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Translation

Pantograph / overhead line interaction for DC - electrified railway lines

Interaction entre caténaire et pantographe pour les lignes ferroviaires en courant continu
Zusammenwirken Stromabnehmer/Oberleitung auf Gleichstromstrecken

Union Internationale des Chemins de fer
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Warning

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Contents

Summary

This leaflet sets out relevant provisions for ensuring minimum conditions of interoperability between different pantograph and OHL designs used on direct-current railways. It also contains suitable recommendations for improving the interaction between them in order to reduce infrastructure and rolling-stock operating costs taking account of reliability and cost factors.

For each of the four speed ranges involved, from $V \leq 100$ km/h to $V \leq 250$ km/h the leaflet sets out the criteria which the pantograph and OHL equipment shall meet (height and stagger, gradient, permissible maximum uplift, maximum current drawn when stationary, bow dimensions and profiles, contact-strip materials, current-collection parameters, maximum static force when stationary).

The recommendations given for the pantograph and OHL equipment (maximum span, maximum wave-propagation speed, regularity coefficient, span deflection, maximum number of uplifted pantographs per train, maximum distance between any two uplifted pantographs, etc.) are designed to improve the quality of pantograph-OHL interaction.

To assess interaction between catenary and OHL equipment the leaflet recommends using mathematical simulation programs and lists the data required for validating such programs.

1 - Purpose of leaflet

The aim of this leaflet is to ensure proper working between overhead lines and pantographs of different designs used on direct-current railways, taking account of reliability and cost factors.

It sets out the minimum interoperability requirements with which different OHL and pantograph designs shall comply in service, for future construction or upgrading work on the lines and train components concerned, with account taken of reliability and cost factors.

It also issues recommendations for both pantograph and OHL with a view to improving their interaction, as a means of reducing infrastructure and rolling stock operating costs.

Design solutions for OHL and pantograph may be developed in order to increase authorised line speeds, provided the stipulated current-collection limits are observed.

The constructional provisions required to deliver the performance levels indicated in the leaflet shall be drawn up by the competent authority in the country in which the particular infrastructure is located, with account also being taken of relevant provisions in other leaflets.

This document also caters for the current situation on the railways.

2 - Speed ranges

Direct-current railways comprise lines fitted out for an extremely varied range of speeds. Technological progress has seen speeds increase from the modest levels of the first systems to around 200 km/h for upgraded lines of the European high-speed network and even to 250 km/h, the highest speed currently used in revenue operation.

The speed ranges used when compiling the tables in this leaflet allow for the variations in key parameters experienced by railways that actually operate d.c. systems.

The leaflet also takes account of the rules that are currently being adopted for d.c. systems by the European Union for its own Trans-European high-speed network.

3 - Pantograph bow geometry

For the future, the leaflet stipulates the use of a bow design with the same standard transverse geometry as that used on a.c. lines and described in *UIC Leaflet 794* , with the appropriate physical characteristics for d.c. operation.

Any new or existing lines that undergo major electrical work shall be able to accommodate a pantograph with this standard bow geometry.

To guarantee interoperability in the short term, provision should be made where appropriate for transitional values taking account of the characteristics of the lines worked.

4 - Fundamental requirements to be met by OHL and pantograph in order to ensure proper interaction between the different parts

4.1 - Overhead lines

Table 1 (see page 9) gives values for the parameters to be met for the overhead lines.

4.1.1 - Height and stagger of contact wires

The nominal height of the contact wires shall lie within the range indicated in n° 1 of table 1.

Contact wire height must be kept as constant as possible.

In dealing with special points on the line (bridges, level crossings, tunnels, etc.), the height may vary provided the values given in the railway's own design standards are respected and the relative gradient of the contact wire in relation to the track in no. 4 of table 1 is complied with. The same table shows the extreme height values (maximum and minimum) that may be used.

The stagger indicated in no. 5 of table 1 ensures compatibility with the 1 600 mm bow width specified in Table 2 (see page 10).

4.1.2 - Permissible maximum uplift of contact wires

The permissible maximum uplift of the contact wires as the pantograph passes shall be limited in order to protect both the overhead lines and the pantograph. The presence of any crosswinds can also be fundamental.

Since the crosswind characteristics (direction, strength, frequency) are extremely variable and closely related to the local environment of the line, and since the uplift also depends on the upward force exerted by the bow and the aerodynamic characteristics of the tractive unit, a maximum value for uplift in the absence of wind has been given.

A safety margin should be built into the system on construction to take account of extreme situations.

4.1.3 - Maximum current drawn when stationary

The contact between overhead contact wires and pantograph strips shall allow the necessary current to be drawn to power the train's on-board installations (air-conditioning, heating, auxiliaries, etc.) without damaging the contact wires or strips through exceeding the permissible maximum temperature of the wires and thereby substantially increasing the risk of rupture.

The thermal behaviour of the system is influenced by the physical characteristics of the components, particularly the materials in the contact strip, by the wear and number of wires and contact strips, also by the contact force exerted by the pantograph.

Since the many factors involved all have a major influence on the final temperature of the components during contact, the indications given in no. 7 of table 1 (see page 9) relate to clearly-defined conditions.

The corresponding limits to be observed under different conditions should be specifically studied.

4.2 - Pantograph

Table 2 (see page 10) gives values for the parameters to be met by the pantographs.

4.2.1 - Bow geometry

The profile of the pantograph bow to be adopted in the long term is given in Appendix A. Where a transition phase is necessary, bi- or multilateral agreements should be drawn up using the profiles shown in *UIC Leaflet 608*.

4.2.2 - Validation of current-collection quality

Current-collection quality can be validated using two methods, one based on measuring contact forces, the other on arc-counting. The two methods may be used jointly or independently of each other.

The first method uses a mechanical criterion which provides relevant data through analysis of the dynamic behaviour of the pantograph + OHL system.

The second uses an electrical criterion which provides relevant data through analysis of the electrical behaviour of the pantograph + OHL system.

The technical specifications for applying these measuring methods and the characteristics of the components to be used are the subject of specific documents.

4.2.3 - Contact-strip composition and characteristics

Given the very high current strengths to be drawn, the materials in the strips must deliver high performance levels without excessively abrading the surface of the contact wires, in order to keep wear of both wires and strips to a minimum.

The leaflet recommends the generalised use of impregnated carbon as a long-term solution.

The possibility of concluding bi- or multilateral agreements covering particularly severe cases is left open.

5 - Recommendations for improving the quality of interaction between pantograph and OHL

5.1 - Overhead lines

Table 3, (see page 11), gives recommendations for overhead-line parameter values designed to improve interaction between OHL and pantograph.

5.2 - Pantograph

Table 4, (see page 11), gives recommendations for pantograph parameter values designed to improve interaction between OHL and pantograph.

6 - Recommendations for a mathematical model

The use of mathematical simulation programs to assess the probable interaction between different OHL and pantograph types under different operating conditions is strongly recommended.

These simulation programs are generally based on the finite-element method and must be able to accommodate variable input data as required.

Data on the following parameters is required as a minimum:

- geometrical and physical parameters of the OHL (number of wires and messenger wires, etc.);
- geometrical and physical parameters of the pantograph;
- number of pantographs and the distance between them;
- static and aerodynamic force of the pantograph;
- modelling of OHL and pantograph as close as possible to reality;
- mass, spring and damper modelling of the pantograph;
- calculation and sampling frequencies.

The simulation programs should as a minimum provide data on the values of instantaneous contact forces: F_m, $F_m - 3\sigma$, $F_m + 3\sigma$

and on the position of the OHL and pantograph.

It is essential to validate the simulation programs through line tests before the simulation results are actually used.

Table 1 : Requirements to be met by the OHL

No.	Parameter	V ≤ 100 km/h	100 < V ≤ 200 km/h	200 < V ≤ 220 km/h	220 < V ≤ 250 km/h
1	Nominal height of contact wire (mm)	5000 - 5600	5000 - 5500	5000 - 5500	5000 - 5300
2	Extreme height values at special points (mm)	4900 and 6200	4900 and 6200	4900 and 5500	------
3	Height tolerance at support when erected (mm)	+60 0	+60 0	+60 0	+20 0
4	Maximum relative gradient of contact wire in relation to track (‰)	a	a	1	1
5	Lateral stagger of contact wire in maximum crosswind (mm)	≤ 400	≤ 400	≤ 400	≤ 400
	Permissible maximum uptlift at support when pantograph passes, in the absence of crosswind (mm) - tensioned OHL - compound OHL	 60 60	 100 60	 100 60	 100 -
7	Permissible maximum current drawn by pantograph (A)[b]	reserved [c]			

a. See CENELEC standard 50119

b. Reference conditions: two copper wires, two impregnated carbon strips, 90 N contact force, contact length 2 x 50 mm. Under a 1,5 kV catenary, the maximum current strength under the same conditions but with a contact force of 140 N is 300 Amps.

c. Value to be determined following subsequent tests on current collection when stationary.

Table 2 : Fundamental requirements to be met by the pantograph

No.	Parameter	$V \leq 100$ km/h	$100 < V \leq 200$ km/h	$200 < V \leq 220$ km/h	$220 < V \leq 250$ km/h
1	Pantograph bow width (mm)	1600			
2	Projected length of conducting section of bow (mm)	1200			
3	Bow profile	Figure 1 - page 11			
4	Permissible maximum F_m at maximum speed (in absence of wind) (N)	120	180	220	260
5	Current-collection criterion-Minimum $F_m - 3\sigma$ (N)[a]	>0 [b]	>0 [b]	>0 [b]	>0 [b]
6	Current-collection criterion for arcs (NQ)[c]	0,14% [b]	0,14% [b]	0,14% [b]	0,14% [b]
7	Safety device to protect against crosswinds (limiting pantograph movement)	Not necessary	Not necessary	Desirable	Desirable
8	Composition of contact strip	Impregnated carbon[d]			
9	Device to detect pantograph-bow defects	Desirable	Desirable	Necessary	Necessary
10	Maximum static force exerted by pantograph-bow defects	90	90	90	90
11	Electrical connection between pantographs	If such a connection exists, it must be possible to cut it off			

a. Fm is the mean contact-force value after statistical analysis of results obtained from contact-force measurements.
b. Provisional value to be confirmed through analysis of present and future measurements.
c. Cumulative duration of arcs in relation to current-collection time in traction mode, for arcs lasting at least 0,5 ms and a minimum current strength of 30% of the maximum rated output of the tractive unit.
d. Other materials may be used on the basis of bi- or multilateral agreements.

Table 3 : Recommendations for the OHL

No.	Parameter	V ≤ 100 km/h	100 < V ≤ 200 km/h	200 < V ≤ 220 km/h	220 < V ≤ 250 km/h
1	Maximum span (m)	65	65	65	65
2	Minimum wave propagation speed (m/s)	90	100	100	110
3	Regularity coefficient (%): - tensioned OHL - compound OHL	 <40 <70	 <40 <70	 <40 <70	 <40
4	Span deflection at reference temperature (‰)	≤1	≤1	≤1	≤1

Table 4 : Recommendations for the pantograph

No.	Parameter	V ≤ 100 km/h	100 < V ≤ 200 km/h	200 < V ≤ 220 km/h	220 < V ≤ 250 km/h
1	Maximum number of active pantographs per train	4	4	2	2
2	Minimum spacing between two active pantographs per train (m)	35	35	200	200
3	Secondary damping	Desirable	Desirable	Necessary	Necessary

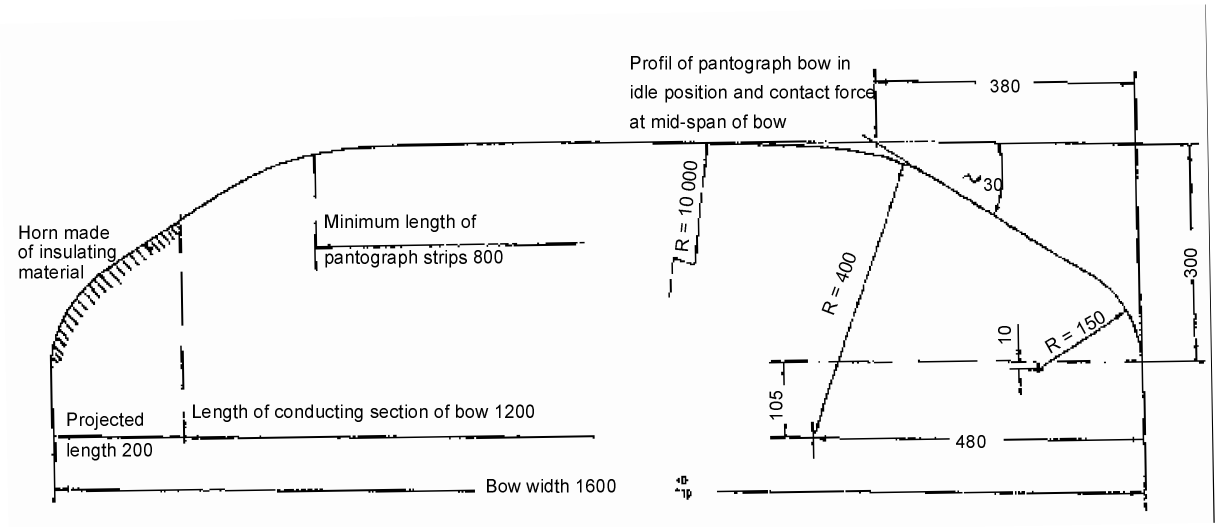

Fig. 1 - Standard bow profile

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