.

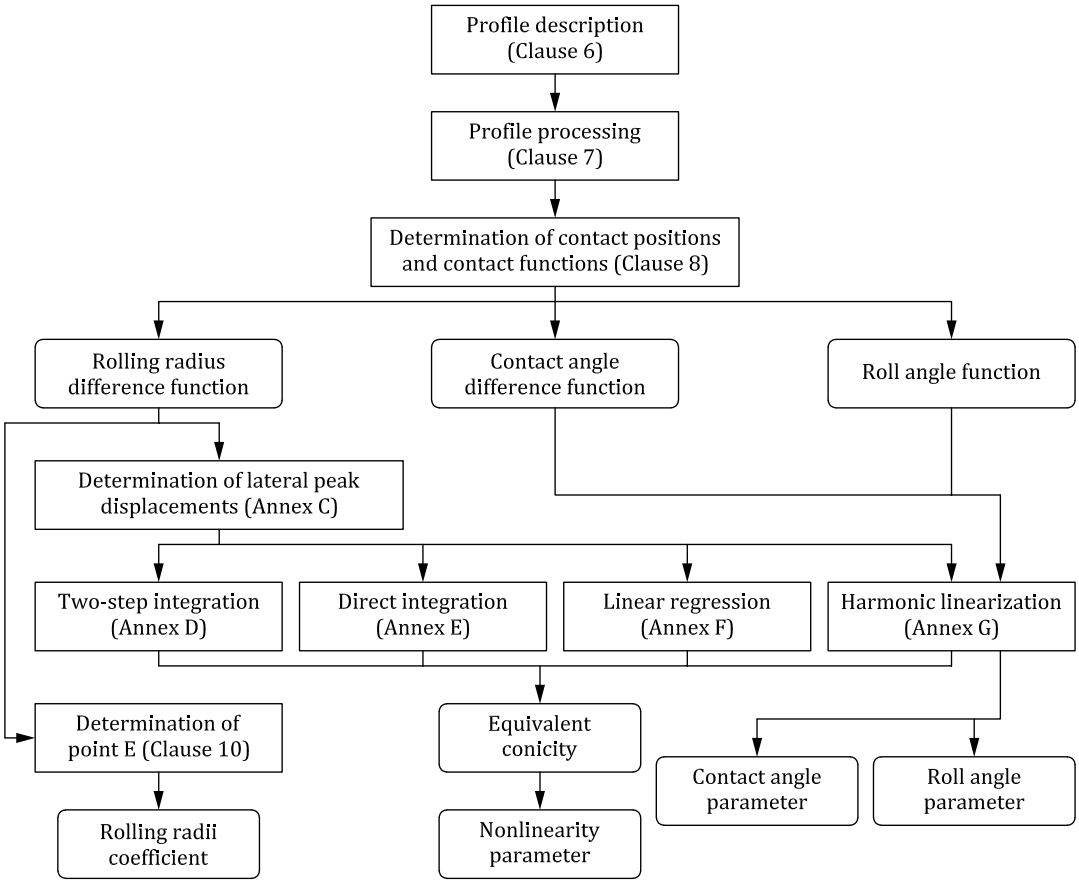


Figure 1 — Process of contact geometry parameter determination

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,

— track gauge,

— profile orientation in relation to the track plane:

  — rail inclination as installed and due to axle loading,

  — wheel inclination due to axle bending and wheel deformation,

— wheel diameter difference, if relevant.

Guidance regarding the above geometry parameters is provided in Annex L.

Any wheel-rail contact parameter calculation shall document assumptions related to the geometry parameters listed above.

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