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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Railway applications – Current collection systems – Technical criteria for the interaction between pantograph and overhead line (to achieve free access)

Applications ferroviaires – Systèmes de captage de courant – Critères techniques d'interaction entre le pantographe et la ligne aérienne de contact (réalisation du libre accès)

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RAILWAY APPLICATIONS – CURRENT COLLECTION SYSTEMS – TECHNICAL CRITERIA FOR THE INTERACTION BETWEEN PANTOGRAPH AND OVERHEAD LINE (TO ACHIEVE FREE ACCESS)

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This standard is based on EN 50367.

The text of this standard is based on the following documents:

FDIS	Report on voting
9/1396/FDIS	9/1433/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

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RAILWAY APPLICATIONS – CURRENT COLLECTION SYSTEMS – TECHNICAL CRITERIA FOR THE INTERACTION BETWEEN PANTOGRAPH AND OVERHEAD LINE (TO ACHIEVE FREE ACCESS)

1 Scope

Combination of different overhead contact lines and pantographs will provide various interaction performances.

This International Standard defines parameters for interoperability in the field of interaction between the pantograph and the overhead contact line. The standard specifies the interface requirements of rolling stock and infrastructure to achieve free access.

This standard describes parameters and values for all planned lines and future lines.

Annex B gives some essential parameters for existing lines.

The energy supply system is not covered by this standard.

2 Normative references

The following referenced documents are indispensable for the application 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 60494-1:2002, *Railway applications – Rolling stock – Pantographs – Characteristics and tests – Part 1: Pantographs for mainline vehicles*

IEC 62313:2009, *Railway applications – Power supply and rolling stock – Technical criteria for the coordination between power supply (substation) and rolling stock*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply:

3.1
maximum collected current
highest value of current that is collected by a pantograph from an overhead contact line

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

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

3.4
mean contact force
statistical mean value of the contact force

3.5
maximum contact force
maximum value of the contact force

3.6
minimum contact force
minimum value of the contact force

3.7
overhead contact line
contact line placed above (or beside) the upper limit of the vehicle gauge and supplying vehicles with electric energy through roof-mounted current collection equipment

[IEV 811-33-02]

3.8
neutral section
section of a contact line provided with a sectioning point at each end to prevent successive electrical sections, differing in voltage, phase or frequency being connected together by the passage of current collectors

[IEV 811-36-16, modified]

3.9
nominal voltage
voltage by which an installation or part of an installation is designated

[IEC 60850]

3.10
contact wire height
distance from the top of the rail to the lower face of the contact wire, measured perpendicular to the track

[EN 50119]

3.11
minimum contact wire height
minimum value of the contact wire height occurring in any possible case during the lifetime of the overhead contact line

3.12
nominal contact wire height
nominal value of the contact wire height at a support in the normal conditions

[EN 50119]

3.13
maximum contact wire height
maximum value of the contact wire height occurring in any possible case during the lifetime of the overhead contact line

3.14
automatic dropping device
device that lowers the pantograph in the event of pantograph head failure or damage of the pantograph head

[IEC 60494-1]

3.15
arcing
flow of current through an air gap between a contact strip and a contact wire usually indicated by the emission of intense light

3.16
percentage of arcing
this is given by the following formula:

$$NQ = \frac{\sum t_{\text{arc}}}{t_{\text{total}}} \times 100$$

where

t_{arc} is the duration of an arc lasting longer than 5 ms;

t_{total} is the measuring time with a current greater than 30 % of the nominal current.

The result, given in per cent, is a characteristic for a given speed of the vehicle

3.17
maximum width
maximum distance measured along the axis of the track between the outer edges of the contact strips

3.18
kinematics envelope
maximum envelope of the pantograph head under all operating conditions

3.19
skew of pantograph head
vertical distance between the highest point of the pantograph head and the contact point

3.20
percentage of all arcing
this is given by the following formula:

$$AQ = \frac{\sum t_{\text{arc}}}{t_{\text{total}}} \times 100$$

where

t_{arc} is the duration of an arc measured with visible light of arcing;

t_{total} is the measuring time with a current greater than 30 % of the nominal current.

The result, given in per cent, is a characteristic for a given speed of the vehicle

3.21
percentage of contact loss
this is given by the following formula:

$$CQ = \frac{\sum t_{\text{cl}}}{t_{\text{total}}} \times 100$$

where

t_{cl} is the duration of contact loss (e.g. measurement with waveform of collected current of pantograph which is connected with another pantograph);

t_{total} is the measuring time with a current greater than 30 % of the nominal current.

The result, given in per cent, is a characteristic for a given speed of the vehicle

4 Symbols and abbreviations

C	length of common part
D	overall length of neutral section
D'	length of neutral zone
D	length of insulator inserted in the contact wire
F_m	mean contact force
F_{max}	maximum contact force
F_{min}	minimum contact force
GC	gauge C according UIC leaflet 506
L	distance between closest pantographs
L'	distance covered by farthest pantographs
L''	distance between 3 consecutive pantographs
l	maximum width
NQ	percentage of arcing
AQ	percentage of all arcing
CQ	percentage of contact loss
σ_{max}	maximum standard deviation of contact force

5 Geometry

5.1 General

The infrastructure manager shall ensure that the values for the geometric characteristics of the overhead contact line are as shown in Table 1 and Table 2.

The pantographs of the train shall fulfil the geometric characteristics as shown in Table 4, according to the type of infrastructure on which it will circulate under the rules of free access.

5.2 Overhead contact line characteristics

For free access, the parametric requirements to achieve interaction that are dependent on the geometry of the overhead contact line are as follows:

– contact wire height;
– gauge;
– permissible contact wire gradient;
– permissible lateral deflection of the contact wire under action of cross wind;
– contact wire uplift at the support;
– neutral section.

Newly built high-speed lines shall allow the circulation of vehicles complying with GC as defined in UIC leaflet 506. For line speed more than 250 km/h, the contact wire height shall not exceed a certain limit for aerodynamic reasons, which excludes gauges higher than GC (as for piggyback services). The requirements for the contact wire uplift at the support are

defined in 5.2.1.3 of EN 50119:2001 in Europe. The permissible contact wire gradient is defined in 5.2.8.2 of EN 50119:2001 in Europe. The wind speed to be considered will be defined by the infrastructure manager.

The functional requirements of neutral sections are defined as follows:

– trains shall be able to move from one section to an adjacent one (which is fed from a different phase or system) without bridging the neutral section;
– the neutral section shall be designed in such a way that trains with several pantographs at an overall distance of maximum 400 m can cross with their pantographs up;
– power consumption of the train shall be brought to zero, except in case of changeover section, when entering the phase separation section. See also IEC 62313;
– the infrastructure manager shall provide adequate means to allow a train that stops underneath the neutral section to restart. See also IEC 62313;
– in the case of trains with several pantographs, the pantographs shall be lowered for the entire length of the neutral section if some of the above requirements cannot be met. Technical or operational measures shall be taken to meet safety and availability requirements.

For compatibility between neutral sections and pantograph arrangements, see 5.2 and Clause A.1.

Range of nominal contact wire height shall be in accordance with Table 1.

Minimum contact wire height shall be calculated in accordance with 5.10.4 of EN 50119:2001 in Europe.

Table 1 – Overhead contact line characteristics for a.c. and d.c. systems

Dimensions in metres

Line speed (km/h)	$v \leq 200$	$200 < v < 250$	$v \geq 250$
Range of nominal contact wire height	5,0 up to 5,75	5,0 up to 5,5	5,00 up to 5,3
Maximum contact wire height a.c.	6,2	6,0	5,5
Maximum contact wire height d.c	6,2	6,2	5,3

The wind speed and the pantograph length to be considered will be defined by the infrastructure manager.

Maximum lateral deviation of the contact wire from the track centre line under action of a cross wind is calculated for pantographs 1 450 mm, 1 600 mm.

The permissible contact wire deviation under the action of a cross wind shall be calculated for contact wire heights above 5300 mm and/or on curved track. It shall be calculated using the half-width of the dynamic envelope of the pantograph passage, L_2. L_2 shall be calculated in accordance with Clause A.3.

The smaller value of either 0,4 m or (1,4 – L_2) m for 1 600 mm pantograph.

The smaller value of either 0,55 m or (1,7 – L_2) m for 1 950 mm pantograph.

The overhead contact line shall conform to EN 50119 in Europe.

5.3 Pantograph characteristics

The geometry of the pantograph is characterised by the following major interaction parameters (see Table 2):

- geometric profile of pantograph head;
- range of working height;
- length of contact strips;
- maximum width;
- skew of pantograph head.

For a current collection without interruption, functional requirements are described in this clause. These requirements are related to the geometric profile of the pantograph head and to the dynamic behaviour of the vehicle (i.e. kinematics envelope) and ensure that at least one contact wire is always inside the conducting range of the pantograph head (including all tolerances).

The permissible value for the skew of the pantograph head is 60 mm.

The maximum lateral deviation of the pantograph head is specified in Clause A.3.

Additional characteristics, related to the train, shall also be implemented as follows:

- automatic dropping device;
- minimum and maximum spacing between two operating pantographs;
- an electrical connection between operating pantographs in a.c. systems shall not be used (except in case of changeover section);
- lowering times under normal conditions. From the moment of initiation, the pantograph shall lower to the minimum voltage insulating distance in less than 3 s. The pantograph shall lower to the housed position in less than 10 s.

NOTE 1 The limits for maximum width are important for the correct operation of sectioning devices. The limits for distances between operating pantographs are important for the correct operation of neutral sections. See Clause A.1.

NOTE 2 For d.c. systems, when an electrical connection between operating pantographs exists, a device to interrupt this connection should be provided.

The design of the pantograph shall ensure performance in accordance with Clause 7 for the speed range and a contact wire height according to Table 1. The maximum value of working height shall be the value which has sufficient margin to infrastructure.

For compatibility between pantographs arrangement and neutral sections, see Clause A.1.

Table 2 – Pantograph characteristics for a.c. and d.c. systems

Line speed (km/h) / Category	$v \leq 160$ $v \geq 250$
Profile of pantograph head [a]	See Clause A.2
Maximum width (m) [b]	0,65
Automatic dropping device [c]	Necessary
Minimum and maximum spacing between two operating pantographs (m)	See Clause A.1
Skew of pantograph head (mm)	60
Maximum lateral deviation of the pantograph head	See Clause A.3

[a] See Figures B.2 to B.8 for the national profiles for existing lines.

[b] Maximum width, see Clause A.1.

[c] If do not use recommended contact strips – to be discussed by infrastructure manager.

The pantograph shall conform to IEC 60494-1.

6 Material interfaces

6.1 General

The wear of contact wire and contact strips as well as the permissible current at the contact point depend significantly on the materials of these two components. In order to achieve a satisfactory performance, the characteristics of contact wire and contact strips shall be in accordance with 6.1 and 6.2.

6.2 Contact wire

The contact wire shall comply with the requirements of EN 50149 in Europe and shall be used in accordance with EN 50119 in Europe.

Permissible materials of contact wire are copper and copper-alloy.

NOTE If other materials are used, it is recommended to furnish proof that the characteristics are equal to or better than the characteristics of the permitted materials.

6.3 Contact strips

The contact strips shall comply with the requirements of IEC 60494-1. The type of contact strip used shall be in accordance with the following properties:

– current capacity;
– contact force;
– contact strip material.

The material of the contact strips shall be subject to acceptance by the infrastructure manager. Recommended material for the contact strips is plain carbon, if necessary impregnated with added material.

For the use of other materials, it is necessary to furnish proof that the characteristics are equal to or better than the characteristics of the recommended materials.

NOTE 1 Other commonly used materials for contact strips are

– copper-steel, copper alloy, copper,
– copper-clad carbon,
– sintered material.

The operation with different contact strip material on the infrastructure network (see Table C.1) shall be based on an agreement between infrastructure manager and transport company.

NOTE 2 If mixed materials for contact strips in the networks are used, the wear of contact strips and/or contact wire could increase. For the results of investigation, see Table C.2.

The contact strips material shall conform to EN 50405 in Europe.

For additional tests for d.c.-systems, see Clause A.4.

7 Interaction performance

7.1 General

The performance of the overhead contact line and pantograph interface shall be subject to approval by the infrastructure manager.

7.2 Current capacity

The current in the overhead contact line depends on speed, train weight, distance between trains, line gradient, overhead contact line construction. The properties of pantograph and contact wire shall be such that overheating does not occur.

The maximum current depends on the following parameters:

– number and material of contact wires;
– number and material of contact strips;
– actual contact forces at the contact point;
– train speed;
– environmental conditions.

The current demand of the train shall comply with the working limits of the overhead contact line. See IEC 62313.

The static contact force should be adjustable for safe current collection at standstill.

A static contact force at standstill of 70 N $^{+20\ N}_{-10\ N}$ for a.c. systems and 90 N $^{+20\ N}_{-20\ N}$ for d.c. systems 1,5 kV and 110 N $^{+10\ N}_{-20\ N}$ for 3 kV shall be used.

For some d.c. systems, it may be necessary to use a static contact force around 140 N to improve the contact of carbon collector strips with the contact wire to avoid a hazardous heating of the contact wire when the train is at standstill with its auxiliaries working.

The maximum current at standstill shall be specified according to the auxiliary load, if not values given Table 3 shall applied.