SIST

SLOVENSKI STANDARD
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Železniške naprave - Aerodinamika - 6. del: Zahteve in preskusni postopki za oceno vpliva bočnega vetra

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-à-vis des vents traversiers

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45.060.01	Železniška vozila na splošno	Railway rolling stock in general

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

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

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European foreword

This document (EN 14067-6:2018+A1:2022) 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of an identical text or by endorsement, at the latest by January 2023, and conflicting national standards shall be withdrawn at the latest by January 2023.

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

This document includes Amendment 1 approved by CEN on 6 June 2022.

This document supersedes [A1⟩ EN 14067-6:2018 ⟨A1].

The start and finish of text introduced or altered by amendment is indicated in the text by tags [A1⟩ ⟨A1].

This European Standard is part of the series “Railway applications — Aerodynamics” which consists of the following parts:

— *Part 1: Symbols and units*;

— *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*.

Any feedback and questions on this document should be directed to the users’ national standards body. A complete listing of these bodies can be found on the CEN website.

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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 (non-tilting, tilting, running direction).

1 Scope

This document gives guidelines for the cross wind assessment of railways.

This document is applicable to all passenger vehicles, locomotives and power cars (with a maximum train speed above 140 km/h up to 360 km/h) and freight wagons (with a maximum train speed above 80 km/h up to 160 km/h) and track gauges from 1 435 mm to 1 668 mm inclusive. For passenger vehicles, locomotives and power cars with a maximum train speed between 250 km/h and 360 km/h, a requirement to demonstrate the cross wind stability is imposed. This document is not applicable to light rail and urban rail vehicles.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 14067-4, *Railway applications – Aerodynamics – Part 4: Requirements and test procedures for aerodynamics on open track*

EN 14363, *Railway applications - Testing and Simulation for the acceptance of running characteristics of railway vehicles - Running Behaviour and stationary tests*

EN 15663, *Railway applications - Vehicle reference masses*

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:

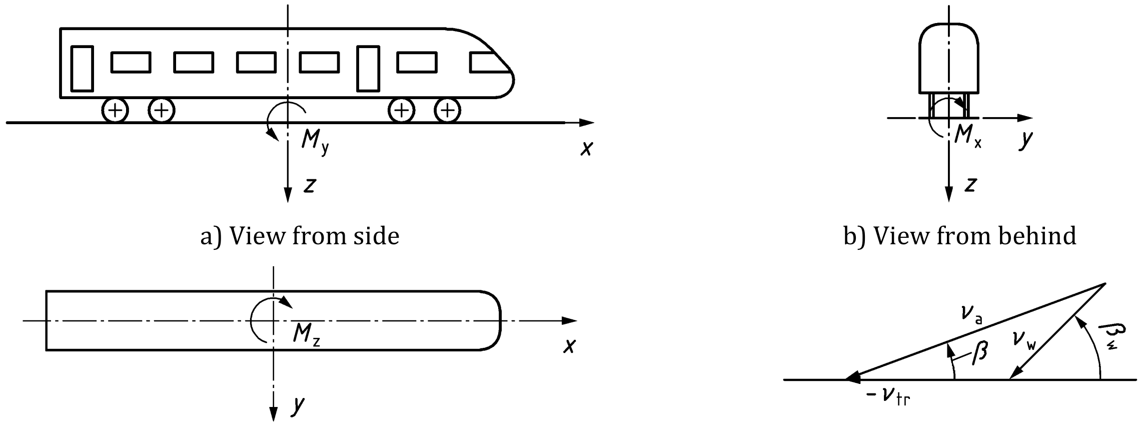
- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
bias
systematic error affecting an estimate

Note 1 to entry: 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.

3.2
coordinate system
system denoting the axis for forces, moments, dimensions and wind speeds as defined in Figure 1

Note 1 to entry: The coordinate system is shown in Figure 1.



a) View from side

b) View from behind

c) View from top

d) Speed vector diagram

Figure 1 — Coordinate system

Note 2 to entry: A positive β means that the apparent wind v_a is coming from the right hand side of the train.

3.3
lee rail
rail on the side of the track that is away from the direction from which the wind is blowing

4 Symbols and abbreviations

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

Table 1 — Symbols and abbreviations

Symbol	Unit	Significance	Explanation or remark
A	m²	Reference area	
A_0	m²	Reference normalization area	10 m²
A^*	-	Constant in formula for σ_u	
$\tilde{A}$	-	Normalized gust amplitude	
$\underline{A}_{ij}$	-	Rotation matrix from B_j to B_i	
a	m	Bogie semi-spacing	
a_{ij}	N	Wheel loads	i = 1, 2: (front, back) j = 1, 2: (right, left)
a_m	s/m	Dispersion	Dispersion determined by extreme value analysis of wind tunnel data
a_q	m/s²	Uncompensated lateral acceleration; also equivalent to cant deficiency	$a_q = \frac{v_{tr}^2}{R_c} - \frac{gH_{cant}}{2b_A}$
$a_{q\text{-}max}$	m/s²	Maximum value of uncompensated lateral acceleration	
B_E	-	Embankment blockage ratio	The ratio of the height of the tallest

Symbol	Unit	Significance	Explanation or remark
			model embankment to the free height of the wind tunnel
B_V	-	Vehicle blockage ratio	The ratio of the total model vehicle reference area to the wind tunnel free cross-sectional area
b	-	Coefficient function of $\tilde{r}_g$	
b_A	m	1/2 lateral contact spacing	See 5.4.2.3
$b_{A,min}$	m	Minimum lateral contact spacing	
b_1	m	y position of right secondary suspension spring	
b_2	m	y position of left secondary suspension spring	
C	-	Coherence function for the resulting wind speed	
C_{90}	-	Coherence function for a wind angle of 90°	
$C_{(z0)}$	-	Function of roughness length in definition of longitudinal integral length scale	
CWC		Characteristic wind curve	
CWC_i	m/s	Evaluation of the stochastic CWC wind speed	
c	m/s	Speed of sound	
c_{Fi}	-	Force coefficient based on A_0	$c_{Fi} = \frac{2 \cdot F_i}{\rho \cdot v^2 A_0}$, i = x, y, z
c_M	-	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
$c_{Mx,lee}$	-	Rolling moment coefficient around lee rail	
$\bar{c}_{Mx,lee}$	-	Mean rolling moment coefficient around lee rail	
$\hat{c}_{Mx,lee}$	-	Peak rolling moment coefficient around lee rail	
$c_{Mx,lee,bmk}$	-	Benchmark value of rolling moment coefficient around lee rail	Rolling moment coefficient determined from the benchmark tests
$\hat{c}_{Mx,lee,bmk}$	-	Benchmark value of peak rolling moment coefficient around lee rail	
$c_{Mx,lee,test}$	-	Measured test results for rolling moment coefficient around lee rail for benchmark vehicle	

Symbol	Unit	Significance	Explanation or remark
$\hat{c}_{Mx,\text{lee, m}}$	-	Peak rolling moment coefficient around lee rail uncorrected for bias	
$\bar{c}_{Mx,\text{lee,m}}$	-	Mean measured rolling moment coefficient around lee rail uncorrected for bias	
$c_{s\varnothing,i}$	Nm	Torsion suspension constant	
c_u	-	Coefficient in the Cooper theory	
c_v	-	Coefficient in the Cooper theory	
$c_{y,BGi}$	m	y position of bogie *i* in local coordinates (centre of gravity)	*i* = 1: front bogie, *i* = 2: rear bogie
$c_{z,BGi}$	m	z position of bogie *i* in local coordinates (centre of gravity)	*i* = 1: front bogie, *i* = 2: rear bogie
$c_{x,CB}$	m	x position of car body in local coordinates (centre of gravity)	
$c_{y,CB}$	m	y position of car body in local coordinates (centre of gravity)	
$c_{z,CB}$	m	z position of car body in local coordinates (centre of gravity)	
$c\Theta$	-	$\cos\left(\Theta_{Bi}\right)$	
$c\Phi$	-	$\cos\left(\Phi_{Bi}\right)$	
$c\Psi$	-	$\cos\left(\Psi_{Bi}\right)$	
d	m	Characteristic length	3 m
d_0	m	Reference normalization length	3 m
$\underline{dr}_{kpi}$	m	Deflection of the *i* primary spring	*i* = 1: front bogie, *i* = 2: rear bogie
$\underline{dr}_{cpj,i}$	m	Deflection of the *j* primary spring	*j* = 1(right), 2 (left). *i* = 1: front bogie, *i* = 2: rear bogie
$\underline{dr}_{csj,i}$	m	Deflection of the *j* secondary spring	*j* = 1(right), 2 (left). *i* = 1: front bogie, *i* = 2: rear bogie
$d\phi_{cs,i}$	rad	Rotation angle of the bogie anti-roll bar	*i* = 1: front bogie, *i* = 2: rear bogie
F_i	N	Aerodynamic force	
$F_i(t)$	N	Aerodynamic force	Time dependent version of F_i
F_x F_y F_z	N	Aerodynamic forces in the directions of coordinates	
f	Hz	Wind frequency	
f_{gust}	Hz	Characteristic gust frequency	

Symbol	Unit	Significance	Explanation or remark
f_{BL}	-	Blockage correction factor	Function of x_B
$\underline{f}_{ci}$	N	Spring force vector of primary and secondary spring	i = 1: front bogie, i = 2: rear bogie
$f_{ci,x}$	N	Spring force of primary and secondary springs in x direction	i = 1: front bogie, i = 2: rear bogie
$f_{ci,y}$	N	Spring force of primary and secondary springs in y direction	i = 1: front bogie, i = 2: rear bogie
$f_{ci,z}$	N	Spring force of primary and secondary springs in z direction	i = 1: front bogie, i = 2: rear bogie
$\underline{f}_{cpj,i}$	Nm	Primary suspension constant	i = 1, 2: (front, back) j = 1, 2: (right, left)
$\underline{f}_{csj,i}$	Nm	Secondary suspension constant	i = 1, 2: (front, back) j = 1, 2: (right, left)
f_{emb}	-	Embankment speed up factor	
$\underline{f}_{f,Bi}$	N	Spring force vector of primary and secondary springs on body Bi	i = 1: front bogie, i = 2: rear bogie
$f_{f,BGi}$	N	Suspension force on bogie i	
$\underline{f}_{f,CB}$	N	Spring force vector of primary and secondary springs on car body	
$f_{f,WSi}$	N	Suspension force on wheel set i	
f_h	-	Function of the embankment blockage ratio, B_E	
$f_{\Delta Q}$	-	Relative windward wheel unloading factor	0,9
f_L	-	Function of vehicle length	
f_m	-	Method factor	To account for uncertainties in the 3-mass model.
$\underline{f}_{m,Bi}$	N	Mass force vector on body Bi	i = 1: front bogie, i = 2: rear bogie
$\underline{f}_{m,CB}$	N	Mass force vector on car body	
f_n	Hz	n-frequency	$f_n = \frac{\omega_n}{2\pi} = \frac{n\omega_0}{2\pi}$
f_{samp}	Hz	Data acquisition frequency	The sampling frequency (rate) for acquiring data in the wind tunnel
$\underline{f}_{total,Bi}$	N	Total force vector acting on body Bi	i = 1: front bogie, i = 2: rear bogie
$\underline{f}_{total,BGi}$	N	Total force vector acting on bogie i	i = 1: front bogie, i = 2: rear bogie
$\underline{f}_{total,CB}$	N	Total force vector acting on car body	

Symbol	Unit	Significance	Explanation or remark
$\underline{f}_{\mathrm{total,WS}i}$	N	Total force vector acting on wheel set *i*	
f_{u}	-	Normalized wind frequency	
$\tilde{f}_{\mathrm{u}}$	-	Normalized wind frequency in the Cooper theory	
$\hat{f}_{\mathrm{u}}$	-	Normalized wind frequency in the Cooper theory	
$\tilde{f}_{\mathrm{v}}$	-	Normalized wind frequency in the Cooper theory	
$\hat{f}_{\mathrm{v}}$	-	Normalized wind frequency in the Cooper theory	
$\underline{f}_{\mathrm{Wi,CB}}$	N	Wind force acting on car body	
G	-	Gust factor	
g	m/s²	Acceleration due to gravity	
H	-	Aeroadmittance function in Cooper theory	
H_{cant}	m	Cant height	
h	m	Vehicle height	
h_2	m	Vertical position vector component	
h_{BL}	m	Boundary layer height	
h_{z}	m	Height from ground	
h_{z0}	m	Roughness height	
h_{VEH}	m	Height of the vehicle from top of rail to roof	
I_{i}	-	Turbulence index for the *i*-wind component	*i = u, v, w*
$I_{\mathrm{u}}(z)$	-	Turbulence intensity	The standard deviation of the wind tunnel velocity at height *z* divided by the mean velocity at that height
k_{p}	N/m	Primary spring stiffness	
k_{s}	N/m	Secondary spring stiffness	
$k_{\mathrm{standstill}}$	-	Dimensionless characteristic wind speed for a vehicle at standstill	
k_{v}	-	Vehicle blockage factor	Correction factor applied to the mean or peak wind tunnel velocity to allow for the effects of the constraints of the tunnel walls on the local flow over the vehicle