



# SLOVENSKI STANDARD

## SIST EN 14067-6:2018

01-oktober-2018

Nadomešča:  
SIST EN 14067-6:2011

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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 für die 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

**Ta slovenski standard je istoveten z: EN 14067-6:2018**

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**ICS:**

45.060.01      Železniška vozila na splošno      Railway rolling stock in general

**SIST EN 14067-6:2018**

**en,fr,de**

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EUROPEAN STANDARD

EN 14067-6

NORME EUROPÉENNE

EUROPÄISCHE NORM

July 2018

ICS 45.060.01

Supersedes EN 14067-6:2010

English Version

## 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

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

This European Standard was approved by CEN on 3 March 2018.

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## European foreword

This document (EN 14067-6:2018) 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of an identical text or by endorsement, at the latest by January 2019, and conflicting national standards shall be withdrawn at the latest by January 2019.

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 supersedes EN 14067-6:2010.

This document has been prepared under a mandate given to CEN/CENELEC/ETSI by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive 2008/57/EC.

For the relationship with EU Directive 2008/57/EC, see informative Annex ZA, which is an integral part of this document.

The main changes with respect to the previous edition are listed below:

- a) References to Part 1 were removed, the coordinate system and all relevant symbols from Part 1 were added to this part.
- b) New requirements were added for passenger vehicles and locomotives running at  $250 \text{ km/h} \leq v_{\text{max}} \leq 360 \text{ km/h}$ .
- c) New tables were added with reference CWCs for passenger vehicles and locomotives running at  $250 \text{ km/h} \leq v_{\text{max}} \leq 360 \text{ km/h}$ .
- d) Formula (1) was corrected as well as the factor  $f_L$  in Table 3.
- e) Guidance on application of reference CWCs in cross wind risk assessments of railway lines is given in Clause 8.
- f) The migration rule (former Annex M) has been removed from the general document and will be provided in national forewords, wherever required.
- g) A new Annex M has been added and provides extended CWCs.
- h) Annex ZA has been updated.
- i) Extension of the scope to track gauges 1 435 mm to 1 668 mm.

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;

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- *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, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

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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).

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## EN 14067-6:2018 (E)

### 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.

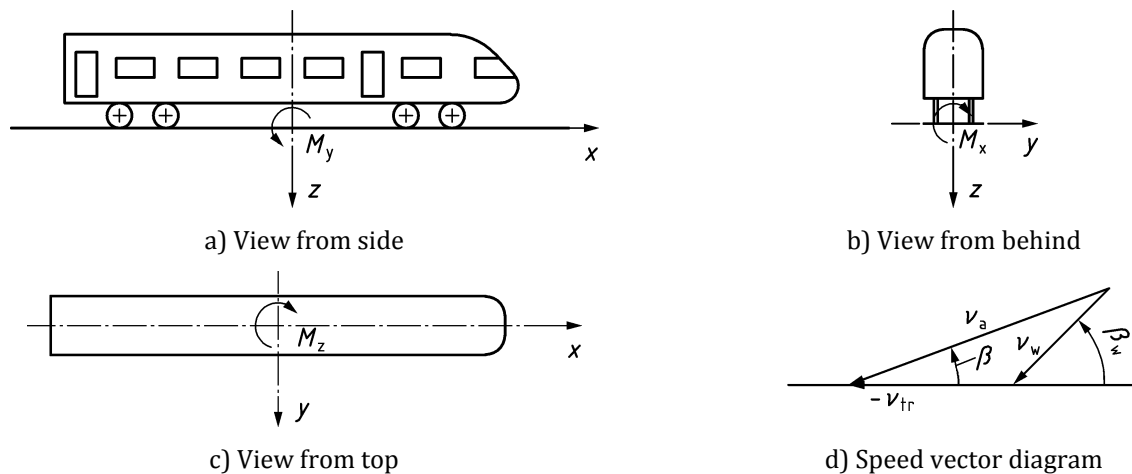


Figure 1 — Coordinate system

Note 2 to entry: A positive  $\beta$  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
$A$	$\text{m}^2$	Reference area	
$A_0$	$\text{m}^2$	Reference normalization area	10 $\text{m}^2$
$A^*$	-	Constant in formula for $\sigma_u$	
$\tilde{A}$	-	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
$a_q$	$\text{m/s}^2$	Uncompensated lateral acceleration; also equivalent to cant deficiency	$a_q = \frac{v_{\text{tr}}^2}{R_c} - \frac{gH_{\text{cant}}}{2b_A}$
$a_{q\text{-max}}$	$\text{m/s}^2$	Maximum value of uncompensated lateral acceleration	
$B_E$	-	Embankment blockage ratio	The ratio of the height of the tallest

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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°	
$C_{(z_0)}$	-	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
$\hat{c}_{M_{x,lee,m}}$	-	Peak rolling moment coefficient around lee rail uncorrected for bias	
$\bar{c}_{M_{x,lee,m}}$	-	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)	
$c\Theta$	-	$\cos(\Theta_{Bi})$	
$c\Phi$	-	$\cos(\Phi_{Bi})$	
$c\Psi$	-	$\cos(\Psi_{Bi})$	
$d$	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	

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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 $B_i$	$i = 1$ : 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 $B_i$	$i = 1$ : 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 $B_i$	$i = 1$ : 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
$f_{\text{total,WS}i}$	N	Total force vector acting on wheel set $i$	
$f_u$	-	Normalized wind frequency	
$\tilde{f}_u$	-	Normalized wind frequency in the Cooper theory	
$\hat{f}_u$	-	Normalized wind frequency in the Cooper theory	
$\tilde{f}_v$	-	Normalized wind frequency in the Cooper theory	
$\hat{f}_v$	-	Normalized wind frequency in the Cooper theory	
$f_{\text{Wi,CB}}$	N	Wind force acting on car body	
$G$	-	Gust factor	
$g$	m/s <sup>2</sup>	Acceleration due to gravity	
$H$	-	Aeroadmittance function in Cooper theory	
$H_{\text{cant}}$	m	Cant height	
$h$	m	Vehicle height	
$h_2$	m	Vertical position vector component	
$h_{\text{BL}}$	m	Boundary layer height	
$h_z$	m	Height from ground	
$h_{z0}$	m	Roughness height	
$h_{\text{VEH}}$	m	Height of the vehicle from top of rail to roof	
$I_i$	-	Turbulence index for the $i$ -wind component	$i = u, v, w$
$I_u(z)$	-	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	
$k_{\text{standstill}}$	-	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
$\bar{k}_e$	-	Mean wind embankment blockage factor	Correction factor applied to the mean