SLOVENSKI STANDARD
SIST-TP CEN/TR 17315:2019

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Železniške naprave - Zavore - Računski postopki za ocenjevanje zavorne razdalje pri specifičnem preskušanju zaščite pred zdrsavanjem koles

Railway applications - Braking - Calculations for the estimation of stopping distance for specific Wheel Slide Protection testing

Bahnanwendungen - Bremsn - Bremswegberechnungen für den Schleuderschutz

Applications ferroviaires - Freinage - Calculs pour l'estimation des distances d'arrêt pour les essais spécifiques aux dispositifs d'anti-enrayage

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ICS:

45.040	Materiali in deli za železniško tehniko	Materials and components for railway engineering

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ICS 45.040

English Version

Railway applications - Braking - Calculations for the estimation of stopping distance for specific Wheel Slide Protection testing

Applications ferroviaires - Freinage - Calculs pour l'estimation des distances d'arrêt pour les essais spécifiques aux dispositifs d'anti-enrayage

Bahnanwendungen - Bremsen - Bremswegberechnungen für den Schleuderschutz

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CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

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European foreword

This document (CEN/TR 17315:2019) has been prepared by Technical Committee CEN/TC 256 “Railway applications”, the secretariat of which is held by DIN.

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.

Introduction

EN 15595 for Wheel Slide Protection (WSP) provides methods for testing a WSP system (Clause 7) and criteria for the evaluation of its performance under test (Clause 8). This includes tests and evaluation of the stopping performance of a vehicle/train with the WSP system fitted, carried out as track tests or on a WSP simulator.

For the evaluation of stopping performance during slide tests (see 8.3), the standard specifies the maximum permitted stopping distance extension for a vehicle/train, measured as a percentage of its dry rail stopping distance (Table 8). The maximum extension values are derived from estimations of the wheel/rail adhesion improvement produced by the operation of the WSP system and the associated vehicle stopping distances expected in the slide tests, calculated as detailed in this document.

1 Scope

This document gives guidelines for the calculation of vehicle stopping distances when testing a WSP system using the methods specified in EN 15595, the standard for Wheel Slide Protection, under the conditions defined in that standard.

This document is only applicable to the calculation of stopping distances for the evaluation of the results of WSP tests carried out in accordance with EN 15595.

This document does not apply to calculations used to determine the stopping performance of a WSP equipped train under operational conditions as it is only applicable for specific WSP test conditions.

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 14478, *Railway applications — Braking — Generic vocabulary*

EN 15595:2018, *Railway applications — Braking — Wheel slide protection*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 14478 and the following 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
adhesion profile
predefined set of data representing the adhesion characteristics of a section of running line

3.2
dry rail
conditions where 100 % of the brake force of the vehicle can be applied with no wheelset sliding more than 2 %

3.3
dry rail stopping distance
actual measured stopping distance in dry rail conditions

3.4
low adhesion
conditions where the wheel/rail adhesion is in the range 0,08 to 0,05

3.5
very low adhesion
conditions where the wheel/rail adhesion is in the range 0,05 to 0,03

3.6
extremely low adhesion
conditions where the wheel/rail adhesion is below 0,03

3.7
slide test
test performed under low, very low and extremely low adhesion conditions

3.8
drag test
test to simulate braking on a falling gradient, performed with an auxiliary tractive unit to achieve a constant speed with a constant brake application

4 Symbols and abbreviations

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

Table 1 — Symbols

Symbol	Definition	Unit
g	Acceleration due to gravity	m/s^2
v_{ref}	WSP vehicle reference speed	km/h
v_t	True train speed	km/h
τ_x	Wheel/rail adhesion coefficient	—
τ	Initial adhesion coefficient	—
WSP	Wheel slide protection	—

5 Calculations

5.1 Wheel/rail adhesion improvement

5.1.1 General

The formulae in this clause are means that give an indication for the stopping distance that can be achieved by a certain trainset with low adhesion.

The formulae take into account different characteristics of the vehicle that are tested and are a practicable compromise to evaluate track tests.

The formulae cannot give exact values for the stopping distance in true conditions. Therefore each result is evaluated according to the flow chart given in EN 15595:2018, Figure 4.

5.1.2 Stopping distance calculation

The theoretical stopping distance for a vehicle with speed dependent retardation rates is shown below (see Formula (1)):

$$s = v_0 \times \left(t_a + \frac{t_{ab}}{2} \right) + \frac{(v_0)^2 - (v_1)^2}{2\tau_{ave,0} \times g} + \cdots + \frac{(v_x)^2}{2\tau_{ave,x} \times g} \quad (1)$$

where

s	is the stopping distance, expressed in m;
t_a	is the delay time from the start of braking until the brake starts filling, expressed in s;
t_{ab}	is the build-up time of the brake cylinder pressure up to 95 % of the maximum pressure, expressed in s;
v_0	is the initial vehicle speed, expressed in m/s;
v_1 to v_x	are the speeds at the different brake forces, expressed in m/s;
$\tau_{ave,0}$ to $\tau_{ave,x}$	are the average wheel/rail adhesions required for each speed range and calculated from Formula (2).

The average wheel/rail adhesion required for each speed range τ_{ave} is calculated as set out in Formula (2).

$$\tau_{ave} = \frac{m_1}{m_{total}} \times \tau_1 + \cdots + \frac{m_n}{m_{total}} \times \tau_n \quad (2)$$

where

τ_1 to τ_n	are the wheel/rail adhesions that provide the effective brake force between wheel and rail on each of the wheelsets;
m_1 to m_n	are the axle loads of the wheelsets;
m_{total}	is the total static mass on all the wheelsets;
n	number of wheelsets.

For unbraked wheelsets τ_i is set to zero, for braked wheelsets τ_i is taken from the brake calculation:

where

τ_i	is the τ of the wheelsets number i, where i is between 1 and n.

Examples of the use of theses formulae are shown in Annex A.

5.1.3 Dry rail conditions

The actual measured stopping distance in dry conditions, with WSP operational, is the stopping distance corresponding to the nominal performance required for the vehicle within the specified tolerances.

$\tau_{ave,dry}$ is calculated from Formula (2) for dry rail conditions.

The friction coefficients $\tau_{i,dry}$ should be taken from the brake calculation, updated after the brake distance measurement. If the measured frictional coefficient depends on the initial speed, the mean frictional coefficient for the different speed classes can be used.

5.1.4 Low adhesion

The aim of the WSP under low adhesion conditions is to improve the levels of wheel/rail adhesion experienced by the wheelsets by attempting to control at an absolute slide of up to 30 km/h at speeds greater than 40 km/h.

Wheel/rail adhesion improvement is measured using WSP equipment alone, without any other adhesion enhancing equipment such as magnetic track brake, sanding, etc.

WSP can be configured to improve wheel/rail adhesion by controlling the slide. Experience has shown that for sprayed rails the WSP can achieve an improved wheel/rail adhesion $\tau_{wet,improved}$. This can be estimated for each sprayed wheelset using Formula (3). This estimation is valid only if the initial speed is higher than 80 km/h. Below 80 km/h, $\tau_{wet,improved}$ can be taken as the measured initial wheel/rail adhesion.

$$\tau_{wet,improved} = 0,09 + \left(\tau_{dry} - 0,12\right) \times 0,33 \quad (3)$$

where

τ_{dry} is the wheel/rail adhesion that provides the effective brake force between wheel and rail on the wheelset under dry rail conditions.

NOTE 1 For low values of τ_{dry} where $\tau_{wet,improved}$ calculated by Formula (3) is greater than τ_{dry} then $\tau_{wet,improved} = \tau_{dry}$.

NOTE 2 Formula (3) has been derived from the experience of the traditional brake rate for coaches and has the additional factors to modify the improvement from the experience of vehicles with a higher and lower braking rates achieving different improvements of the wheel/rail adhesion with WSP operation.

The number of wheelsets experiencing low adhesion is shown in Table 2 dependent on train length.

Table 2 — Wheelsets experiencing low adhesion

No. of wheelsets n_{tot}	No. of wheelsets experiencing low adhesion $n_{low\ adhesion}$
≤ 6	5 (see NOTE)
≤ 9	6
≤ 15	7
≥ 16	8
NOTE Where the number of wheelsets is less than 5, the number to be used is the number of wheelsets.	

In sprayed conditions τ_{ave} is calculated from Formula (2) above where the wheelsets experiencing low adhesion, $n_{low\ adhesion}$ are defined as using the $\tau_{wet,improved}$ generated by the operation of the WSP system.

The number of wheelsets ($n_{tot} - n_{low\ adhesion}$) is treated as if they are experiencing dry conditions.

Unbraked wheelsets are not to be counted either as wheelsets experiencing low adhesion or included in the total wheelset count.

The use of Formula (2) with the low adhesion and dry wheelsets substituted is shown below as:

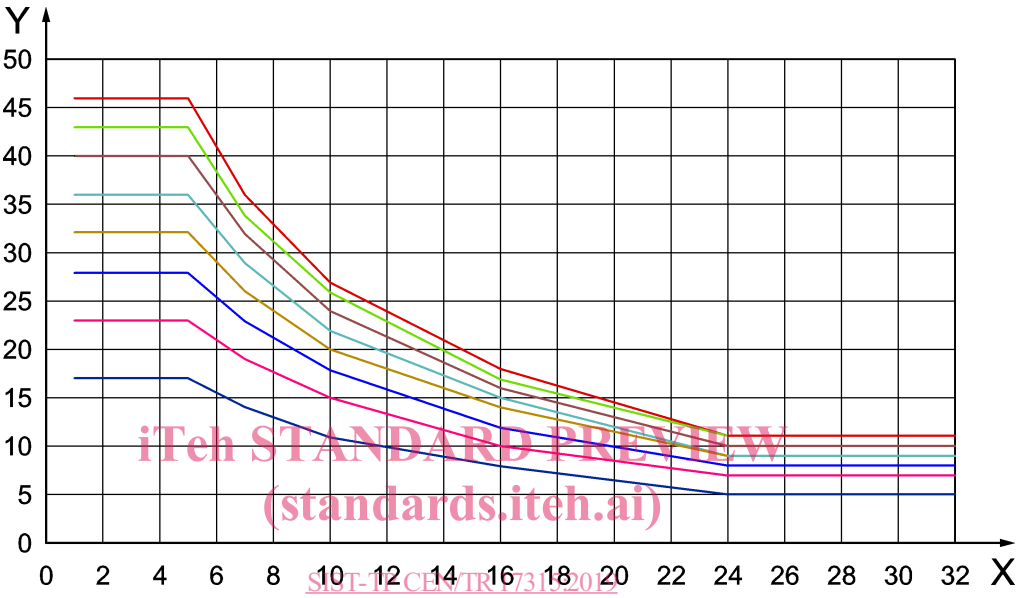
$$\tau_{ave,wet} = \sum_{i=1}^{n_{low\ adhesion}} \frac{m_i}{m_{total}} \times \tau_{i,\ wet,\ improved} + \sum_{n_{low\ adhesion}+1}^{n_{total}} \frac{m_i}{m_{total}} \times \tau_{i,dry} \quad (4)$$

The vehicle/train under test should achieve the stopping distances calculated from Formula (1) using $\tau_{ave,wet}$ from Formula (4) to demonstrate the WSP performance under low adhesion conditions (according to brake calculation and verified by tests).

5.2 Graphical representation of the Stopping Distance Extensions

The Maximum Allowed Stopping Distance Extensions for initial speed 160 km/h and with a utilization of wheel/rail adhesion in dry conditions of τ_{dry} = 0,10 to 0,17 are shown in Figure 1.

Y has been calculated from Formula (1) using $\tau_{ave,wet}$ from Formula (4).



Key

X No of wheelsets

Y Maximum Allowed Stopping Distance Extension, expressed in %

— τ_{dry} = 0,17

— τ_{dry} = 0,16

— τ_{dry} = 0,15

— τ_{dry} = 0,14

— τ_{dry} = 0,13

— τ_{dry} = 0,12

— τ_{dry} = 0,11

— τ_{dry} = 0,10

Figure 1 — Maximum Allowed Stopping Distance Extensions