SLOVENSKI STANDARD
oSIST prEN 50318:2017

01-februar-2017

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

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Bahnanwendungen - Stromabnahmesysteme - Validierung von Simulationssystemen für das dynamische Zusammenwirken zwischen Dachstromabnehmer und Oberleitung

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Applications ferroviaires - Systèmes de captage de courant - Validation des simulations de l'interaction dynamique entre le pantographe et la caténaire

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29.280 Električna vlečna oprema Electric traction equipment

oSIST prEN 50318:2017 **en**

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

DRAFT
prEN 50318

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ICS 29.280

Will supersede EN 50318:2002

English Version

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

Applications ferroviaires - Systèmes de captage de courant - Validation des simulations de l'interaction dynamique entre le pantographe et la caténaire

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This draft European Standard is submitted to CENELEC members for enquiry.
Deadline for CENELEC: 2017-02-10.

It has been drawn up by CLC/SC 9XC.

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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European foreword

This document has been prepared by CLC/SC 9XC, “Electric supply and earthing systems for public transport equipment and ancillary apparatus (fixed installations) of CLC/TC 9X “Electrical and electronic applications for railways”.

It is currently submitted to the Enquiry.

This document will supersede EN 50318:2002.

The following dates are proposed:

-	latest date by which the existence of this document has to be announced at national level	(doa)	dor + 6 months
-	latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	dor + 12 months
-	latest date by which the national standards conflicting with this document have to be withdrawn	(dow)	dor + 36 months (to be confirmed or modified when voting)

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Annexes designated “normative” are part of the body of the standard. In this standard, Annex A and Annex B are normative.

This document has been prepared under a mandate given to CENELEC by the European Commission and supports essential requirements of EU Directive(s).

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

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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 European Standard specifies functional requirements for the validation of such simulation methods to ensure confidence in, and mutual acceptance of the results of the simulations.

This standard deals with:

– input and output parameters of the simulation,

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

– comparison between different simulation methods, and

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

This standard 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, 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 50119, *Railway applications — Fixed installations — Electric traction overhead contact lines*

EN 50206-1, *Railway applications — Rolling stock — Pantographs: Characteristics and tests — Part 1: Pantographs for main line vehicles*

EN 50206-2, *Railway applications — Rolling stock — Pantographs: Characteristics and tests — Part 2: Pantographs for metros and light rail vehicles*

EN 50317, *Railway applications — Current collection systems — Requirements for and validation of measurements of the dynamic interaction between pantograph and overhead contact line*

EN 50367, *Railway applications — Current collection systems — Technical criteria for the interaction between pantograph and overhead line (to achieve free access)*

3 Terms and definitions

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

3.1
contact point
point of mechanical contact between a contact strip and a contact wire

3.2
contact force
vertical force applied by the pantograph to the overhead contact line. The contact force is the sum of the forces of all contact points

3.3
static force
mean vertical force exerted upward by the collector head on the overhead contact line, and caused by the pantograph raising device, whilst the pantograph is raised and the vehicle is at standstill

[SOURCE: EN 50206-1]

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3.4
aerodynamic force
vertical force applied to the pantograph as a result of air flow around the pantograph components

3.5
mean contact force
arithmetic mean of contact force

3.6
standard deviation of contact force
square root of the sum of the square errors divided by the number of output values minus 1 of the contact force

3.7
skewness of contact force
parameter that quantifies the symmetry of the shape of a data distribution, calculated as

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

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3.8
excess of kurtosis of contact force
parameter that quantifies whether the shape of the data distribution matches the Gaussian distribution calculated as

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

3.9
statistical minimum of contact force
value of contact force represented by F_m - 3 σ,

Note 1 to entry: In case of a Gaussian distribution 99,865 % of all contact forces will be higher than the statistical minimum.

Note 2 to entry: As the distribution of forces in pantograph/OCL interaction is not a Normal (Gaussian) distribution, then this will not be the minimum contact force observed.

3.10
statistical maximum of contact force
value of contact force represented by $F_m + 3\sigma$

Note 1 to entry: In case of a Gaussian distribution 99,865 % of all contact forces will be less than the statistical maximum.

Note 2 to entry: As the distribution of forces in pantograph/OCL interaction is not a Normal (Gaussian) distribution, then this will not be the maximum contact force observed.

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3.11
minimum of contact force
minimum contact force while the pantograph passes over the analysis section

3.12
maximum of contact force
maximum contact force while the pantograph passes over the analysis section

3.13
loss of contact
condition when the contact force is zero

3.14
simulation method
any 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

3.15
pantograph model
mathematical model in a one- or more-dimensional geometry describing the dynamic characteristics of the pantograph

3.16
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

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3.17
transfer function of a pantograph
ratio of an applied force to the response of the pantograph, depending on frequency

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3.18
apparent mass function 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

3.19
hardware in the loop (HIL)
hybrid simulation/test rig measuring method, where a real pantograph responds interacting with a simulation model of the overhead contact line

3.20
multibody model
method representing a dynamic mechanical system (e.g. pantograph) based on interconnected rigid or flexible bodies

3.21
collector head
part of the pantograph supported by the frame, which includes contact strips, horns and may include a suspension

3.22
dynamic overhead contact line model
mathematical model in a two- or three-dimensional geometry describing the dynamic characteristics of an overhead contact line for interaction with pantographs

3.23
static model of an overhead contact line
mathematical model that describes the steady state of an overhead contact line at rest

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3.24
wave propagation speed of the contact wire
speed of a transversal wave, which runs along the contact wire

3.25
maximum uplift at the support
maximum value of the vertical uplift of the contact wire at each support within the analysis section, while the pantograph passes

3.26
analysis section
subset of the total overhead contact line model length which consists of those parts over which the passage of the pantographs is not influenced by initial transients and end effects of the model

3.27
frequency range of interest
frequency range within which the dynamic performance of the overhead contact line – pantograph system is considered

3.28
dynamic interaction
behaviour between pantograph(s) and overhead contact line in contact, described by contact forces and vertical displacements of contact point(s)

3.29
frequency band analysis
analysis inside a frequency range of interest using subranges of frequencies to study special topics

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NOTE to entry: The use of subranges for frequencies give a relation of results with regarding geometrical characteristics of the system, like dropper passing or span passing frequencies.

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3.30
elasticity of overhead contact line
uplift divided by the force implied to the contact wire in static state.

3.31
range of vertical displacement of the point of contact
difference between maximum and minimum dynamic height of contact point, related to the track.

4 Symbols and abbreviations

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

α, β	proportional damping coefficients
σ	standard deviation of contact force
$a_{head,meas}$	measured vertical acceleration at the contact point
$a_{head,model}$	simulated vertical acceleration at the contact point
c_n	damping of element n
C_s	structural damping matrix
E	modulus of elasticity
e	elasticity of contact line
ek	excess of kurtosis of contact force
F	contact force
F_m	mean contact force

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$F_{applied,meas}$	measured vertical force applied at the contact point
$F_{applied,model}$	simulated vertical force applied at the contact point
f_1	minimum frequency
f_i	actual frequency
f_n	maximum frequency
k_n	stiffness of element n
K	stiffness matrix
m_n	mass of element n
M	mass matrix
$m_{app,meas}$	measured apparent mass
$m_{app,model}$	apparent mass of the model
Q	accuracy of the pantograph simulation model
sk	skewness of contact force
OCL	overhead contact line
HIL	hardware in the loop

5 General

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5.1 Typical application

One of the purposes of the application of this standard is to inform the process for seeking authorisation for an OCL or pantograph design. In Annex C, Figure C.1 shows the route through to assessment of an OCL system in accordance with the ENE TSI [1], and Figure C.2 the assessment of a pantograph in accordance with the LOC & PAS TSI [2], for European Interoperability. Note that other process flows will be applicable for other purposes, such as research, technical development, etc.

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5.2 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 minimise the costs of line tests.

In order to be used with confidence the simulation method shall be validated. The validation for a simulation method shall be done in a process described in Figure 1.

A simulation method 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.

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

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

2. A first validation step shall be done by a “Desktop Assessment” in accordance to Clause 11. The reference model data shall be chosen from reference models in Annex A as most relevant for the conditions to validate for.

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

For validation of simulation methods 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.

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3. 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.

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

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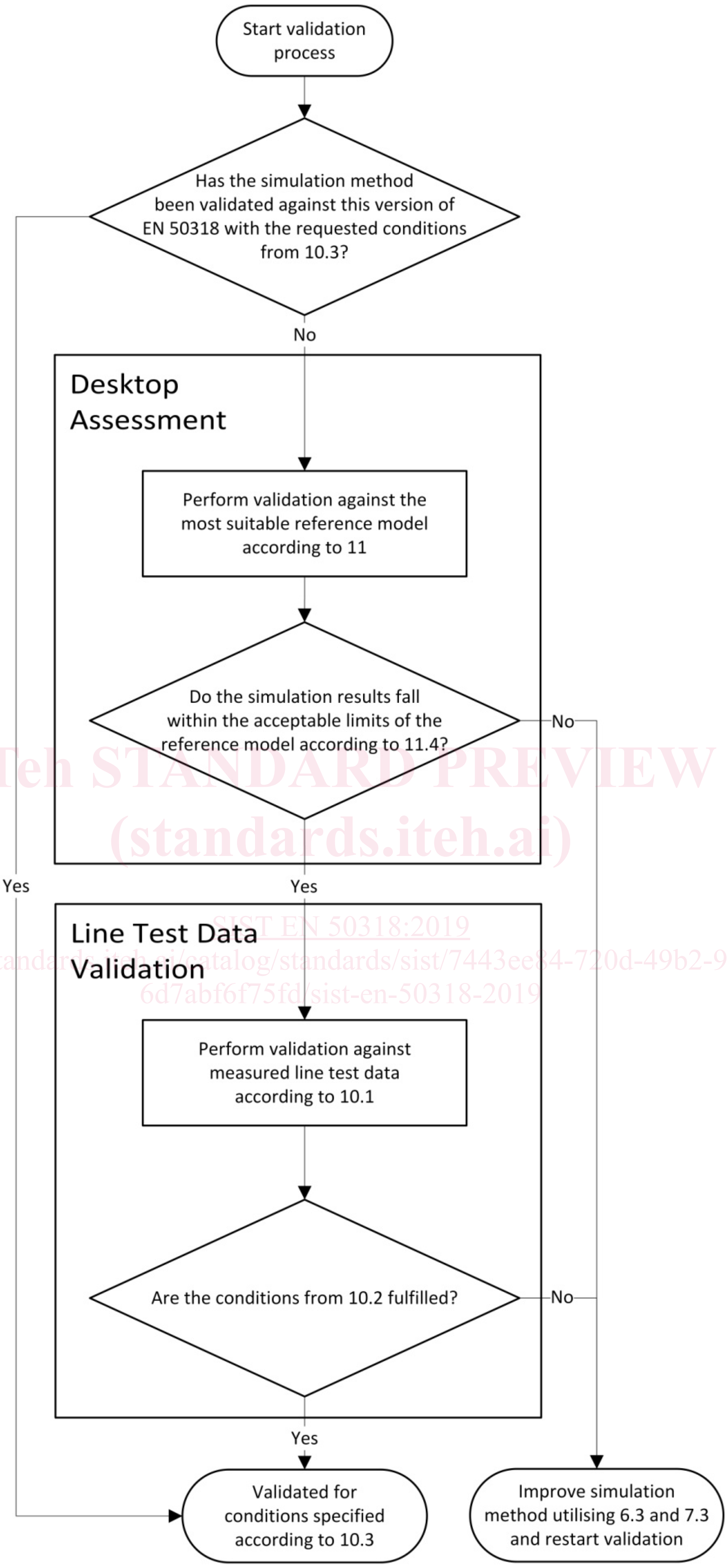

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294 **Figure 1 — Evaluation process**

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6 Modelling of the pantograph

6.1 General requirements

A pantograph model shall describe the dynamic characteristics of a pantograph, regarding interaction with overhead contact lines, in the frequency range of interest.

Commonly used pantograph models are:

– mass – spring – damper – models (lumped parameter models);

– transfer function models;

– multi-body models;

– physical pantographs, when hardware in the loop (HIL) is adopted.

The pantograph may be modelled with one or more dimensional geometry, depending on the phenomena to be investigated.

The characteristics of control and the dynamic characteristics of active pantographs shall be available for the modelling method.

Aerodynamic effects on the pantograph shall as a minimum be considered by enhancing the mean contact force as a function of speed.

6.2 Input data requirements

6.2.1 General

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Depending on the modelling method and the individual pantograph characteristics, the relevant parameters appropriate to fully describe the pantograph shall be available for simulation.

These parameters shall take into account other dependencies (operation height, stagger, non-linearities, frequency), as required.

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Common parameters of pantographs are:

– kinematics;

– transfer function;

– natural frequencies;

– mass distribution;

– degree of freedom of joints;

– damping characteristics;

– spring characteristics;

– friction values;

– stiffness;

– bump stops;

– location of application of the static force;

– location of application of the aerodynamic forces.

NOTE Aerodynamic forces usually depend on the orientation, operation height and position of the pantograph and the type of train.