SLOVENSKI STANDARD

oSIST prEN 17997-1:2023

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Železniške naprave - Zavore - Opredelitev parametrov zavorne krivulje ETCS za vlake Gama - 1. del: Parametri krivulje zaviranja v sili

Railway applications - Braking - Definition of ETCS brake curve parameters for Gamma trains - Part 1: Emergency brake curve parameters

Bahnanwendungen - Bremsen - Bestimmung der ETCS-Bremskurvenparameter für Gamma-Züge - Teil 1: Schnellbremskurvenparameter

Applications ferroviaires - Freinage - Détermination des paramètres des courbes de freinage ETCS pour les trains Gamma - Partie 1 : Paramètres des courbes de freinage d’urgence

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Railway applications - Braking - Definition of ETCS brake curve parameters for Gamma trains - Part 1: Emergency brake curve parameters

Applications ferroviaires - Freinage - Détermination des paramètres des courbes de freinage ETCS pour les trains au Gamma - Partie 1 : paramètres pour les courbes de freinage d'urgence

Bahnanwendungen - Bremsen - Bestimmung der ETCS-Bremskurvenparameter für Gamma-Züge - Teil 1: Schnellbremskurvenparameter

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

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European foreword

This document (prEN 17997-1:2023) has been prepared by Technical Committee CEN/TC 256 "Railway applications", the secretariat of which is held by DIN.

This document is currently submitted to the CEN Enquiry.

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Introduction

European Train Control System (ETCS) specifications have become part of, or are referred to the Technical Specifications for Interoperability (TSI) for railway control-command systems, as part of the European legislation, managed by the European Union Agency for Railways (ERA).

The Braking model specification in this document is based on the definition in the System Requirements Specification (SRS) SUBSET-026, Version 3.6.0 of 13/05/2016, published by the European Union Agency for Railways: ETCS B3 R2 GSM-R B1.

Based on a generic "brake system architecture model" a procedure is described to design a train specific software model which is applied for calculating the rolling stock correction factors and a method for determination of the nominal emergency and service braking deceleration for normal and degraded modes is described. Furthermore, the derivation of all the required traction and braking model parameters is specified.

This document describes the different steps to define ETCS emergency brake parameters for ETCS gamma braking model trains intended to operate on lines equipped with ETCS Baseline 3 [10].

1 Scope

This document specifies the methodology to define the train related braking model and required brake on-board parameters to enable speed and distance monitoring for trains equipped and operated on railway lines using ETCS Baseline 3.

This document is only applicable for ETCS Gamma braking model trains (i.e. the train is said to be a “gamma” train). This document does not specify the way these parameters are transferred to and can be used by the ETCS on-board system (e.g. during start of mission - SoM).

The ETCS “conversion models” are not covered by this document and are described in EN 16834:2019, Annex F. The ETCS “conversion models” are intended for use with trains where the braking performance is expressed using braked weight percentages (“lambda” train).

Any trackside related input parameters, including national values, are not covered in this document. Information can be found in the SUBSET-026 (see [11]).

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 15595:2018+AC:2021, *Railway applications — Braking — Wheel slide protection*

EN 16834:2019, *Railway applications — Braking — Brake performance*

EN 17343:2020, *Railway applications — General terms and definitions*

ISO 24478:2023, *Railway applications — Braking — General vocabulary*

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 17343:2020, ISO 24478:2023 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp/

— IEC Electropedia: available at https://www.electropedia.org/

3.1.1
base unit
smallest considered unit of a certain system on the lowest level of the level model

3.1.2
building block
validated information for the characteristics of a sub brake system (e.g. Magnetic Track Brake), that is derived from the delta between test results of configurations with and without the sub brake system

3.1.3
highly improbable event
event which is extremely unlikely to occur and can be neglected

Note 1 to entry: See also EN 50126-1:2017, Table C.1 [5].

3.1.4
brake system architecture model
calculation model for the calculation of some ETCS brake parameters which can be applied for K_{dry} definition with Monte Carlo simulation

3.1.5
level model
model that enables the consideration of structural information of the vehicle in the brake system architecture model

3.1.6
technical function
function, which can be generated by a single component or a complete system

Note 1 to entry: The technical function of the brake system is to generate braking force.

3.1.7
structural information
information about the levels, units and structure used in a brake system

3.1.8
statistical information
information that describes the failure or/and the deviation behaviour of a technical function

3.1.9
failure coefficient
coefficient that represents the effect of the failure of a technical function on the braking force of a brake unit/group of brake units and is linked to the probability of failure of the technical function

3.1.10
deviation coefficient
coefficient that represents the effect of the deviation of a technical function on the braking force of a brake unit/group of brake units and is linked to the statistical distribution of deviation of the technical function

3.2 Symbols and abbreviated terms

For the purposes of this document, the symbols and abbreviated terms given in Table 1 apply.

Table 1 — Symbols and abbreviated terms

Symbol	Definition	Unit
$A_{\text{brake safe}}(\text{C, V, EBCL})$	safe emergency brake deceleration, also called A_brake_safe in SUBSET-026-3 [11]	m/s^2
$A_{\text{brake safe dry}}(\text{C, V, EBCL})$	safe emergency brake deceleration on dry rails	m/s^2
$A_{\text{nominal}}(\text{C, V})$	nominal deceleration in emergency brake, also called A_brake_emergency in SUBSET-026-3 [11]	m/s^2
$A_{\text{nominalSB}}(\text{C, V})$	nominal deceleration in service brake, also called A_brake_normal_service in SUBSET 026-3 [11]	m/s^2
$A_{\text{normal}}(\text{C, V})$	normal service brake deceleration, also called A_brake_ normal_service in SUBSET-026-3 [11]	m/s^2
C	identification of the configuration of the brakes (combination of special brake, degraded modes with brakes isolated, multiple unit operation, etc.)	—
F	braking force	N
$K_{\text{dry}}(\text{C, V, EBCL})$	correction factor, also called Kdry_rst in SUBSET-026-3 [11]	—
$K_{\text{i}}(\text{C, V})$	correction factor for one random selected combination “i” (also called case “i”) of parameters (influencing braking force and failure behaviour) for calculation of deceleration	—
$K_{\text{n}}(\text{V})$	speed dependent correction factors for gradient on the normal service brake; split in $K_{n+(V)}$ (uphill) and $K_{n-(V)}$ (downhill)	—
$K_{\text{wet}}(\text{C, V})$	correction factor, also called Kwet_rst in SUBSET-026-3 [11]	—
P	probability of failure	—
$t_{\text{eEB}}(\text{C})$	equivalent emergency brake response time, also called T_brake_emergency (for emergency brake) in SUBSET-026-3 [11]	s
$t_{\text{eSB}}(\text{C})$	equivalent service brake response time, also called T_brake_service (for service brake) in SUBSET-026-3 [11]	s
$t_{\text{tco}}(\text{C})$	traction cut-off time, also called T_traction_cut_off in SUBSET-026-3 [11], 3.13.2.2.2	s
V	identification of the speed interval	—
V_{max}	maximum design speed of the train	—
α	weighting factor representing the part of a brake unit/group of brake units/brake type force in the total braking force	—
α'	ratio of the maximum force generated by a traction unit compared to the total braking force at train level	—
β	factor representing the product of all deviations and failure impacting the braking force of a brake unit	—
β'	factor representing the probability of traction cut-off failures leading to a reduction of total braking force by generation of a traction force	—
BCU	brake control unit	—

Symbol	Definition	Unit
DBU	disc brake unit	—
EBCL	emergency brake confidence level	—
ECB	eddy current brake	—
ED	electro-dynamic brake	—
ETCS	European Train Control System	—
FIT	failures in time	—
MTB	magnetic track brake	—
Rnd	random function	—
TBU	tread brake unit	—

4 ETCS on-board brake model parameters

4.1 ETCS on-board emergency brake model parameters

4.1.1 Nominal emergency brake deceleration $A_{nominal}$

$A_{nominal}$(C,V) is the established deceleration during an emergency braking for a given reference case of the train (configuration, load) for a defined speed interval (see [11] and [12]). The determination of $A_{nominal}$ is described in 7.2.

4.1.2 Correction factor K_{dry}(C, V, EBCL)

K_{dry}(C,V,EBCL) is a rolling stock correction factor that, applied to $A_{nominal}$, gives the safe emergency brake deceleration of the considered train (configuration, load) on dry rails according to the required confidence level, and for a defined speed interval (see [11] and [12]).

$$A_{\text{brake safe dry}}\left(\text{C, V, EBCL}\right) = K_{\text{dry}}\left(\text{C, V, EBCL}\right) \times A_{\text{nominal}}\left(\text{C, V}\right) \quad (1)$$

The determination of K_{dry}(C, V, EBCL) is described in 7.3.

4.1.3 Correction factor K_{wet}(C, V)

K_{wet}(C,V) is a rolling stock correction factor that considers in a limited way the loss of deceleration with regards to emergency braking on dry rails, when the emergency brake is applied on wet rails, in accordance with wheel/rail adhesion reference conditions, and for a defined speed interval (see [11] and [12]).

$$A_{\text{brake safe}}\left(\text{C,V, EBCL}\right) = \left(K_{\text{wet}}\left(\text{C,V}\right) + \text{M}_{\text{NVAVADH}} \times \left(1 - K_{\text{wet}}\left(\text{C, V}\right)\right)\right) \times A_{\text{brake safe dry}}\left(\text{C, V, EBCL}\right) \quad (2)$$

NOTE $M_{NVAVADH}$ is a trackside ETCS parameter and is not described in this document.

The determination of K_{wet}(C, V) is described in 7.4.

4.1.4 Emergency brake response time

The equivalent emergency brake response time t_{eEB} (see 7.5) is used to model the transition between the emergency brake demand and the fully established emergency braking force (see [11] and [12]).

4.1.5 Traction cut-off time

The traction cut-off time t_{tco} (see 7.6) is used to model the transition between the emergency brake demand or traction cut-off demand and to the moment the acceleration due to traction (A_traction) is zero after a trainwide control signal for an emergency brake application.

4.2 ETCS on-board service brake model parameters

4.2.1 General

The service brake performance is not safety relevant. So no worst-case conditions (e.g. correction factors, adhesion conditions) are considered for its calculation.

4.2.2 Nominal service brake deceleration $A_{nominalSB}$

$A_{nominalSB}$(C,V) is the established deceleration during a full service braking for a given reference case of the train (configuration, load) for a defined speed interval (see [11]).

The determination of $A_{nominalSB}$ is described in 8.2.

4.2.3 Service brake response time

The equivalent service brake response time t_{eSB} (see 8.3) is used to model the transition between the service brake demand and the fully established service brake braking force (see [11]).

4.2.4 Normal service brake deceleration and K_n correction factors

The normal service brake deceleration A_{normal}(C,V) is used in combination with the speed dependent on-board correction factors for gradient K_n+(V) and K_n-(V) to calculate $A_{normal\_service}$(V,d). This deceleration is used to calculate the guidance curve (GUI), which is an optional braking curve in ETCS (see [11]).

Recommendations for determining A_{normal} are described in 8.4.

5 Brake system architecture model

5.1 General

The term “brake system architecture model” describes the model, which is applied when calculating the correction factor K_{dry}(C, V, EBCL), and which is consistent with the determination of the nominal decelerations.

For this purpose, the architecture model is a set of formulas and algorithms formed from parameters that influence braking performance.

The parameters consider both statistical and structural information related to braking.

The structural information depends on the specific vehicle architecture. The structural information shows how many brake units are affected when a specific parameter deviates or fails.

The statistical information contains both the probability and impact of a failure of a component (considering the structural information) and the behaviour of its deviation from the nominal values.

Both information elements are to be considered in the generation of the architecture model.

The following clauses describe the steps to be followed for building a brake system architecture model representative of the real performance of the train, from a braking point of view.

The steps are organized to avoid missing any component in the architecture model that may have a significant impact on the braking performance of the train.

The process is suitable for both new and existing vehicles or trains. Examples of the process are given in Annex C.

The technical scope is determined by the parameters that are considered in the brake system architecture model. The basic intention of the technical scope is to consider all relevant effects on the braking performance.

The definition of train related brake model includes all the parameters with influence on the braking performance. These parameters are not limited to the braking system, but can also come from other systems, such as power supply, vehicle control and the traction system.

Technical systems need energy to provide braking force. This energy is usually stored. There are pressure vessels or batteries for this purpose. Within the scope is the brake energy storage of the systems. Outside the scope are the systems that recharge the brake energy storage (e.g. compressors, generators).

If a system operates without brake energy storage, the systems for providing the energy are the subject of the scope.

The capacity of the brake energy storage is usually dimensioned in such a way that minimum one braking application under any condition (environmental, load, speed, etc.) can be carried out without recharging. If this is not possible, the scope also refers to the systems for charging the brake energy storages.

Another consideration limit results from the maximum resolution that is achieved with the calculation model. The smallest unit is the so-called "base unit". Below the base unit, the resolution does not need to be increased.

If relevant influences below the base unit are worked out within the framework of the technical analysis, these shall be considered in a suitable manner (see "model simplification" 5.2.4).

The brake system architecture model considers random failures and deviations of braking force relevant components. Systematically caused failures of technical functions or components are not considered. These are, among others, errors in construction documents or design documents. Errors due to incorrect programming of software components are also included to systematically caused failures. These systematically caused errors shall be excluded by other suitable measures.

5.2 General procedure description for K_{dry}(C, V, EBCL) determination

5.2.1 General

The process is split in 3 steps as presented in Figure 1.

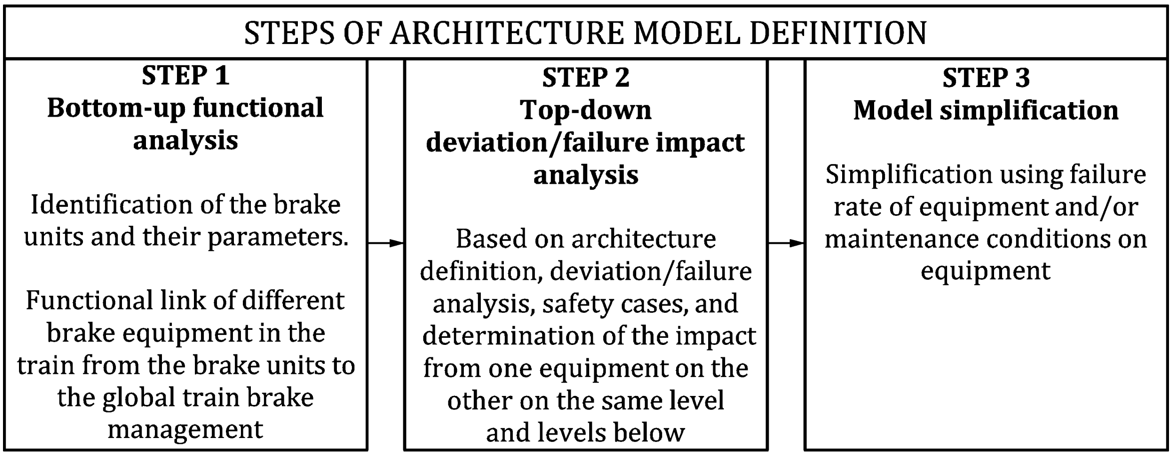

Figure 1 — General process description for the development of the brake system architecture model