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INTERNATIONAL STANDARD

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

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RAILWAY APPLICATIONS – CURRENT COLLECTION SYSTEMS – VALIDATION OF SIMULATION OF THE DYNAMIC INTERACTION BETWEEN PANTOGRAPH AND OVERHEAD CONTACT LINE

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The text of this International Standard is based on the following documents:

Draft	Report on voting
9/3145/FDIS	9/3163/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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RAILWAY APPLICATIONS – CURRENT COLLECTION SYSTEMS – VALIDATION OF SIMULATION OF THE DYNAMIC INTERACTION BETWEEN PANTOGRAPH AND OVERHEAD CONTACT LINE

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

IEC 60913:2024, *Railway applications – Fixed installations – Electric traction overhead contact line systems*

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 contactline (to achieve free access)*

3 Terms and definitions

For the purposes 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 https://www.electropedia.org/
- ISO Online browsing platform: available at https://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
F
<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
F_m
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
sk
parameter that quantifies the symmetry of the shape of a data distribution

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

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

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

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

3.10
maximum 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 and 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 one or more simulation methods

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 method (simulation and dynamic laboratory test), 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
pantograph head
pantograph pan
part of the pantograph comprising the contact strips and their mountings, horns and possibly a suspension

[SOURCE: IEC 60050-811:2017, 811-32-05]

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
compound catenary
overhead contact line with one or two contact wires suspended from an auxiliary messenger wire which is suspended from the main messenger wire

[SOURCE: IEC 60050-811:2017, 811-33-12 modified: catenary wire to messenger wire, deleted: equipment]

3.23
messenger wire
longitudinal cable supporting the contact wire or wires either directly or indirectly

[SOURCE: IEC 60050-811:2017, 811-33-06, deleted: catenary wire]

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

3.25
contact wire height
distance from the top of the rail to the lower face of the contact wire at rest position without pantograph contacted

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

[SOURCE: IEC 60050-811:2017, 811-33-62 modified; added: at rest position; deleted: (or road surface for overhead contact line system for trolleybus applications)]

3.26
maximum uplift at the support
maximum value of the vertical uplift of the contact wire at a support

3.27
analysis section
subset of the total overhead contact line model length over which the simulation will be evaluated

3.28
frequency range of interest
frequency range within which the dynamic performance of the overhead contact line and pantograph system is considered

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

3.29
dynamic interaction
behaviour between pantograph(s) and overhead contact line when in contact, described by contact forces and vertical displacements of contact point(s)

3.30
frequency band analysis
analysis inside a frequency range of interest using subranges of frequencies to study special topics

3.31
elasticity of overhead contact line
uplift divided by the force applied to the contact wire in a static state

3.32
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

3.33
operation height
vertical distance between actual operating position of the pantograph and pantograph’s housed height

3.34
active pantograph
pantograph fitted with any type of active control system which enhances or alters its dynamic response