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

Bahnanwendungen - Aerodynamik - Teil 6: Anforderungen und Prüfverfahren zur Bewertung von Seitenwind

Applications ferroviaires - Aérodynamique - Partie 6 : Exigences et procédures d'essai pour l'évaluation de la stabilité vis-a-vis des vents traversiers

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Exigences et procédures d'essai pour l'évaluation de la
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Bahnanwendungen - Aerodynamik - Teil 6: Anforderungen
und Prüfverfahren für die Bewertung von Seitenwind

This European Standard was approved by CEN on 24 October 2009.

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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

EN 14067-6:2010 (E)

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

EN 14067-6:2010 (E)

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

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Foreword

This document (EN 14067-6:2010) 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 July 2010, and conflicting national standards shall be withdrawn at the latest by July 2010.

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

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

This European Standard is part of the series "Railway applications – Aerodynamics" which consists of the following parts:

- Part 1: Symbols and units
- Part 2: Aerodynamics on open track
- Part 3: Aerodynamics in tunnels
- Part 4: Requirements and test procedures for aerodynamics on open track
- Part 5: Requirements and test procedures for aerodynamics in tunnels
- Part 6: Requirements and test procedures for cross wind assessment

According to the CEN/CENELEC Internal Regulations, the national standards organizations 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, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

Trains running on open track are exposed to cross winds. The cross wind safety of railway operations depends on vehicle and infrastructure characteristics and operational conditions. Important parameters are:

- aerodynamic characteristics of the vehicle;
- vehicle dynamics (e.g. mass, suspension, bump stops);
- track gauge;
- line characteristics (radius and cant of the track, height of embankments and bridges, walls near the track);
- wind exposure of the line;
- operating speed, mode of operation (conventional, tilting, running direction).

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1 Scope

This European Standard applies to the cross wind assessment of railways taking into consideration the recommendations given in Annex M on the application of the standard (migration rule). The methods presented have been applied to passenger vehicles with a maximum speed up to 360 km/h and to freight vehicles with a maximum speed up to 160 km/h. This European Standard applies to coaches, multiple units, freight wagons, locomotives and power cars.

2 Normative references

The following referenced documents are indispensable for the application 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 14067-1:2003, *Railway applications — Aerodynamics — Part 1: Symbols and units*

EN 14067-2, *Railway applications — Aerodynamics — Part 2: Aerodynamics on open track*

EN 14363, *Railway applications — Testing for the acceptance of running characteristics of railway vehicles — Testing of running behaviour and stationary tests*

EN 15663, *Railway applications — Definition of vehicle reference masses*

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3 Terms and definitions (standards.iteh.ai)

For the purposes of this document, the terms and definitions given in EN 14067-1:2003 and the following apply.

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3.1

lee rail

rail on the lee side of the track

3.2

bias

systematic error affecting an estimate

NOTE In this document, it is expressed as the ratio of a coefficient obtained during benchmark wind tunnel tests to the equivalent coefficient obtained during new wind tunnel tests.

4 Symbols and abbreviations

For the purposes of this document, the symbols given in EN 14067-1:2003 and the following apply.

Table 1 — Symbols

Symbol	Unit	Significance	Explanation or remark
\tilde{A}	-	Normalized gust amplitude	
a_m	s/m	Dispersion	Dispersion determined by extreme value analysis of wind tunnel data

Table 1 (continued)

Symbol	Unit	Significance	Explanation or remark
a_q	m/s ²	Uncompensated lateral acceleration	
A_{xz}	m ²	Reference side area of the model vehicle	The side area of the model vehicle
A_0	m ²	Reference normalisation area	10 m ²
b_A		Lateral contact spacing	
$b_{A,min}$		Minimum lateral contact spacing	
c_{Fi}	-	Non-dimensional force coefficient based on A_0	$c_{Fi} = \frac{2 \cdot F_i}{\rho \cdot v^2 A_0}$, $i = x, y, z$
c_{Mi}	-	Non-dimensional moment coefficient based on A_0 and d_0	$c_{Mi} = \frac{2 \cdot M_i}{\rho \cdot v^2 A_0 d_0}$, $i = x, y, z$
$c_{Mx,lee}$	-	Non-dimensional rolling moment coefficient around leeward rail	
$c_{Mx,lee,bmk}$	-	Benchmark value of rolling moment coefficient around leeward rail	Rolling moment coefficient determined from the benchmark tests
d_0	m	Reference normalisation length	3 m
F	Hz	Frequency	
f_h		Function of the embankment blockage ratio, B_E	
$f_{\Delta Q}$	-	Relative windward wheel unloading factor	0,9
f_m		Method factor	To account for uncertainties in the 3 mass model.
h	m	Vehicle height	
h_{cant}	m	Cant	
h_{VEH}	m	Height of the vehicle from top of rail to roof	
h_{BL}	m	Boundary layer height	
I_i		Turbulence index for the i -wind component	$i = u, v, w$
$I_u(z)$	-	Turbulence intensity	The standard deviation of the wind tunnel velocity at height z divided by the mean velocity at that height
L	m	Vehicle length	
L_{VEH}	m	Length parameter of the vehicle car body	
$^x L_i$	m	Longitudinal integral length scale of the i -wind velocity component along the x direction	$i = u, v, w$

Table 1 (continued)

Symbol	Unit	Significance	Explanation or remark
${}^y L_i$	m	Lateral integral length scale of the <i>i</i> -wind velocity component along the <i>y</i> direction	$i = u, v, w$
${}^x L_u$	m	Turbulence length scale	Longitudinal streamwise velocity turbulence length scale in the core stream
${}^x L_{u_FS}$	m	Full scale turbulence length scale	
M_m	Nm	Restoring moment due to the vehicles masses	
M_{Ia}	Nm	Moment due to uncompensated lateral acceleration	
M_{CoG}	Nm	Moment due to the lateral movement of the centre of gravity of suspended masses	
$M_{x,lee}$	Nm	Rolling moment around leeward rail	
m	kg	Vehicle mass (to be considered for cross wind assessment)	Refers to operational mass in working order according to EN 15663
m_0	kg	Unsprung masses	Refers to operational mass in working order according to EN 15663
m_1	kg	Primary suspended masses	Refers to operational mass in working order according to EN 15663
m_2	kg	Secondary suspended masses	Refers to operational mass in working order according to EN 15663
ΔQ	N	Wheel unloading	
Q_0	N	Average static wheel load	
$\Delta Q/Q_0$	-	Relative wheel unloading	
R_C	m	Radius of curve	
Re_{max}		Maximum Reynolds number	The maximum achievable Reynolds number in a wind tunnel test
S_U	$m^2/s^2/Hz$	Power spectral density	
S_t	-	Model time scale	The ratio of time at model scale to time at full scale
T_{samp}	s	Data acquisition duration	The sampling duration for acquiring data
Tu_x		Turbulence level	$Tu_x = \left(\overline{u'^2} / \bar{u}^2 \right)^{0.5}$

Table 1 (continued)

Symbol	Unit	Significance	Explanation or remark
U_{mean}	m/s	Mean wind speed	Refers to the upwind at 4 m height above ground
U	m/s	Wind (tunnel) velocity	
$U(t)$	m/s	Instantaneous wind (tunnel) velocity	
U_{turb}	m/s	Wind velocity turbulent component along the mean wind direction	
v_a	m/s	Relative wind velocity	
v_{max}	m/s	Maximum train speed	
v_W	m/s	Wind speed	
V_x	m/s	Magnitude of wind speed vector	Refers to the upwind at 4 m height above ground
x_B	%	Blockage ratio at $\beta = 30^\circ$	Total modelled configuration projected side area to the wind tunnel cross section
y_B	m	(Maximum) displacement of the contact point on the wheel in the wheel flange direction	
z	m	Height from the ground	
z_{CoG}	m	Height of the centre of gravity of the total vehicle	
$z_{\text{CoG},0}$	m	Height of the centre of gravity of the unsprung masses	
$z_{\text{CoG},1}$	m	Height of the centre of gravity of the primary suspended masses	
$z_{\text{CoG},2}$	m	Height of the centre of gravity of the secondary suspended masses	
z_0	m	Roughness height	
β	°	Yaw angle	The angle between the vehicle axis and the relative wind acting on the train. In a wind tunnel with stationary train model, it is the angle between the train axis and the wind tunnel axis
$\delta_{99\%}$	m	Boundary layer thickness	z coordinate at which the local velocity equals 99 % of the free stream velocity
ε_{max}		Maximum tolerance target value	
$\varepsilon_{\text{mean}}$		Mean tolerance target value	
ρ_0	kg/m ³	Reference air density	$\rho_0 = 1,225 \text{ kg/m}^3$

5 Methods to assess cross wind stability of vehicles

5.1 General

This clause presents various methods to assess the cross wind stability of railway vehicles.

The basic principle is that the cross wind stability of rolling stock is given by values of characteristic wind speeds that the rolling stock can withstand before exceeding some wheel unloading limit values. When these characteristic wind speeds are listed for varying input parameters such as train speeds, uncompensated lateral accelerations or wind angles of attack, the resulting set of characteristic wind speeds is called the characteristic wind curves (CWC).

The cross wind stability of a train is given by the cross wind stability of the most cross wind sensitive vehicle in the train consist.

It has to be noted that the CWC indicate the cross wind stability of the train related to a characteristic state of the wheel vertical forces; the characteristic wind curves do not indicate an overturning threshold.

For a given train running at a range of speeds, the CWC define the maximum natural wind speed that a train can withstand before a characteristic limit for wheel unloading is exceeded. The criterion that defines the CWC is the average value of wheel unloading, ΔQ , of the most critical running gear. The term "average" means that, in case of bogies, wheel unloading is averaged over the wheel sets of the bogie. For the relative assessment of cross wind stability of vehicles the reference air density ρ_0 is fixed at 1,225 kg/m³. Further, the vehicle mass to be considered is defined as the "operational mass in working order" according to EN 15663.

The assessment of cross wind stability of vehicles separates into evaluations of the aerodynamic characteristics (i.e. the aerodynamic coefficients) and the vehicle dynamic characteristics.

Subclause 5.2 states the applicability of the various methods for the purpose of rolling stock assessment.

Subclause 5.3 provides various methods for the determination of aerodynamic coefficients of passenger and freight vehicles and locomotives.

Subclause 5.4 provides various methods for the determination of wheel unloading.

Subclause 5.5 gives information on the required presentation form of CWC of passenger and freight vehicles and locomotives.

5.2 Applicability of cross wind methodologies for rolling stock assessment purposes

Subclauses 5.3 and 5.4 provide various methods for the assessment of the aerodynamic and vehicle dynamic characteristics. In general, these methods divide into simple and complex methods. The simpler methods are easier to apply, but imply an extra uncertainty supplement because they are tuned to be conservative in comparison to the complex ones.

Table 2 specifies which method shall be applied for rolling stock assessment purposes depending on type of rolling stock and its maximum speed v_{\max} .

If various methods are permitted, the choice of the method depends on the degree of accuracy necessary for the problem. As a general principle, however, it is logical to start with the simplest appropriate procedures and then to shift to more complex methods if necessary.

All vehicles shall be assessed using any of the methods in Table 2.

In case of a fixed train composition it is sufficient to prove the cross wind stability of only the most cross wind sensitive vehicle in the train consist. In other cases, it is necessary to prove the cross wind stability of each vehicle.