

DIN EN 14067-6:2010-05 (E)

Railway applications - Aerodynamics - Part 6: Requirements and test procedures for cross wind assessment

Contents

Page

Foreword.....	7
Introduction	8
1 Scope	9
2 Normative references	9
3 Terms and definitions	9
4 Symbols and abbreviations	9
5 Methods to assess cross wind stability of vehicles	13
5.1 General.....	13
5.2 Applicability of cross wind methodologies for rolling stock assessment purposes	13
5.3 Determination of aerodynamic coefficients	14
5.3.1 General.....	14
5.3.2 Predictive equations.....	14
5.3.3 Simulations by Computational Fluid Dynamics (CFD)	16
5.3.4 Reduced-scale wind tunnel measurements	18
5.4 Determination of wheel unloading.....	23
5.4.1 General.....	23
5.4.2 Simple method using a two-dimensional vehicle model (three mass model).....	23
5.4.3 Advanced quasi-static method.....	26
5.4.4 Time-dependent MBS method using a Chinese hat wind scenario.....	29
5.5 Presentation form of characteristic wind curves (CWC)	37
5.5.1 General.....	37
5.5.2 CWC presentation form for passenger vehicles and locomotives.....	37
5.5.3 CWC presentation form for freight wagons	39
6 Method to acquire the needed railway line data.....	40
6.1 General.....	40
6.2 Presentation form of railway line data.....	40
6.2.1 General.....	40
6.2.2 Plan profile	40
6.2.3 Vertical profile	41
6.2.4 Track design speed	42
6.2.5 Walls.....	43
6.2.6 Meteorological input data for line description.....	43
6.2.7 Integrated line database.....	44
6.2.8 Required minimum resolution/accuracy	46
7 Methods to assess the wind exposure of a railway line	46
8 Methods to analyse and assess the cross wind risk	46
9 Required documentation	47
9.1 General.....	47
9.2 Assessment of cross wind stability of passenger vehicles and locomotives	47
9.3 Assessment of cross wind stability of freight vehicles.....	47
9.4 Acquisition of railway line data	48
Annex A (informative) Application of methods to assess cross wind stability of vehicles within Europe.....	49
Annex B (informative) Blockage correction	53
Annex C (normative) Wind tunnel benchmark test data for standard ground configuration	55

Annex D (informative) Other ground configurations for wind tunnel testing	59
Annex E (informative) Wind tunnel benchmark test data for other ground configurations	63
Annex F (informative) Embankment overspeed effect	76
Annex G (informative) Atmospheric boundary layer wind tunnel testing	77
Annex H (informative) Five mass model	83
Annex I (normative) Mathematical model for the Chinese hat	98
Annex J (informative) Stochastic wind model	105
Annex K (informative) Stability of passenger vehicles and locomotives against overturning at standstill according to national guidelines	113
Annex L (informative) Information on methods to assess the wind exposure of a railway line	116
Annex M (informative) Migration rule for this European Standard	119
Annex ZA (informative) Relationship between this European Standard and the Essential Requirements of EU Directive 2008/57/EC	120
Bibliography	124

Figures

Figure 1 — Sketch of the wind tunnel configuration single track ballast (front view, 1:1 scale)	22
Figure 2 — Sketch of the wind tunnel configuration single track ballast (side and top view, 1:1 scale)	22
Figure 3 — Illustration of three mass model	24
Figure 4 — Illustration of contact point	28
Figure 5 — Example of the spatial distribution of the wind using a Chinese hat gust model	30
Figure 6 — Illustration of wind decay within Chinese hat gust model	32
Figure 7 — Application of Chinese hat wind scenario: Example of temporal wind distribution for $v_{tr} = 200$ km/h, $v_W = 30$ m/s, vehicle length = 24 m	33
Figure 8 — Illustration of geometric approach considering the angle of attack	36
Figure 9 — Illustration of geometric approach considering the angle of attack of CWC on straight track	37
Figure C.1 — Contour of a wind tunnel model of the ICE 3 endcar	55
Figure C.2 — Contour of a wind tunnel model of the TGV Duplex powercar	57
Figure C.3 — Contour of a wind tunnel model of the ETR 500 powercar	58
Figure D.1 — Sketch of the wind tunnel configuration flat ground with 235 mm gap	59
Figure D.2 — Sketch of ballast geometry	60
Figure D.3 — Sketch of the embankment geometry	60
Figure D.4 — Sketch of the wind tunnel configuration flat ground without gap	61
Figure D.5 — Ballast and rail configuration for uncanted track in Great Britain	62
Figure D.6 — Saw tooth canted ballast and rail in Great Britain	62
Figure F.1 — Illustration of embankment overspeed effect	76
Figure G.1 — Upper and lower limits for mean velocity profiles	78
Figure H.1 — Illustration of five mass model	84

Figure I.1 — Coordinate system.....	98
Figure I.2 — Dependency of f on U_{mean} and U_{max}	100
Figure J.1 — Flow chart of the methodology.....	106
Figure J.2 — Parameters C and m as a function of z_0 for the calculation of x_{L_u} (Couninhan expression).....	108

Tables

Table 1 — Symbols	9
Table 2 — Application of cross wind methodologies for rolling stock assessment	14
Table 3 — Parameter set for the standard ground configuration (standard gauge)	15
Table 4 — Method factor f_m for UIC standard gauge (1 435 mm) for various vehicle types	24
Table 5 — Functions for the Chinese hat gust model.....	34
Table 6 — Form for CWC table for passenger vehicles and locomotives in non-tilting mode.....	38
Table 7 — Form for CWC table for trains in active tilting mode	38
Table 8 — Form for CWC table for freight wagons	39
Table 9 — Layout for plan profile parameters	41
Table 10 — Layout for vertical profile parameters	42
Table 11 — Layout for track design speed.....	42
Table 12 — Layout for wall	43
Table 13 — Layout for line database: meteorological part.....	44
Table 14 — Layout for integrated line database.....	45
Table 15 — Required minimum resolution/accuracy	46
Table A.1 — Application of methodological elements for rolling stock assessment purpose within Europe (aerodynamic assessment)	49
Table A.2 — Application of methodological elements for rolling stock assessment purpose within Europe (vehicle dynamic assessment)	51
Table C.1 — Reference data for aerodynamic coefficients of the ICE 3 endcar model for the ground configuration "single track with ballast and rail" according to 5.3.4.11	56
Table C.2 — Reference data for aerodynamic coefficients of the TGV Duplex powercar model for the ground configuration "single track with ballast and rail" according to 5.3.4.11	57
Table C.3 — Reference data for aerodynamic coefficients of the ETR 500 powercar model for the ground configuration "single track with ballast and rail" according to 5.3.4.11	58
Table E.1 — Benchmark data for aerodynamic coefficients of ICE 3 endcar on flat ground with gap, measured by DB AG on a 1:7-scale model at 80 m/s in DNW wind tunnel	63
Table E.2 — Benchmark data for aerodynamic coefficients of ICE 3 endcar on the windward side on the double track ballast and rail, measured by CSTB on a 1:15-scale model at 50 m/s in CSTB wind tunnel	64
Table E.3 — Benchmark data for aerodynamic coefficients of ICE 3 endcar on the leeward side on the double track ballast and rail, measured by CSTB on a 1:15-scale model at 50 m/s in CSTB wind tunnel	65

Table E.4 — Benchmark data for aerodynamic coefficients of ICE 3 endcar on the windward side of standard embankment of 6 m height, measured by CSTB on a 1:15-scale model at 50 m/s in CSTB wind tunnel	66
Table E.5 — Benchmark data for aerodynamic coefficients of ICE 3 endcar on the leeward side of the standard embankment of 6 m height, measured by CSTB on a 1:15-scale model at 50 m/s in CSTB wind tunnel	67
Table E.6 — Benchmark data for aerodynamic coefficients of TGV Duplex powercar on flat ground with gap, measured by DB AG on a 1:7-scale model at 80 m/s in DNW wind tunnel	68
Table E.7 — Benchmark data for aerodynamic coefficients of TGV Duplex powercar on the windward side on the double track ballast and rail, measured by CSTB on a 1:15-scale model at 25 m/s in CSTB wind tunnel	69
Table E.8 — Benchmark data for aerodynamic coefficients of TGV Duplex powercar on the leeward side on the double track ballast and rail, measured by CSTB on a 1:15-scale model at 25 m/s in CSTB wind tunnel	70
Table E.9 — Benchmark data for aerodynamic coefficients of TGV Duplex powercar on the windward side of the standard embankment of 6 m height, measured by CSTB on a 1:25-scale model at 40 m/s in CSTB wind tunnel	71
Table E.10 — Benchmark data for aerodynamic coefficients of TGV Duplex powercar on the leeward side of the standard embankment of 6 m height, measured by CSTB on a 1:25-scale model at 40 m/s in CSTB wind tunnel	72
Table E.11 — Benchmark data for aerodynamic coefficients of ETR 500 powercar on flat ground with gap, measured by Politecnico di Milano on a 1:10 -scale model at 12 m/s in MPWT wind tunnel.....	73
Table E.12 — Benchmark data for aerodynamic coefficients of ETR 500 powercar on the windward side of the standard embankment of 6 m height, measured by Politecnico di Milano on a 1:10-scale model at 12 m/s in MPWT wind tunnel.....	74
Table E.13 — Benchmark data for aerodynamic coefficients of ETR 500 powercar on the leeward side of the standard embankment of 6 m height, measured by Politecnico di Milano on a 1:10 -scale model at 12 m/s in MPWT wind tunnel.....	75
Table H.1 — Body parameters.....	90
Table H.2 — Secondary suspension parameters	90
Table H.3 — Primary suspension parameters	91
Table H.4 — General parameters	91
Table H.5 — Aerodynamic coefficients	91
Table H.6 — Resulting CWC for example vehicle 1: v_{CWC} in [m/s] depending on the vehicle speed and the unbalanced lateral acceleration a_q at a yaw angle of $\beta_W = 90^\circ$	92
Table H.7 — Resulting CWC for example vehicle 1: v_{CWC} in [m/s] depending on yaw angle β_W and the unbalanced lateral acceleration a_q at $v_{max} = 160$ km/h	93
Table H.8 — Body parameters.....	94
Table H.9 — Secondary suspension parameters	94
Table H.10 — Primary suspension parameters	95
Table H.11 — General parameters	95
Table H.12 — Aerodynamic coefficients	95
Table H.13 — Resulting CWC for example vehicle 2: v_{CWC} in [m/s] depending on the vehicle speed and the unbalanced lateral acceleration a_q at a yaw angle of $\beta_W = 90^\circ$	96

Table H.14 — Resulting CWC for example vehicle 2: v_{CWC} in [m/s] depending on the yaw angle β_W and the unbalanced lateral acceleration a_q at $v_{max} = 200$ km/h	97
Table I.1 — Calculation example for Chinese hat gust scenario with $U_{max} = 30,0$ m/s, $v_{tr} = 200$ km/h, vehicle length = 24 m	102
Table ZA.1 – Correspondence between this European standard, the HS TSI RST, published in the Official Journal on 26 March 2008, and Directive 2008/57/EC	120
Table ZA.2 – Correspondence between this European standard, the HS TSI INS, published in the Official Journal on 19 March 2008, and Directive 2008/57/EC	121
Table ZA.3 – Correspondence between this European Standard, the CR TSI RST Freight Wagon dated July 2006 and its intermediate revision approved by the Railway Interoperability and Safety Committee on 26 November 2008 and Directive 2008/57/EC	122
Table ZA.4 – Correspondence between this European standard, the CR TSI INF (Final draft Version 3.0 dated 2008.12.12), and Directive 2008/57/EC	122
Table ZA.5 – Correspondence between this European standard, the CR TSI Locomotive and Passenger Rolling Stocks (Preliminary draft Rve 2.0 dated 14 November 2008) and Directive 2008/57/EC	123