SLOVENSKI STANDARD

oSIST prEN IEC 63453:2023

01-september-2023

Železniške naprave - Sistemi tokovnega odjema - Veljavnost simuliranja medsebojnih dinamičnih vplivov med tokovnim odjemnikom in kontaktnim vodnikom

Railway applications - Current collection systems - Validation of simulation of the dynamic interaction between pantograph and overhead contact line

Ta slovenski standard je istoveten z: **prEN IEC 63453:2023**

ICS:

29.280	Električna vlečna oprema	Electric traction equipment

oSIST prEN IEC 63453:2023 **en**

9/2962/CDV

COMMITTEE DRAFT FOR VOTE (CDV)

PROJECT NUMBER: **IEC 63453 ED1**	
DATE OF CIRCULATION: **2023-06-16**	CLOSING DATE FOR VOTING: **2023-09-08**
SUPERSEDES DOCUMENTS: **9/2836A/CD, 9/2877B/CC**	

IEC TC 9 : ELECTRICAL EQUIPMENT AND SYSTEMS FOR RAILWAYS	
SECRETARIAT: France	SECRETARY: Mr Denis MIGLIANICO
OF INTEREST TO THE FOLLOWING COMMITTEES:	PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary.
FUNCTIONS CONCERNED: ☐ EMC ☐ ENVIRONMENT ☐ QUALITY ASSURANCE ☐ SAFETY	
☒ SUBMITTED FOR CENELEC PARALLEL VOTING **Attention IEC-CENELEC parallel voting** The attention of IEC National Committees, members of CENELEC, is drawn to the fact that this Committee Draft for Vote (CDV) is submitted for parallel voting. The CENELEC members are invited to vote through the CENELEC online voting system.	☐ NOT SUBMITTED FOR CENELEC PARALLEL VOTING

This document is still under study and subject to change. It should not be used for reference purposes.

Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

Recipients of this document are invited to submit, with their comments, notification of any relevant "In Some Countries" clauses to be included should this proposal proceed. Recipients are reminded that the CDV stage is the final stage for submitting ISC clauses. (SEE AC/22/2007 OR NEW GUIDANCE DOC).

TITLE:

Railway applications – Current collection systems – Validation of simulation of the dynamic interaction between pantograph and overhead contact line

PROPOSED STABILITY DATE: 2028

NOTE FROM TC/SC OFFICERS:

IEC 63453 ED1 is the conversion of EN 50318:2018 into an IEC Standard

Contents

Page

Railway applications – Current collection systems – Validation of simulation of the dynamic interaction between pantograph and overhead contact line

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.

3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.

4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.

5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.

6) All users should ensure that they have the latest edition of this publication.

7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.

8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.

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

IEC 63453 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways . It is an International Standard,.

1 Scope

Simulation techniques are used to assess the dynamic interaction between overhead contact lines and pantographs, as part of the prediction of current collection quality. This document specifies functional requirements for the validation of such simulation tools to ensure confidence in, and mutual acceptance of the results of the simulations.

This document deals with:

– input and output parameters of the simulation;

– comparison with line test measurements, and the characteristics of those line tests;

– validation of pantograph models;

– comparison between different simulation tools;

– limits of application of validated methods to assessments of pantographs and overhead contact lines.

This document applies to the current collection from an overhead contact line by pantographs mounted on railway vehicles. It does not apply to trolley bus systems.

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.

IEC 60913:2013, *Railway applications — Fixed installations — Electric traction overhead contact lines*

IEC 60494-1:2013, *Railway applications — Rolling stock — Pantographs - Characteristics and tests — Part 1: Pantographs for main line vehicles*

IEC 62846:2016, *Railway applications —Current collection systems — Requirements for and validation of measurements of the dynamic interaction between pantograph and overhead contact line*

IEC 62486:2017, *Railway applications — Current collection systems — Technical criteria for the interaction between pantograph and overhead contact line (to achieve free access)*

3 Terms and definitions

For the purpose of this document, the following terms and definitions apply.

ISO and IEC maintain terminology 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
contact point
<for a pantograph> location of mechanical contact between a pantograph contact strip and a contact wire

3.2
contact force
<for a pantograph> vertical force applied by a pantograph to the overhead contact line

Note 1 to entry: The contact force is the sum of forces of all contact points of one pantograph.

3.3
static contact force
vertical force exerted upward by the collector head on the overhead contact line system at standstill

[SOURCE: IEC 60494-1:2013, 3.3.5]

3.4
aerodynamic force
additional vertical force applied by the pantograph as a result of air flow around the pantograph assembly

3.5
mean contact force
statistical mean value of the contact force

Note 1 to entry: Fm is formed by the static and aerodynamic components of the pantograph contact force.

[SOURCE: IEC 62486:2017, 3.11]

3.6
standard deviation <of contact force>
square root of the sum of the squared sample variance divided by the number of output values minus 1

3.7
skewness
parameter that quantifies the symmetry of the shape of a data distribution

$$sk = \frac{\sum \frac{\left(F - F_m\right)^3}{n}}{\left(\sum \frac{\left(F - F_m\right)^2}{n}\right)^{\frac{3}{2}}} \quad (1)$$

3.8
excess of kurtosis
parameter that quantifies whether the shape of the data distribution matches the Gaussian distribution

$$ek = \frac{\sum \frac{\left(F - F_m\right)^4}{n}}{\left(\sum \frac{\left(F - F_m\right)^2}{n}\right)^{2}} - 3 \quad (2)$$

3.9
minimum of contact force
minimum value of the contact force while the pantograph passes over the analysis section

3.10
maximum of contact force
maximum value of the contact force while the pantograph passes over the analysis section

3.11
contact loss
condition where the contact force is zero

Note 1 to entry: Contact loss surely induces arcing except in the case of coasting. However, if two or more pantographs are connected electrically each other, arc will immediately disappear and then the condition will shift to 'current loss'.

[SOURCE: IEC 62486:2017, 3.22]

3.12
simulation method
numerical method that uses a fixed set of input parameters describing a system (e.g. pantograph/overhead contact line system) to calculate a set of output values representative of the dynamic behaviour of this system

3.13
simulation tool
software implementing (a) simulation method(s)

3.14
pantograph model
mathematical model in a one- or more-dimensional geometry describing the dynamic characteristics of the pantograph

3.15
mass – spring – damper – model
lumped parameter model
method representing a dynamic mechanical system (e.g. pantograph) as a series of discrete concentrated masses connected together by spring and damper elements

3.16
transfer function <of a pantograph>
ratio of an applied input on pantograph head to the response of the pantograph, depending on frequency

3.17
apparent mass <of a pantograph>
transfer function describing the relation between applied contact force and resulting acceleration at the contact point for the frequency range of interest

3.18
hardware in the loop
hybrid simulation/test rig measuring method, where a real pantograph responds interacting with a simulation model of the overhead contact line

3.19
multi-body model
method representing a dynamic mechanical system (e.g. pantograph) based on interconnected rigid or flexible bodies

3.20
collector head
pantograph head
part of the pantograph supported by the frame which includes contact strips, horns and can include a suspension

[SOURCE: IEC 60494-1:2013, 3.2.3, modified – the term "pantograph head" has been added.]

3.21
overhead contact line model
mathematical model in a two- or three-dimensional geometry describing the characteristics of an overhead contact line for interaction with pantographs

3.22
wave propagation velocity <of the contact wire>
speed of a transversal wave, which runs along the contact wire

3.23
contact wire height at rest position
distance from the top of the rail (or road surface for overhead contact line system for trolleybus applications) to the lower face of the contact wire, measured perpendicular to the track

Note 1 to entry: The contact wire height is measured perpendicular to the track or road surface.

3.24
maximum uplift at the support
maximum value of the vertical uplift of the contact wire at a support

3.25
analysis section
subset of the total overhead contact line model length over which the simulation will be evaluated

3.26
frequency range of interest
frequency range within which the dynamic performance of the overhead contact line – pantograph system is considered

Note 1 to entry: For validation with measurements this range correlates with the frequency range defined in IEC 62846.

3.27
dynamic interaction
behaviour between pantograph(s) and overhead contact line when in contact, described by contact forces and vertical displacements of contact point(s)

3.28
frequency band analysis
analysis inside a frequency range of interest using subranges of frequencies to study special topics

3.29
elasticity of overhead contact line
uplift divided by the force applied to the contact wire in a static state

3.30
range of vertical position of the point of contact
difference between maximum and minimum dynamic height of the contact point, relative to the track, during dynamic interaction between the pantograph and the contact wire

3.31
operation height
vertical distance between actual operating position of the pantograph and pantographs housed height

3.32
active pantograph
pantograph fitted with any type of active control system which enhances or alters its dynamic response

4 Symbols and abbreviations

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

Abbreviations:

CT	centre of the track
CW	contact wire
CWH	contact wire height
FFT	fast Fourier transformation
HIL	hardware in the loop
MT	mast type
MW	messenger wire
Mxx	support or mast number
OCL	overhead contact line
ROCL	rigid overhead contact line
SDx	number of dropper to stitch wire
STx	span type number as reference to Figure Span number
SW	stitch wire

Symbols:

$a_{cp,meas}$	measured vertical acceleration at the contact point
$a_{cp,model}$	simulated vertical acceleration at the contact point
C_s	structural damping matrix
c_n	damping of element n
Dx	dropper number
E	modulus of elasticity
e	elasticity of overhead contact line
ek	excess of kurtosis of contact force
F	contact force
$F_{applied,meas}$	measured vertical force applied at the contact point
$F_{applied,model}$	simulated vertical force applied at the contact point
F_m	mean contact force
F_{sa}	lateral force at steady arm
f_i	actual frequency
f_n	maximum frequency
f_1	minimum frequency
K	stiffness matrix
k_n	stiffness of element n
L_{dr}	dropper length
Lx_{dr}	dropper length (for CW no. x)
L_{sa}	length of steady arm
M	mass matrix
$m_{app,meas}$	measured apparent mass
$m_{app,model}$	apparent mass of the model
m_n	mass of element n
Q	accuracy of the pantograph simulation model
sk	skewness of contact force
X	distance between left mast and dropper no. x
α, β	proportional damping coefficients
σ	standard deviation of contact force

5 General

5.1 Overview of the validation process

The theoretical study of the dynamic interaction between pantograph and overhead contact line by computer simulation makes it possible to obtain much information about the system and to minimize the costs of line tests.

To be used with confidence the simulation tool shall be validated. The validation for a simulation tool shall be done in a process described in Figure 1.

A simulation tool validated according to this standard, shall be considered for application to overhead contact line/pantograph combinations and conditions only within the limits of validity defined in 10.3.

A new validation shall be made when the conditions to apply simulation are outside the limitations defined in 10.3 for existing validations.

The validation for a simulation tool shall be done with the steps which are shown in Figure 1. The steps are:

1) A first validation step shall be done by a “desktop assessment” in accordance to Clause 11. The most relevant reference model data shall be chosen from the reference models in Annex A for the conditions for which validation is required.

   NOTE This desktop assessment will improve the confidence in the simulation tool. As Annex A cannot cover all possible solutions and combinations a choice from this subset is necessary.

   For validation of simulation tools implemented for new technologies in ways that are totally different from the current state of the art, and which are not able to use models with the data according to Annex A, the “desktop assessment” may be omitted.

NOTE Typically, all simulation tools for OCL from type “Flexible overhead contact line” according to IEC 60913 can use models with data according to Annex A.

2) The final assessment shall be done by a “Line Test Data Validation” based on test results according to 10.1 to demonstrate the accuracy of simulation according to 10.2.

   Annex B provides data sets from line test measurements in accordance with IEC62846 to allow for a validation for a given model within the limitations according to 10.3.

If the accuracy according to either 10.2 or to 11.4 cannot be achieved, then the simulation tool shall be improved according to 6.3 for pantograph model adjustments and according to 7.3 for overhead contact line model before revalidation.