

DIN EN 14067-6:2022-09 (E)

Railway applications - Aerodynamics - Part 6: Requirements and test procedures for cross wind assessment (includes Amendment A1:2022)

Contents		Page
European foreword		6
Introduction		7
1	Scope	8
2	Normative references	8
3	Terms and definitions	8
4	Symbols and abbreviations	9
5	Methods and requirements to assess cross wind stability of vehicles	22
5.1	General	22
5.2	Applicability of cross wind methodologies for rolling stock assessment purposes	23
5.3	Determination of aerodynamic coefficients	25
5.3.1	General	25
5.3.2	Predictive formula	25
5.3.3	Simulations by Computational Fluid Dynamics (CFD)	26
5.3.4	Reduced-scale wind tunnel measurements	29
5.4	Determination of wheel unloading due to cross winds	34
5.4.1	General	34
5.4.2	Simple method	34
5.4.3	Advanced quasi-static method	37
5.4.4	Time-dependent MBS method using a Chinese hat wind scenario	40
5.5	Presentation form of characteristic wind curves (CWCs)	47
5.5.1	General	47
5.5.2	CWC presentation form for passenger vehicles and locomotives	48
5.5.3	CWC presentation form for freight wagons	49
5.6	Requirements	50
5.6.1	Requirements for passenger vehicles and locomotives running at 250 km/h $v_{max} < 360$ km/h	50
5.6.2	Requirements for passenger vehicles and locomotives running 140 km/h $< v_{max} < 250$ km/h	53
5.6.3	Requirements for freight wagons	53
6	Method to acquire the needed railway line data	54
6.1	General	54
6.2	Presentation form of railway line data	54
6.2.1	General	54
6.2.2	Plan profile	54
6.2.3	Vertical profile	55
6.2.4	Track design speed	56
6.2.5	Walls	57
6.2.6	Meteorological input data for line description	57
6.2.7	Integrated line database	58
6.2.8	Required minimum resolution/accuracy	60
7	Methods to assess the wind exposure of a railway line	60
8	Guidance for the analysis and assessment of the cross wind risk	61

8.1	General	61
8.2	Infrastructure with train speeds at or above 250 km/h	61
8.3	Infrastructure with train speeds below 250 km/h	61
9	Required documentation	62
9.1	General	62
9.2	Assessment of cross wind stability of passenger vehicles and locomotives	62
9.3	Assessment of cross wind stability of freight vehicles	62
9.4	Acquisition of railway line data	62
Annex A (informative) Application of methods to assess cross wind stability of vehicles within Europe		63
Annex B (informative) Blockage correction		67
B.1	Dynamic pressure method	67
B.2	German method	67
B.3	UK method	67
B.4	Slotted walls	68
Annex C (normative) Wind tunnel benchmark test data for standard ground configuration		69
C.1	General	69
C.2	ICE 3 leading vehicle wind tunnel model	69
C.3	TGV Duplex power car wind tunnel model	70
C.4	ETR 500 power car wind tunnel model	71
Annex D (informative) Other ground configurations for wind tunnel testing		73
D.1	Flat ground with gap (TSI HS RST)	73
D.2	Double track ballast and rails (TSI HS RST)	73
D.3	Standard embankment of 6 m height (TSI HS RST)	74
D.4	Flat ground without gap (Finnish method)	75
D.5	Double track ballast and rails (UK method)	75
Annex E (informative) Wind tunnel benchmark test data for other ground configurations		77
E.1	General	77
E.2	ICE 3 leading vehicle wind tunnel model	77
E.3	TGV Duplex power car wind tunnel model	81
E.4	ETR 500 power car wind tunnel model	86
Annex F (informative) Embankment overspeed effect		90
Annex G (informative) Atmospheric boundary layer wind tunnel testing		91
G.1	General	91
G.2	Benchmark tests	91
G.3	Wind simulation	92
G.3.1	Boundary layer profiles	92
G.3.2	Turbulence intensities	92
G.3.3	Turbulence integral length scale	93
G.4	Model scale and blockage requirements	93
G.5	Modelling accuracy	93
G.6	Instrumentation requirements	93
G.6.1	General	93
G.6.2	Speed measurement	93
G.6.3	Force and moment balance	94
G.7	Data acquisition requirements	94
G.7.1	General	94
G.7.2	Time scale, sampling frequency and acquisition duration	94
G.7.3	Measurement of temperature and atmospheric pressure	95

G.8	Calculation of mean values	95
G.9	Calculation of peak values	95
G.10	Calculation of air density	96
G.11	Calculation of the uncorrected rolling moment coefficient	96
G.12	Determination of the lee rail roll moment coefficient	97
G.13	Data interpolation	97
Annex H (informative) Five mass model		98
H.1	General	98
H.2	Derivation of formulae	100
H.3	Example calculations	104
H.3.1	General	104
H.3.2	Example vehicle 1	105
H.3.3	Example vehicle 2	108
Annex I (normative) Mathematical model for the Chinese hat		113
I.1	Mathematical model for Chinese hat	113
I.2	Example calculation for Chinese hat	116
Annex J (informative) Stochastic wind model		122
J.1	General	122
J.2	Assumptions	122
J.3	Application range	122
J.4	General Approach	122
J.4.1	General	122
J.4.2	First step: wind tunnel tests (aerodynamic properties determination)	123
J.4.3	Second step: calculation of turbulent wind speed	123
J.4.4	Third step: evaluation of aerodynamic forces	127
J.4.5	Fourth step: simulation of vehicle dynamics	128
J.4.6	Fifth step: evaluation of characteristic wind speed	128
Annex K (informative) Stability of passenger vehicles and locomotives against overturning according to national guidelines		130
K.1	General	130
K.2	According to DB Guideline 80704 (Germany)	130
K.3	According to Railway Group Standard GM/RT 2141 (Great Britain)	132
Annex L (informative) Information on methods to assess the wind exposure of a railway line		133
L.1	General	133
L.2	Wind map approaches	133
L.3	Transfer approaches	134
Annex M (informative) Extended CWCs		136
Bibliography		139