

DIN EN 15302:2011-01 (E)

Railway applications - Method for determining the equivalent conicity (includes Amendment A1:2010)

Contents		Page
Foreword.....		9
Introduction		10
1 Scope		13
2 Normative references		13
3 Symbols		14
4 Principle of determining the equivalent conicity.....		15
4.1 Integration of the equation of the wheelset movement of a conical profile		15
4.2 Determining the wavelength of a conical profile.....		16
4.3 Definition of equivalent conicity for nonlinear profiles		17
5 Description of the reference procedure		17
5.1 General principles.....		17
5.2 Determining the wheel and rail profiles		18
5.2.1 Principles of measurement.....		18
5.2.2 Accuracy of the measuring system		18
5.3 Determining the rolling radius difference function Δr		18
5.4 Determining the equivalent conicity		19
6 Benchmark calculation		19
6.1 Overview.....		19
6.2 Validation of evaluation method		19
Annex A (informative) Example of presentation of Δr function and conicity.....		21
Annex B (informative) Example of method for determining the equivalent conicity by integration of the nonlinear differential equation		22
B.1 Principle.....		22
B.2 Steps of the procedure.....		25
B.3 Special cases		26
Annex C (informative) Example of method for determining the equivalent conicity by linear regression of the Δr function		28
C.1 Principles.....		28
C.2 Steps of the procedure.....		28
C.3 Particularities		28
Annex D (normative) Reference profiles.....		29
D.1 Wheel A.....		29
D.1.1 Drawing.....		29
D.1.2 Analytic definition.....		29
D.1.3 Cartesian coordinates		30
D.2 Wheel B.....		31
D.2.1 Drawing.....		31
D.2.2 Analytic definition.....		31
D.2.3 Cartesian coordinates		32
D.3 Wheel H.....		33
D.3.1 Drawing.....		33
D.3.2 Analytic definition.....		33
D.3.3 Cartesian coordinates		34
D.4 Wheel I		35
D.4.1 Drawing.....		35
D.4.2 Analytic definition.....		35

D.4.3	Cartesian coordinates.....	36
D.5	Rail A.....	37
D.5.1	Drawing.....	37
D.5.2	Analytic definition	37
D.5.3	Cartesian coordinates.....	38
Annex E	(normative) Calculation results with reference profiles	39
E.1	Wheel A / Rail A	40
E.1.1	Diagram of Δr , $\tan \gamma_a$, $\tan \gamma_c$ functions and representation of contact points	40
E.1.2	Representation of the curves of kinematic rolling movement of the wheelset on track	41
E.1.3	Numerical values for Δr function	42
E.1.4	Numerical values for $\tan \gamma_c$ function	43
E.2	Wheel B / Rail A	44
E.2.1	Diagram Δr , $\tan \gamma_a$, $\tan \gamma_c$ functions and representation of contact points	44
E.2.2	Representation of the curves of kinematic rolling movement of the wheelset on track	45
E.2.3	Numerical values for Δr function	46
E.2.4	Numerical values for $\tan \gamma_c$ function	47
E.3	Wheel H / Rail A	48
E.3.1	Diagram of Δr , $\tan \gamma_a$, $\tan \gamma_c$ functions and representation of contact points	48
E.3.2	Representation of the curves of kinematic rolling movement of the wheelset on track	49
E.3.3	Numerical values for Δr function	50
E.3.4	Numerical values for $\tan \gamma_c$ function	51
E.4	Wheel I / Rail A.....	52
E.4.1	Diagram of Δr , $\tan \gamma_a$, $\tan \gamma_c$ functions and representation of contact points.....	52
E.4.2	Representation of the curves of kinematic rolling movement of the wheelset on track	53
E.4.3	Numerical values for Δr function	54
E.4.4	Numerical values for $\tan \gamma_c$ function	55
E.5	Modified Wheel A (-2 mm on left wheel diameter) / Rail A	56
E.5.1	Diagram of Δr , $\tan \gamma_a$, $\tan \gamma_c$ functions and representation of contact points.....	56
E.5.2	Representation of the curves of kinematic rolling movement of the wheelset on track	57
E.5.3	Numerical values for Δr function	58
E.5.4	Numerical values for $\tan \gamma_c$ function	59
E.6	Modified Wheel B (-2 mm on left wheel diameter) / Rail A	60
E.6.1	Diagram of Δr , $\tan \gamma_a$, $\tan \gamma_c$ functions and representation of contact points.....	60
E.6.2	Representation of the curves of kinematic rolling movement of the wheelset on track	61
E.6.3	Numerical values for Δr function	62
E.6.4	Numerical values for $\tan \gamma_c$ function	63
E.7	Modified Wheel H (-2 mm on left wheel diameter) / Rail A	64
E.7.1	Diagram of Δr , $\tan \gamma_a$, $\tan \gamma_c$ functions and representation of contact points.....	64
E.7.2	Representation of the curves of kinematic rolling movement of the wheelset on track	65
E.7.3	Numerical values for Δr function	66
E.7.4	Numerical values for $\tan \gamma_c$ function	67
E.8	Modified Wheel I (-2 mm on left wheel diameter) / Rail A.....	67
E.8.1	Diagram of Δr , $\tan \gamma_a$, $\tan \gamma_c$ functions and representation of contact points.....	67
E.8.2	Representation of the curves of kinematic rolling movement of the wheelset on track	69
E.8.3	Numerical values for Δr function	70
E.8.4	Numerical values for $\tan \gamma_c$ function	71
E.9	(Right Wheel A – Left Wheel B) / Rail A.....	72
E.9.1	Diagram of Δr , $\tan \gamma_a$, $\tan \gamma_c$ functions and representation of contact points.....	72
E.9.2	Representation of the curves of kinematic rolling movement of the wheelset on track	73
E.9.3	Numerical values for Δr function	74
E.9.4	Numerical values for $\tan \gamma_c$ function	75
Annex F	(normative) Tolerances on equivalent conicity	76
F.1	Wheel A / Rail A	77

F.1.1	Diagram.....	77
F.1.2	Numerical values	78
F.2	Wheel B / Rail A.....	80
F.2.1	Diagram.....	80
F.2.2	Numerical values	81
F.3	Wheel H / Rail A.....	83
F.3.1	Diagram.....	83
F.3.2	Numerical values	84
F.4	Wheel I / Rail A.....	86
F.4.1	Diagram.....	86
F.4.2	Numerical values	87
F.5	Modified Wheel A (-2 mm on left wheel diameter) / Rail A	89
F.5.1	Diagram.....	89
F.5.2	Numerical values	90
F.6	Modified Wheel B (-2 mm on left wheel diameter) / Rail A	92
F.6.1	Diagram.....	92
F.6.2	Numerical values	93
F.7	Modified Wheel H (-2 mm on left wheel diameter) / Rail A	95
F.7.1	Diagram.....	95
F.7.2	Numerical values	96
F.8	Modified Wheel I (-2 mm on left wheel diameter) / Rail A	98
F.8.1	Diagram.....	98
F.8.2	Numerical values	99
F.9	(Right Wheel A – Left Wheel B) / Rail A.....	101
F.9.1	Diagram.....	101
F.9.2	Numerical values	102
Annex G	(informative) Examples of calculation results with introduced errors.....	104
G.1	Wheel A / Rail A – Random error in mm.....	104
G.2	Wheel A / Rail A — Random error in mm	105
G.3	Wheel A / Rail A — Random error in mm	106
G.4	Wheel A / Rail A — Grid error in mm	107
G.5	Wheel A / Rail A — Grid error in mm	108
G.6	Wheel A / Rail A — Grid error in mm	109
G.7	Wheel H / Rail A — Random error in mm	110
Annex H	(informative) Guideline for application of errors	111
H.1	Grid error	111
H.2	Random error	114
Annex I	(informative) Guidelines for application	117
Annex ZA	(informative) Δ_1 Relationship between this European Standard and the Essential Requirements of EU Directive 2008/57/EC of the European Parliament and of the Council of 17 June 2008 on the interoperability of the rail system within the Community (Recast) Δ_1	119
Bibliography	124

Figures

Figure 1	— Benchmark process, Step 1	11
Figure 2	— Benchmark process, Step 2.....	11
Figure 3	— Benchmark process, Step 3.....	12
Figure 4	— Dimensions on the wheelset.....	15
Figure 5	— $y = f(x)$ function.....	16
Figure A.1	— $\Delta r = f(y)$ function and $\tan \gamma_c = f(y)$	21

Figure B.1 — Representation of dx, dy	22
Figure B.2 — Representation of $ds, d\Psi$	22
Figure B.3 — Representation of r_1, r_2, e	23
Figure B.4 — $\Delta r = f(y)$ characteristic with negative slope.....	26
Figure B.5 — Calculation of $\int \Delta r dy$ integral	26
Figure B.6 — Determination of y_{em} , calculation of $\int \Delta r dy$ and determination of \hat{y}	27
Figure B.7 — Determination of $y_{emin} = f(\hat{y})$ and $y_{emax} = f(\hat{y})$ functions.....	27
Figure B.8 — Determination of C constant	27
Figure D.1 — Wheel A	29
Figure D.2 — Wheel B	31
Figure D.3 — Wheel H	33
Figure D.4 — Wheel I.....	35
Figure D.5 — Rail A	37
Figure E.1a — Diagram of $\Delta r, \tan \gamma_a, \tan \gamma_e$ functions and representation of contact points — Wheel A / Rail A.....	40
Figure E.1b — Representation of the curves of kinematic rolling movement of the wheelset on track — Wheel A / Rail A.....	41
Figure E.2a — Diagram $\Delta r, \tan \gamma_a, \tan \gamma_e$ functions and representation of contact points — Wheel B / Rail A.....	44
Figure E.2b — Representation of the curves of kinematic rolling movement of the wheelset on track — Wheel B / Rail A.....	45
Figure E.3a — Diagram of $\Delta r, \tan \gamma_a, \tan \gamma_e$ functions and representation of contact points — Wheel H / Rail A	48
Figure E.3b — Representation of the curves of kinematic rolling movement of the wheelset on track — Wheel H / Rail A.....	49
Figure E.4a — Diagram of $\Delta r, \tan \gamma_a, \tan \gamma_e$ functions and representation of contact points — Wheel I / Rail A.....	52
Figure E.4b — Representation of the curves of kinematic rolling movement of the wheelset on track — Wheel I / Rail A.....	53
Figure E.5a — Diagram of $\Delta r, \tan \gamma_a, \tan \gamma_e$ functions and representation of contact points — Modified Wheel A / Rail A	56
Figure E.5b — Representation of the curves of kinematic rolling movement of the wheelset on track — Modified Wheel A / Rail A.....	57
Figure E.6a — Diagram of $\Delta r, \tan \gamma_a, \tan \gamma_e$ functions and representation of contact points — Modified Wheel B / Rail A	60
Figure E.6b — Representation of the curves of kinematic rolling movement of the wheelset on track — Modified Wheel B / Rail A.....	61
Figure E.7a — Diagram of $\Delta r, \tan \gamma_a, \tan \gamma_e$ functions and representation of contact points — Modified Wheel H / Rail A	64
Figure E.7b — Representation of the curves of kinematic rolling movement of the wheelset on track — Modified Wheel H / Rail A.....	65

Figure E.8a — Diagram of Δr , $\tan \gamma_a$, $\tan \gamma_c$ functions and representation of contact points — Modified Wheel I / Rail A	68
Figure E.8b — Representation of the curves of kinematic rolling movement of the wheelset on track — Modified Wheel I / Rail A	69
Figure E.9a — Diagram of Δr , $\tan \gamma_a$, $\tan \gamma_c$ functions and representation of contact points — (Right Wheel A – Left Wheel B) / Rail A	72
Figure E.9b — Representation of the curves of kinematic rolling movement of the wheelset on track — (Right Wheel A – Left Wheel B) / Rail A	73
Figure F.1 — Diagram Wheel A / Rail A	77
Figure F.2 — Diagram Wheel B / Rail A	80
Figure F.3 — Diagram Wheel H / Rail A	83
Figure F.4 — Diagram Wheel I / Rail A	86
Figure F.5 — Diagram modified Wheel A / Rail A	89
Figure F.6 — Diagram modified Wheel B / Rail A	92
Figure F.7 — Diagram modified Wheel H / Rail A	95
Figure F.8 — Diagram modified Wheel I / Rail A	98
Figure F.9 — Diagram (Right Wheel A — Left Wheel B) / Rail A	101
Figure G.1 — Wheel A / Rail A — Random error in mm	104
Figure G.2 — Wheel A / Rail A — Random error in mm	105
Figure G.3 — Wheel A / Rail A — Random error in mm	106
Figure G.4 — Wheel A / Rail A — Grid error in mm	107
Figure G.5 — Wheel A / Rail A — Grid error in mm	108
Figure G.6 — Wheel A / Rail A — Grid error in mm	109
Figure G.7 — Wheel H / Rail A — Random error in mm	110
Figure H.1 — Transformation of the point $P(x, y)$ to grid with grid widths Δy , Δz	111
Figure H.2 — Grid transformation with grid widths of 0,5 mm	112
Figure H.3 — Variation of the grid origin	112
Figure H.4 — 50 variants of grid origins	114
Figure H.5 — Random error of measuring points	116

Tables

Table D.1 — Wheel profile: R-UIC 519-A — Right wheel	30
Table D.2 — Wheel profile: R-UIC 519-B — Right wheel	32
Table D.3 — Wheel profile: R-UIC 519-H — Right wheel	34
Table D.4 — Wheel profile: R-UIC 519-I — Right wheel	36
Table D.5 — Rail profile: S-UIC 519-A — Right rail	38
Table E.1a — Contact geometry wheel / rail: $\Delta r = f(y)$ — Wheel profile: R-UIC 519-A — Rail Profile: S-UIC 519-A	42
Table E.1b — Contact geometry wheel / rail: Conicity — Wheel profile: R-UIC 519-A — Rail profile: S-UIC 519-A	43

Table E.2a — Contact geometry wheel / rail: $\Delta r = f(y)$ — Wheel profile: R-UIC 519-B — Rail profile: S-UIC 519-A	46
Table E.2b — Contact geometry wheel / rail: Conicity — Wheel profile: R-UIC 519-B — Rail profile: S-UIC 519-A	47
Table E.3a — Contact geometry wheel / rail: $\Delta r = f(y)$ — Wheel profile: R-UIC 519-H — Rail profile: S-UIC 519-A	50
Table E.3b — Contact geometry wheel / rail: Conicity — Wheel profile: R-UIC 519-H — Rail profile: S-UIC 519-A	51
Table E.4a — Contact geometry wheel / rail: $\Delta r = f(y)$ — Wheel profile: R-UIC 519-I — Rail profile: S-UIC 519-A	54
Table E.4b — Contact geometry wheel / rail: Conicity — Wheel profile: R-UIC 519-I — Rail profile: S-UIC 519-A	55
Table E.5a — Contact geometry wheel / rail: $\Delta r = f(y)$ — Diameter difference of 2 mm — Wheel profile: R-UIC 519-A — Rail profile: S-UIC 519-A	58
Table E.5b — Contact geometry wheel / rail: Conicity — Diameter difference of 2 mm — Wheel profile: R-UIC 519-A — Rail profile: S-UIC 519-A	59
Table E.6a — Contact geometry wheel / rail: $\Delta r = f(y)$ — Diameter difference of 2 mm — Wheel profile: R-UIC 519-B — Rail profile: S-UIC 519-A	62
Table E.6b — Contact geometry wheel / rail: Conicity — Diameter difference of 2 mm — Wheel profile: R-UIC 519-B — Rail profile: S-UIC 519-A	63
Table E.7a — Contact geometry wheel / rail: $\Delta r = f(y)$ — Diameter difference of 2 mm — Wheel profile: R-UIC 519-H — Rail profile: S-UIC 519-A	66
Table E.7b — Contact geometry wheel / rail: Conicity — Diameter difference of 2 mm — Wheel profile: R-UIC 519-H — Rail profile: S-UIC 519-A	67
Table E.8a — Contact geometry wheel / rail: $\Delta r = f(y)$ — Diameter difference of 2 mm — Wheel profile: R-UIC 519-I — Rail profile: S-UIC 519-A	70
Table E.8b — Contact geometry wheel / rail: Conicity — Diameter difference of 2 mm — Wheel profile: R-UIC 519-I — Rail profile: S-UIC 519-A	71
Table E.9a — Contact geometry wheel / rail: $\Delta r = f(y)$ — Wheel profile: right wheel R-UIC519-A / left wheel R-UIC 519-B — Rail profile: S-UIC 519-A	74
Table E.9b — Contact geometry wheel / rail: Conicity — Wheel profile: right wheel R-UIC 519-A / left wheel R-UIC 519-B — Rail profile: S-UIC 519-A	75
Table F.1 — Benchmark calculations: Tolerances — Wheel profile: R-UIC 519-A — Rail profile: S-UIC 519-A	78
Table F.2 — Benchmark calculations: Tolerances — Wheel profile: R-UIC 519-B — Rail profile: S-UIC 519-A	81
Table F.3 — Benchmark calculations: Tolerances — Wheel profile: R-UIC 519-H — Rail profile: S-UIC 519-A	84
Table F.4 — Benchmark calculations: Tolerances — Wheel profile: R-UIC 519-I — Wheel profile: S-UIC 519-A	87
Table F.5 — Benchmark calculations: Tolerances — Wheel profile: R-UIC 519-A — Diameter difference of 2 mm — Rail profile: S-UIC 519-A	90
Table F.6 — Benchmark calculations: Tolerances — Wheel profile: R-UIC 519-B — Diameter difference of 2 mm — Rail profile: S-UIC 519-A	93
Table F.7 — Benchmark calculations: Tolerances — Wheel profile: R-UIC 519-H — Diameter difference of 2 mm — Rail profile: S-UIC 519-A	96

Table F.8 — Benchmark calculations: Tolerances — Wheel profile: R-UIC 519-I — Diameter difference of 2 mm — Rail profile: S-UIC 519-A.....	99
Table F.9 — Benchmark calculations: Tolerances — Wheel profile: right wheel R-UIC 519-A / left wheel R-UIC 519-B — Rail profile: S-UIC 519-A.....	102
Table I.1 — Combinations of profiles and their applications	118
Table ZA.1 — Correspondence between this European Standard, the HS TSI RST published in the OJEU dated 26 March 2008 and Directive 2008/57/EC	120
Table ZA.2 — Correspondence between this European standard, the HS TSI INF, published in OJEU dated 19 March 2008, and Directive 2008/57/EC	121
Table ZA.3 — Correspondence between this European Standard, the CR LOC and PASS RST TSI (final draft Rev 4.0 dated 24 November 2009) and Directive 2008/57/EC	122