SLOVENSKI STANDARD
SIST EN 14531-1:2016

01-marec-2016

Nadomešča:
SIST EN 14531-1:2005

Železniške naprave - Metode za izračun zavornih poti pri ustavljanju in upočasnjevanju ter zavarovanje stoječih vozil - 1. del: Splošni algoritmi, ki temeljijo na izračunu srednje vrednosti za vlakovne kompozicije ali posamezna vozila

Railway applications - Methods for calculation of stopping and slowing distances and immobilisation braking - Part 1: General algorithms utilizing mean value calculation for train sets or single vehicles

Bahnanwendungen - Verfahren zur Berechnung der Anhalte- und Verzögerungsbremswege und der Feststellbremsung - Teil 1: Grundlagen

Applications ferroviaires - Méthodes de calcul des distances d'arrêt, de ralentissement et d'immobilisation - Partie 1: Algorithmes généraux utilisant des valeurs moyennes pour des compositions de trains ou véhicules isolés

Ta slovenski standard je istoveten z: **EN 14531-1:2015**

ICS:

45.060.01	Železniška vozila na splošno	Railway rolling stock in general

SIST EN 14531-1:2016 **en,fr,de**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 14531-1

December 2015

ICS 45.060.01

Supersedes EN 14531-1:2005

English Version

Railway applications - Methods for calculation of stopping and slowing distances and immobilization braking - Part 1: General algorithms utilizing mean value calculation for train sets or single vehicles

Applications ferroviaires - Méthodes de calcul des distances d'arrêt, de ralentissement et d'immobilisation - Partie 1 : Algorithmes généraux utilisant le calcul par la valeur moyenne pour des rames ou des véhicules isolés

Bahnanwendungen - Verfahren zur Berechnung der Anhalte- und Verzögerungsbremswege und der Feststellbremsung - Teil 1: Allgemeine Algorithmen für Einzelfahrzeuge und Fahrzeugverbände unter Berücksichtigung von Durchschnittswerten

This European Standard was approved by CEN on 27 June 2015.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of 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, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 14531-1:2015 E

Contents

Page

European foreword

This document (EN 14531-1:2015) 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 June 2016, and conflicting national standards shall be withdrawn at the latest by June 2016.

This document supersedes EN 14531-1:2005.

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 2008/57/EC.

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

This series of European standards EN 14531, *Railway applications — Methods for calculation of stopping and slowing distances and immobilization braking* consists of:

— *Part 1: General algorithms utilizing mean value calculation for train sets or single vehicles*;

— *Part 2: Step-by-step calculations for train sets or single vehicles*.

The two parts are interrelated and should be considered together when conducting the step-by-step calculation of stopping and slowing distances.

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.

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

Introduction

This European Standard describes a common calculation method for railway applications. It describes the general algorithms utilizing mean value calculation for use in the design and validation of brake equipment and braking performance for all types of train sets and single vehicles. In addition the algorithms provide a means of comparing the results of other braking performance calculation methods.

EN 14531 was originally planned to have six parts covering the calculation methodology to be used when conducting calculations relating to the braking performance of various types of railway vehicles under the heading EN 14531, Railway applications – Methods for calculation of stopping, slowing distances and immobilization braking. The six parts were as follows:

— Part 1: General algorithms

— Part 2: Application to single freight wagon

— Part 3: Application to mass transit (LRV's and D- and E- MU's)

— Part 4: Application to single passengers coach

— Part 5: Application to locomotive

— Part 6: Application to high speed trains

EN 14531-1 was originally published in 2005 followed by EN 14531-6 which was published in 2009.

Following the above it was decided that a common methodology could be used for Parts 2 to 5 and this should be contained under a revised version of Part 1 with a title of *Railway applications — Methods for calculation of stopping and slowing distances and immobilisation braking — Part 1: General algorithms utilizing mean value calculation for train sets or single vehicles* while revising Part 6 to be Part 2 with the title of *Railway applications - Methods for calculation of stopping and slowing distances and immobilization braking - Part 2: Step by step calculations for train sets or single vehicles*.

EN 14531-1:2005 and EN 14531-6:2009 are referenced in the current technical specifications for interoperability (TSIs) (Freight wagons and locomotive and passenger rolling stock (RST)). The tables of the Annex ZA give the equivalence of the TSI referenced clauses of the original EN 14531 series to the clauses of this issue of EN 14531-1 and EN 14531-2.

1 Scope

This European Standard describes general algorithms for the brake performance calculations to be used for all types of train sets, units or single vehicles, including high speed, locomotive and passenger coaches, conventional vehicles and wagons.

This European Standard does not specify the performance requirements. It enables the estimation and/or comparison by calculation of the various aspects of the performance: stopping or slowing distances, dissipated energy, power, force calculations and immobilization braking.

If it is required to validate, verify or assess braking performance it is recommended that a more detailed calculation is performed in accordance with EN 14531-2, i.e. a step by step calculation.

This European Standard contains generic examples of the calculation of brake forces for individual brake equipment types and calculation of stopping distance and immobilization braking relevant to a train (see Annexes C and D).

2 Normative references

The following referenced documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 14478, *Railway applications - Braking - Generic vocabulary*

EN 14531-2, *Railway applications – Methods for calculation of stopping and slowing distances and immobilisation braking – Part 2: Step by step calculations for trains or single vehicles*

prEN 15328, *Railway applications - Braking - Brake pads*

EN 16452, *Railway applications – Braking – Brake blocks*

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

3 Terms, definitions, symbols and indices

3.1 Terms and definitions

For the purpose of this document, the terms and definitions given in EN 14478 and EN 14531-2 and the following apply.

3.1.1
static mass per axle
mass measured by weighing at the wheel-rail interface, or estimated from design evaluation, of each axle in a stationary condition for each operating condition required

3.1.2
static mass of the train
summation of all the static mass values per entity

Note 1 to entry: E.g. per axle, for each operating condition.

3.1.3
equivalent rotating mass
linear conversion of the moment of inertia due to rotating parts coupled to the wheelsets during braking into an equivalent additional static mass

Note 1 to entry: This includes brake discs, gear wheels etc.

3.1.4
brake equipment type
group of equipment that provide braking force

Note 1 to entry: When brake equipment is used on one part of the train under certain conditions and used on another part of the same train under other conditions, two different brake equipment types shall be considered.

3.1.5
tread brake unit/disc brake unit
functional unit from which brake force is delivered, typically consisting of a brake cylinder, slack adjuster portion and all associated component parts

Note 1 to entry: Sometimes referred to as tread/disc brake actuator.

3.1.6
isolated brake equipment
equipment not considered in the calculation due to assumed isolation

Note 1 to entry: E.g. brake equipment of a bogie.

3.1.7
active brake equipment
equipment considered to be operational in the calculation of a specific brake equipment type

3.1.8
mean value calculation
calculation method in which the values used for each active brake equipment type are a mean value based on speed, force or distance as applicable for a particular speed range

3.1.9
decelerating force
force resulting from summation of all forces acting contrary to the direction of movement when considering a train

Note 1 to entry: Each operational brake equipment type produces its own decelerating force which when added to the additional external forces opposing motion results in the total decelerating force of the train.

Note 2 to entry: For the purpose of this standard a decelerating force is considered as a positive value, therefore accelerating force is considered as a negative value.

3.1.10
braking force
force produced by the active brake equipment types to brake the train

Note 1 to entry: It does not include external forces which contribute to the overall decelerating force of the vehicle or train.

3.1.11
external forces
forces typically including rolling resistance, gradient, head wind etc

3.1.12
entity
group or item considered in a calculation

Note 1 to entry: E.g. train, vehicle, bogie, axle, wheel.

3.2 Symbols and indices

For the purposes of this document, the general symbols given in Table 1 and indices given in Table 2 apply.

NOTE Specific symbols and indices are defined in the relevant clauses.

Table 1 — Symbols

Symbol	Definition	Unit
A	area	m^2
a	deceleration	m/s^2
A_s	area of a friction surface swept by the friction elements	m^2
B	braked weight	T
D	wheel diameter	m
F	force	N
F_B	braking force related to the rail	N
F_g	downhill force on the train	N
g_n	standard acceleration of free fall = 9,80665 m/s^2 (see: ISO 80000-3)	m/s^2
i	gradient (rising gradient is positive; e.g. for a gradient of 5 ‰, i = 0,005)	-
i_c	cylinder ratio	-
i_{rig}	rigging ratio	-
i_{tra}	transmission ratio	-
J	inertia due to rotation of masses	$kg \cdot m^2$
m	mass	kg
n	quantity	-
P	power	W
p	pressure	Pa
r	radius	m
s	distance	m

S	safety factor	-
t	time	s
τ	coefficient of adhesion	-
v	speed	m/s
W	energy	J
W_S	energy per unit area	$\frac{J}{m^2}$
λ	braked weight percentage	-
μ	coefficient of friction	-
η	efficiency	-

Table 2 — General indices

Indices	Term
AMG	attraction force for a magnetic track
ap	application point
ax	axle
a	available
B	braking force
BEC	braking force for an eddy current brake
BED	electro-dynamic braking force
BFR	fluid retarder braking force
BMG	braking force for a magnetic track brake
b	block or pad
bog	bogie
C	cylinder
act	unit/actuator
cha	characteristic
Bd	braking force demanded
disc	disc
dyn	dynamic
e	equivalent
ent	entity
ext	external
fin	final state
H	hand brake
i	brake equipment type
j	range or step
im	immobilization, parking, holding
ind	independent of adhesion
nt	internal
inst	instantaneous
max	maximum
min	minimum
mot	motor
MG	magnetic track brake
n	normal direction
R	response
Ra	train resistance to motion
req	required
rig	rigging
rot	rotating
R1	return spring
R2	regulator
S	spring
st	static
T	tangential direction
tot	total
tra	transmission

wind	wind
0	initial state
1, 2, 3, 4 –– etc.	intermediate state

4 Stopping and slowing distances calculation

4.1 General

The principle of the algorithm flow is presented in Annex A, Figure A.1.

In general the formulae contained in this clause are used in the first instance when considering constant brake forces with respect to speed.

In the second instance the formulae may be used as a mean value calculation when considering a non constant speed dependent brake force which is transformed to a mean brake force value. This mean value of brake force is considered as a fully developed force without considering the response time and results in the same braking distance as if calculated using the speed dependent brake force. See Annex E.

The algorithms in this standard use mean values, however if it is necessary to use instantaneous values and algorithms using finite time steps then EN 14531-2 shall be used.

4.2 Accuracy of input values

The accuracy of the calculation described here depends directly on the accuracy of the input data.

The accuracy of the input data values shall be relevant to the purpose of the calculation and shall be traceable as to how these values were established e.g. engineer's estimation, test results, manufacturer’s data etc. Supporting calculations or test reports (or extracts of these documents) should be attached with the performance calculation where applicable.

Representative curves of the performance of a type of brake equipment e.g. electro dynamic brake, can be determined by numerical or practical methods. The values can be given as a table.

4.3 General characteristics

4.3.1 Train formation

The brake system design parameters necessary to conduct the calculation shall be defined at the level of an entity e.g. an axle, bogie or a vehicle.

Calculations shall be performed for each brake equipment type. In so doing, the brake force contributions from each of the brake equipment types (e.g. disc brakes, tread brakes, electrodynamic brakes) shall be taken into consideration. All of the various types of brake equipment applied to one entity shall be identified and accounted for in the calculation.

The parameters which are typically used to define train formation include but are not limited to:

— quantity of motor axles;

— quantity of trailer axles;

— quantity of braked axles for each adhesion dependent brake equipment type;

— quantity of non-adhesion dependent brake equipment type.

NOTE 1 When there are several brake equipment types, it is preferable to identify each type (for example by means of a number: type 1, type 2, etc.).

A train can consist of one or more units or vehicles. For the purpose of this document, no distinction is made between unit and vehicle, therefore the term vehicle is used.

NOTE 2 'Unit' is used in the same sense as described in the technical specification for interoperability (TSI) relating to the rolling stock sub-system – 'Locomotives and Passenger rolling stock' of the Trans-European conventional rail system.

When the brake equipment types fitted to the train are used under different circumstances, e.g. load level, speed range, brake demand etc. each condition or state of the brake shall be considered together with the resultant effect on brake force.

4.3.2 Characteristics of a train

4.3.2.1 Train mass

EN 15663 shall be used to provide a common set of reference masses on which the assessment of loads and performance evaluation can be based; it also describes how each is to be derived.

4.3.2.2 Static mass of the train, or axle (m_{st})

The static mass of the train and/or the static mass of the axle (as defined in 3.1) shall be used to establish the brake force required or the adhesion requirements respectively, for each operating condition required e.g. operational mass in working order, as defined in EN 15663.

When there are different 'static masses per axle values' e.g. due to different vehicle arrangements or axle mounted equipment, the static mass shall be calculated for each axle.

It may be required to assess the effect of the position of a vehicle type in a train e.g. with respect to the adhesion required.

4.3.2.3 Equivalent rotating mass (m_{rot})

The equivalent rotating mass shall be calculated using a theoretical approach or established as a result of tests, using test conditions similar to the expected operating conditions.

The wheel size applicable to the rotating mass shall be identified. Any value of equivalent rotating mass, identified by a % of static mass, is normally calculated using the assumed static mass of each vehicle within the train.

When there are different 'rotating masses per axle' e.g. a mix of trailer and motor axles, the rotating mass shall be calculated for each type.

It may be required to assess the effect of the position of a vehicle type in a train e.g. with respect to the adhesion required.

If an inertia value (*J*) due to the rotating masses is known, rather than the equivalent mass of the rotating parts, then the associated wheel diameter shall be defined, this diameter is normally the new wheel diameter. The formula for the calculation of equivalent rotating mass using inertia is shown below:

$$m_{\text{rot}} = \frac{4 \cdot J}{D^2} \qquad (1)$$

where:

m_{rot}	equivalent rotating mass, in kg
J	Inertia
D	wheel diameter, in m

4.3.2.4 Dynamic mass (m_{dyn})

Dependent on the calculation being conducted the dynamic mass is the sum of the static mass and the equivalent rotating mass for the entity being considered e.g. axle, bogie, vehicle etc.

$$m_{\mathrm{dyn}} = \sum \left(m_{\mathrm{st}} + m_{\mathrm{rot}} \right) \quad (2)$$

where:

m_{dyn} dynamic mass, in kg

m_{st} static mass, in kg

m_{rot} rotating mass, in kg

4.3.2.5 Wheel diameter

The wheel diameter is measured on the nominal rolling circle.

NOTE The wheel diameter used in the emergency brake calculation is usually that which gives the lowest deceleration e.g. in the case of disc brakes, this would normally be the maximum wheel diameter.

When checking the required adhesion τ_{req} the wheel diameter used shall be the size which generates the maximum adhesion demand e.g. in the case of disc brakes, this would normally be the minimum wheel diameter.

If the train is equipped with different sizes of wheels (by design not due to wear) each size of wheel shall be identified in the train composition.

4.3.2.6 Mean train resistance

The train resistance is a component of the train decelerating force provided by the structure of the train, referred to as resistance to motion in EN 14067-4. This however uses instantaneous values. The running resistance formula considers straight and level tracks, zero wind conditions, in open air and at constant speed, The characteristic of train resistance can be by analogy to a similar existing train, or based on a specific calculation or test. When the values are established as a result of tests, the test conditions shall be similar to the expected operating conditions.

As an approximation or first calculation the following mean mathematical formula derived from the instantaneous formula in EN 14067-4 shall be used:

$$\overline{F}_{\mathrm{Ra}} = A + \tfrac{2}{3} \cdot B \cdot \frac{v_0^{\,2} + v_0 \cdot v_{\mathrm{fin}} + v_{\mathrm{fin}}^{\,2}}{v_0 + v_{\mathrm{fin}}} + \tfrac{1}{2} \cdot C \cdot \left(v_0^{\,2} + v_{\mathrm{fin}}^{\,2} \right) \quad (3)$$

where:

$\overline{F}_{\mathrm{Ra}}$ mean value of the train resistance force, in N

v_0 initial speed of the train, in m/s

v_{fin} final speed of the train, in m/s

A characteristic coefficient of the train independent of speed considered as C_1 in EN 14067-4, in N

B characteristic coefficient of the train proportional to the speed considered as C_2 in