BS EN 50206-2:2010

BSI Standards Publication

Railway applications — Rolling stock — Pantographs: Characteristics and tests

Part 2: Pantographs for metros and light rail vehicles

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National foreword

This British Standard is the UK implementation of EN 50206-2:2010. It supersedes BS EN 50206-2:1999 which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee GEL/9, Railway Electrotechnical Applications, to Subcommittee GEL/9/2, Railway Electrotechnical Applications - Rolling stock.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Bahnanwendungen - Schienenfahrzeuge - Merkmale und Prüfungen von Stromabnehmern - Teil 2: Dachstromabnehmer für Stadtbahnen und Straßenbahnen

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CENELEC

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Foreword

This European Standard was prepared by SC 9XB, Electromechanical material on board rolling stock, of Technical Committee CENELEC TC 9X, Electrical and electronic applications for railways. It was submitted to the CENELEC formal vote and was approved by CENELEC as EN 50206-2 on 2010-05-01.

This document supersedes EN 50206-2:1999.

The main changes brought by this revision are:

- simplification and standardisation of the tolerances for static contact force (Annexes A and B);
- adjustment of terms to TSI (static contact force instead of static force);
- deletion of Clause 10;
- update of normative references.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN and CENELEC shall not be held responsible for identifying any or all such patent rights.

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2011-05-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2013-05-01

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Introduction

The electrical power supply of a tractive unit is achieved by the collection of current from the contact wire by means of one or more pantograph(s), installed on the traction unit or on the vehicle.

The contact strip of the pantograph which slides along the contact wire facilitates the transmission of power.

The pantograph and the overhead line equipment form two oscillating sub-systems which can be displaced. There exists a unilateral sliding linkage between them, which shall ensure continuous contact. Their design shall allow for minimum wear of both sub-systems when used.

1 Scope

This European Standard defines the general assembly characteristics which are to be applied to pantographs, to enable current collection from the overhead line equipment. It also defines the tests the pantographs have to perform, excluding insulators.

This European Standard does not apply to pantograph dielectric tests, which are to be performed on the pantograph installed on the vehicle roof. If no other requirement is agreed between customer and supplier, insulation coordination according to EN 50124-1 may be used.

This European Standard does not apply to pantographs used on main line vehicles: these pantographs are considered in EN 50206-1.

This European Standard relates to conventional suspended overhead line equipment and accessories. The systems (or part of them) which are rigidly suspended will require special consideration between the customer and the supplier.

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.

EN 50125-1, *Railway applications – Environmental conditions for equipment – Part 1: Equipment on board rolling stock*

EN 50126 series, *Railway applications – The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)*

EN 50163, *Railway applications – Supply voltages of traction systems*

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

EN 60077-1, *Railway applications – Electric equipment for rolling stock – Part 1: General service conditions and general rules* (IEC 60077-1)

EN 60077-2, *Railway applications – Electric equipment for rolling stock – Part 2: Electrotechnical components – General rules* (IEC 60077-2)

EN 60529:1991, *Degrees of protection provided by enclosures (IP Code)* (IEC 60529:1989)

EN 61373, *Railway applications – Rolling stock equipment – Shock and vibration tests* (IEC 61373)

3 Definitions

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

3.1 General

3.1.1
supplier
manufacturer of the pantograph

3.1.2
customer
either operating authority or vehicle manufacturer

3.1.3
pantograph (see Figure 1)
apparatus that collects current on one or more contact wires. It consists of a base frame, an operating system, a frame and a collector head. It is of variable geometry. In the "operating" position, the apparatus is entirely or partly under voltage. It is electrically insulated only generally at its interfaces, on the vehicle roof. It enables current to be transmitted from the overhead line equipment to the vehicle electrical system

3.2 Design

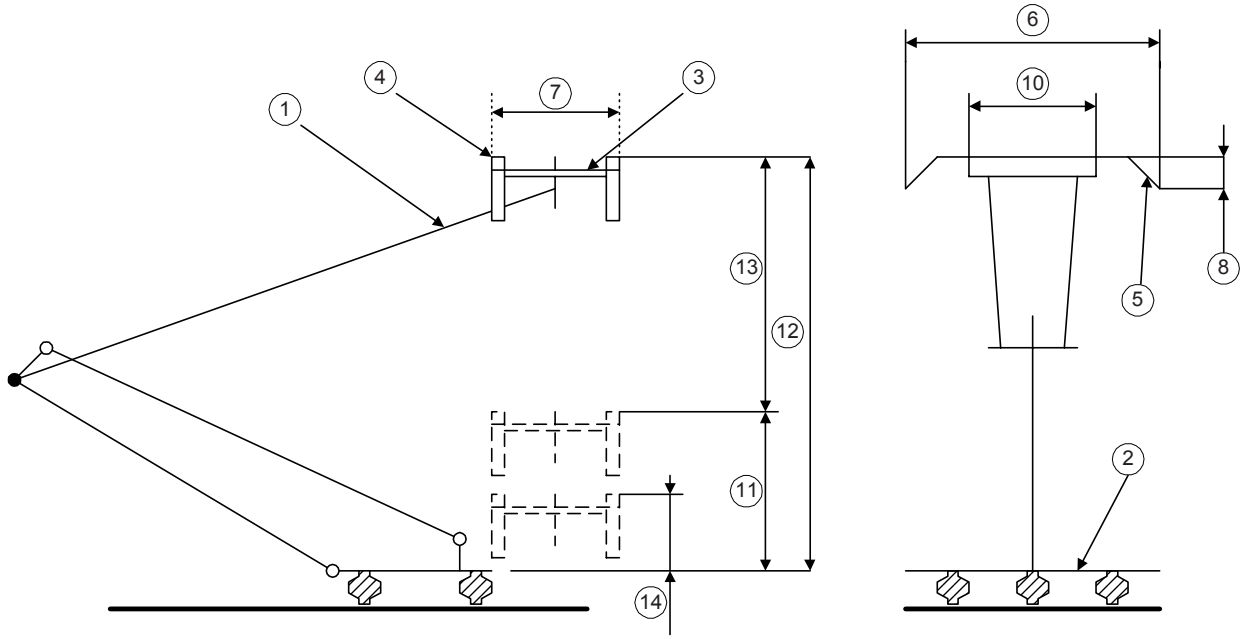
The definitions in Table 1 are related to Figure 1, except items 9, 15, 16, 17, 18.

Table 1 – Design definitions

Def. No.	Term	Item No.	Definition
3.2.1	frame	1	articulated structure which enables the collector head to move in a vertical direction with respect to the base frame of the pantograph
3.2.2	base frame	2	fixed part of the pantograph which supports the frame and is mounted on insulators fixed to the vehicle roof
3.2.3	collector head	3	part of the pantograph supported by the frame which includes contact strips, horns and may include a suspension
3.2.4	contact strip	4	replaceable wearing part of the collector head which interfaces with the overhead line equipment
3.2.5	horns	5	ends of the collector head which ensure smooth engagement with the contact wire
3.2.6	collector head length	6	dimension of collector head measured transversely in the horizontal plane in relation to the vehicle
3.2.7	collector head width	7	dimension of collector head measured longitudinally in relation to the vehicle
3.2.8	collector head height	8	vertical distance between the lowest point of the horns and the upper most point of the contact strips
3.2.9	collector head pivot	9	pitching axis of the collector head
3.2.10	length of contact strips	10	total length of wearable material intended for normal interaction measured transversely in relation to the vehicle
3.2.11	height at "lower operating position"	11	vertical distance between the pantograph mounting plane on the top of insulators and the upper surface of contact strips, the pantograph being raised to the lowest level at which it is designed to collect current
3.2.12	height at "upper operating position"	12	vertical distance between the pantograph mounting plane on the top of insulators and the upper surface of the contact strips, the pantograph being raised to the highest level at which it is designed to collect current
3.2.13	working range	13	difference between the "upper operating position" height and the "lower operating position" height

Table 1 – Design definitions *(continued)*

Def. No.	Term	Item No.	Definition
3.2.14	housed height	14	vertical distance between the pantograph mounting plane on the top of insulators and the upper surface of the contact strips or any other part of the pantograph structure if higher (pantograph being in the housed position)
3.2.15	pantograph "electrical thickness"	15	vertical distance between the highest live part and the lowest live part of the pantograph at housed position
3.2.16	operating system	16	device which provides a force to raise or to lower the pantograph
3.2.17	maximum extension	17	maximum extended height to mechanical stops (without any device which will limit the pantograph extension within the working range)
3.2.18	extension range	18	difference between height at upper operating position and housed height



The sketch in Figure 1 is an example only and does not exclude other types of pantographs (diamond type, for example).

Figure 1 – Pantograph terminology

3.3 General characteristics

All general characteristics are given in the customer specifications. Unless otherwise specified, environmental conditions are defined in EN 50125-1. The category of environment has to be specified by the customer.

3.3.1
rated voltage
voltage at which the pantograph is designed to function

3.3.2
rated current, vehicle at standstill
average value of the current withstood for 30 min by the pantograph at standstill

3.3.3
maximum current, vehicle at standstill
maximum value of the current withstood by the pantograph at standstill for a time given in the customer specification

3.3.4
rated current, vehicle running
continuous current transfer capacity of the pantograph

3.3.5
static contact force
vertical force exerted upward by the collector head on the overhead line equipment

3.3.6
nominal static contact force
specified set point for the static contact force

3.3.7
mean static contact force
average of the actual values of static contact forces evaluated as follows: the static contact forces are measured continually within the working range during raising (F_r) and lowering (F_l) operation. By convention, the mean static contact force at any point is equal to $\frac{F_r + F_l}{2}$

4 Technical requirements

4.1 Gauge

The pantograph, at housed position and operating position, shall comply with the gauge specified in the customer specifications.

4.2 Extension of the pantographs

The customer specifications shall state the values in relationship with items 10 to 13 in Table 1. In the absence of specifications in the tender documents, when the pantograph is raising or lowering, the collector head trajectory over the working range shall be in accordance with Table 2.

Table 2 – Lateral deviation of the collector head

Extension range	Maximum lateral deviation to vertical line
E < 1 m	10 mm
1 m < E < 2 m	20 mm
E > 2 m	30 mm

4.3 Electric values

The supply voltages of traction systems are specified by EN 50163.

The customer specifications shall also state the duration and values of the expected overvoltages for operating and housed pantographs.

Values defined in 3.3.1 to 3.3.3 shall be given in the customer specifications.

4.4 Static contact force tolerances

Static contact forces measured during raising and lowering shall lie within the boundaries defined in Annex A.

4.5 Transverse rigidity

When a transverse force is exerted on the part of the frame which supports the collector head at the upper operating position, the deflection shall not exceed the value defined in 6.6 and no permanent deformation shall occur.

4.6 Collector head

4.6.1 Head profiles

The customer specification shall give values in relationship with items 6 to 8 of Table 1 and collector head outline profiles.

4.6.2 Contact strips

The wear strip material and/or the contact strip design shall be defined in the customer specifications. In the absence of customer specifications DIN 43267 can be considered.

4.7 Operating system

4.7.1 General

The operating system shall be so designed that at standstill and up to the maximum speed of the traction unit any break from the contact wire will not cause permanent damage to the wire or contact strips under normal operating conditions.

The operating system shall be designed to permit the addition of a manual facility allowing operation in case of a lack of energy.

4.7.2 Electric motor

Under environmental conditions considered in EN 50125-1, the electrical motor shall be in accordance with the requirements of EN 60077-1 and EN 60077-2.

In the absence of any special requirements in the customer specifications, the electrical motor shall be protected following IP55 in accordance with the requirements of EN 60529.

4.8 Automatic Dropping Device (A.D.D.)

The pantograph shall be fitted with an automatic dropping device only if requested in the customer specifications.

The automatic dropping device shall initiate the immediate lowering of the pantograph in the event of collector head failure.

The A.D.D. shall not cause additional damage to the pantograph.

4.9 Pantograph mass and force on the roof

The supplier of the pantograph shall specify the mass of the pantograph and the appropriate tolerance with and without insulators. Any additional external forces applied by the operating system shall be defined by the supplier.

4.10 Protection against corrosion

The specifications regarding the application requirements and type of corrosion protection shall be given in the customer specifications.

5 Marking

As a minimum the following shall be labelled on the pantograph:

- manufacturer's name;
- pantograph serial number;
- type of pantograph.

6 Tests

6.1 Categories of tests

6.1.1 Overview

There are four categories of tests:

- type tests;
- routine tests;
- investigation tests;
- combined tests.

The above tests are described in 6.1.2 to 6.1.5.

Annex B summarises the tests which shall be performed.

6.1.2 Type tests

This European Standard distinguishes the basic model of a pantograph from the derived model of the same pantograph. The derived model can incorporate modifications to the basic design which will be considered to be covered by the existing type tests, provided that any such changes can be demonstrated to be at least equal to the basic design through calculation or operational experience.

Type tests shall be performed on a single piece of apparatus of a given design.

Equipment in current manufacture shall be considered to have satisfied the type tests and shall be exempted from them, if the manufacturer provides signed reports of type tests already made on identical apparatus constructed previously.

Supplementary type tests shall be required if they are requested in the customer specification and after agreement with the supplier.

6.1.3 Routine tests

Routine tests shall be carried out to verify that the properties of a product correspond to those measured during the type test. Routine tests shall be performed by the supplier on each equipment. For certain apparatus, after agreement between customer and supplier, routine tests may be replaced by sampling tests (tests performed on a number of apparatus taken at random from a batch).

6.1.4 Investigation tests

Investigation tests are special tests, which are supplementary, and performed on a single item in order to obtain additional information. They are required only if they are specified in the customer specifications.

6.1.5 Combined tests

Combined tests are special and supplementary tests which can only be carried out in an operating environment. They shall take into account the type of vehicle to be used, its speed and direction of travel. They shall be carried out using the track and/or overhead line equipment defined in the customer specifications.

These tests apply to both basic and derived pantograph models.

These tests shall be carried out if they have been specified in the customer specification and after agreement with the supplier.

6.2 General tests

6.2.1 Visual inspection (routine test)

The pantograph shall be completely assembled.

Test acceptance criteria:

The pantograph shall include all electrical and mechanical components, shall be free from physical defects and surface treatments shall have been carried out (see 4.10).

6.2.2 Weighing (type test)

The pantograph shall be completely assembled.

Test acceptance criteria:

The mass of the pantograph shall comply with the contractual mass as specified in 4.9 and shall be within the tolerance limits.

6.2.3 Dimensions

The dimensions of pantograph (including tolerances), as specified on the drawings, shall be verified with appropriate measurement devices.

As a minimum, the following measurements shall be carried out:

- collector head length (routine test);
- collector head height (routine test);
- collector head width (type test);
- head profile (type test);
- length of contact strips (type test);

– housed height (routine test);
– maximum extension (routine test);
– electrical thickness (routine test);
– distance between mounting points (routine test).

Test acceptance criteria:

The dimensions shall be within the tolerances specified on the drawings.

6.2.4 Identification (routine test)

Test acceptance criteria:

The marking shall comply with the requirements described in Clause 5.

6.2.5 Functional check of A.D.D. (routine test)

The test shall be performed for two extensions of the pantograph:

– upper operating position;
– 20 % of the working range above housed position.

The pantograph is raised and the A.D.D. shall be released by simulating a damage.

Test acceptance criteria:

The A.D.D. shall react and no damage shall occur to the pantograph.

6.3 Operating tests

6.3.1 Measurement of static contact force at ambient temperature (routine test)

If a damper is fitted, this shall be disconnected.

The static contact force shall be measured between upper and lower operating position directly under the collector head suspension during a continuous cycle of raising and lowering, at a speed of 0,05 m/s ± 10%.

The measuring device, which shall include load measuring, signal processing and data logging shall have a system accuracy better than 3 %.

Test acceptance criteria:

The measured forces shall comply with 4.4.

6.3.2 Checking of the operating system of the pantograph (routine test)

The pantograph shall be coupled to the whole operating system. The test shall be carried out at ambient temperature and at rated air supply pressure or rated voltage in the case of an electrical operating system.

NOTE For manually operated pantographs, method of operations during test shall be by agreement between customer and supplier.

Test acceptance criteria:

A smooth, steady rise to maximum working height shall be attained free from shocks liable to cause damage.

The rise from housed height to maximum working height shall be achieved in a time not exceeding 10 s from the moment the pantograph starts to rise.

The lowering action shall be free from shocks liable to cause damage.

The lowering of the pantograph from maximum working height shall be achieved in a time not exceeding 10 s from the moment the pantograph starts to lower.

6.3.3 Operating climatic test (supplementary type test)

The tests as described in 6.3.2 shall be carried out at the extremes of temperature and humidity specified in the customer specifications. If the values are not specified, the tests shall be carried out at -25 °C and +40 °C, ambient humidity.

The above tests, at the extremes of temperature shall also be carried out at the minimum and maximum air pressures or voltages specified in the customer specifications.

NOTE For manually operated pantographs, method of operations during test shall be by agreement between customer and supplier.

Test acceptance criteria:

During and after the tests, the pantograph shall operate satisfactorily in accordance with the acceptance criteria given in 6.3.2.

6.4 Endurance tests

NOTE For manually operated pantographs, method of operations during test shall be by agreement between customer and supplier.

6.4.1 Raising/lowering operations (type test)

The pantograph fitted with a collector head which has the largest mass designed for that pantograph, is submitted to 10 000 raising and lowering consecutive operations from housed position up to upper operating position. For the first 500 and last 500 operations, the pantograph shall raise to the maximum extension while the operating system energy supply is at the minimum value indicated in EN 60077-1 and EN 60077-2.

Test acceptance criteria:

After the test, all parameters shall be adjusted to the nominal values.

There shall be no abnormal wear.

There shall be no distortions or fractures. The pantographs shall meet the requirements of 6.3.1 and 6.3.2.

6.4.2 Resistance to vibrations

6.4.2.1 General

The pantograph shall be capable of withstanding the vibration and shock given by the test requirements of EN 61373.

6.4.2.2 Measurement of natural transverse frequency of the pantograph (Fo)

With the pantograph extended to 75 % of its upper operating position, it shall be brought into natural oscillation by releasing it from the position it has when a transverse force of 300 N is applied on the collector head pivot.

6.4.2.3 Transverse vibration tests (supplementary type test)

The pantograph fitted with a collector head which has the largest mass designed for that pantograph shall be installed with its insulators on a vibrating table producing sinusoidal vibrations the amplitude and the frequency of which shall be adjustable in the transverse direction. While this test is carried out, the frequency of the table shall be 10 % lower than transverse natural frequency of oscillation.

The amplitude of oscillation of the table shall be adjusted to make the acceleration (Γ) at the collector head pivot 4 m/s², for an extension equal to 75 % of the upper operating position.

(This value derives from the formula

$$\Gamma = 0{,}7.g.\ Fo^2\ /\ (Fo^2 - 1)$$

where

Fo is the transverse natural frequency of oscillation in hertz and Fo > 3 Hz).

Test acceptance criteria:

After 10^7 cycles, there shall be no deterioration of the pantograph.

6.5 Resistance to shocks (supplementary type test)

Unless otherwise agreed between user and supplier, the following test shall be carried out.

The pantograph shall be raised at the nominal static contact force and tethered between collector head pivot and base frame at 75 % of its upper operating position. A 300 N force shall be applied longitudinally on the collector head pivot, and then abruptly disconnected (Figure 2).

This test shall be carried out 3 times in both longitudinal directions.

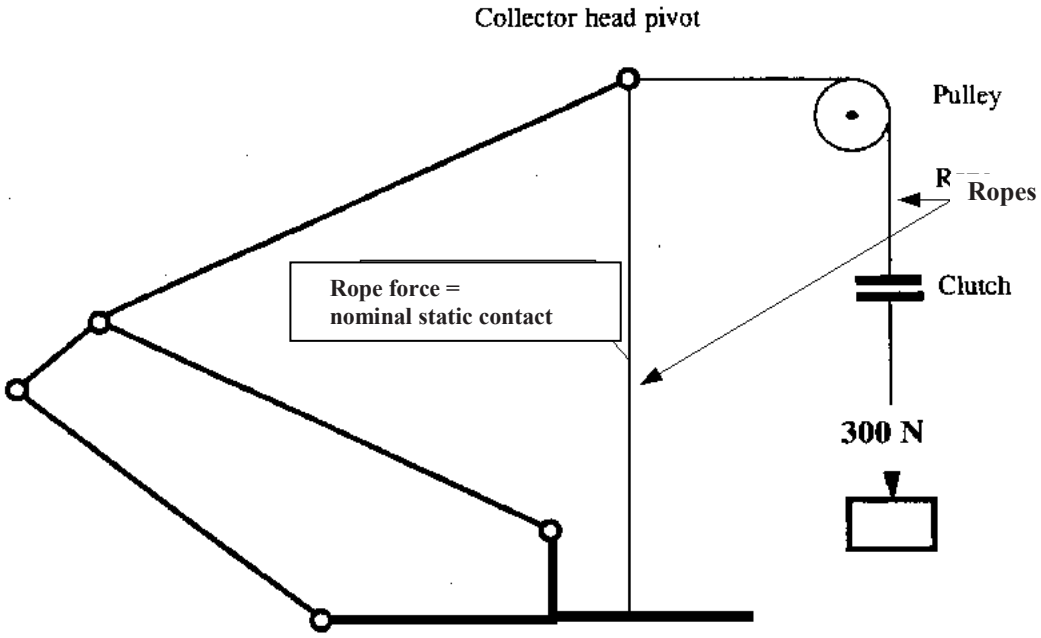


Figure 2 – Test principle

Test acceptance criteria:

There shall be no deterioration of the pantograph.

6.6 Transverse rigidity test (type test)

The pantograph shall be extended to its upper operating position.

When a force of 300 N is applied successively on each side of the part of the frame which supports the collector head, the displacement shall be in accordance with Table 3.

Table 3 – Transverse rigidity

Extension range	Maximum displacement from centre line
E < 2 m	20 mm
2 m ≤ E < 3 m	30 mm
E ≥ 3 m	40 mm

Test acceptance criteria:

After each application force, there shall be no permanent deformation.

6.7 Air tightness tests

6.7.1 General

The following applies if the operating system is of the pneumatic type.

6.7.2 Air tightness tests on operating device cylinder (routine test)

The test, which shall be carried out at ambient temperature, checks the sealing of the operating device's cylinders (or air bellows).

The cylinder (or air bellow) shall be connected to a tank whose volume is the same as the cylinder (or air bellow). The whole assembly shall then be filled at the nominal operating pressure.

Test acceptance criteria:

The pressure in the tank shall not decrease by more than 5 % of the initial pressure after 10 min.

6.7.3 Air tightness climatic test (type test)

A tank, as described in 6.7.2, shall be used in this test. The test shall be carried out at -25 °C and at +40 °C.

If a customer specification requires a larger temperature range, then the test and the acceptance requirement shall be the subject of agreement between customer and supplier.

Test acceptance criteria:

The pressure in the tank shall not decrease by more than 5 % of the initial pressure after 10 min.

6.8 Measurement of degrees of freedom of collector head (routine test)

The collector head degrees of freedom shall be agreed between the customer and the supplier. Strokes and rotations are measured in the working range.

Test acceptance criteria:

The amplitude of the degrees of freedom shall comply with the agreed values. No mechanical interference shall be evident.

6.9 Current collection tests (combined test)

The dynamic interaction between pantograph and overhead line equipment shall be evaluated with a measurement system according to EN 50317 for a given speed and in both directions of movement under a representative section of the overhead line equipment.

Test acceptance criteria:

The limits given in the customer specification must not be exceeded.

6.10 Heating tests

6.10.1 Heating tests: rated and maximum current, vehicle at standstill (supplementary type test)

The pantograph shall be connected in an electric circuit whose supply shall provide for 30 min, a current equal to the rated current at standstill and then immediately after, for a time given in the customer specification with a current equal to the maximum current, vehicle at standstill.

The test shall be carried out with a contact wire of a section and a type identical to those of the mid-life contact wire. The force between the contact strips and the contact wire shall be the nominal static contact force.

During the test the temperature of the contact wire shall be measured as close as possible to the point of contact.

Test acceptance criteria:

The temperature of the contact wire shall not exceed that defined in the customer specification.

6.10.2 Field tests (combined test)

The purpose is to establish that the collector head will carry the rated current, with the vehicle under running conditions, without damage.

The test shall be carried out with the pantograph installed on the roof of the vehicle and with an electrical load given in the customer specifications.

During this test, temperature and current against time shall be recorded on the contact strips and in critical sections of the collector head.

Test acceptance criteria:

There shall be no sign of over-heating on any part of the collector head.

7 Inspection plan

Where a quality management system is used to specify the inspection plan, it should be in accordance with EN 29001 or EN 29002, unless stated otherwise in the customer specification.

8 Reliability

8.1 General

Reliability specification shall be agreed between manufacturer and customer.

8.2 Specification

The reliability specification shall include definitions and categories of failure, and the expected conditions of operation and expected operating life. For a pantograph the failure categories are typically:

- A category: failure of the pantograph which results in damage to the overhead line equipment;
- B category: failure which causes inoperability of the pantograph;
- C category: other failure which permits the vehicle to complete its journey.

Reliability could be expressed as Mean Kilometres between Failures (MKBF), separately for categories A, B and C.

8.3 In-service reliability demonstration

Demonstration of the achievement of the reliability of a pantograph in service shall be monitored by the customer in accordance with EN 50126 series.

9 Maintenance

9.1 Structure

The design life of the pantograph structure (frame, base frame) and operating system shall be $1,5 \times 10^6$ km or 30 years, whichever is sooner.

The structure and operating system may include consumables which have a lower design life. If not otherwise specified in the customer specification, the design life of these consumable parts shall as a minimum be $0,25 \times 10^6$ km or 5 years, whichever is sooner.

9.2 Collector head structure

This structure includes collector head, collector head pivot and connecting shunts. Design life shall be defined in the customer specifications.

9.3 Maintainability

All bearings shall be easily replaceable and their surfaces shall not form part of a main component.

The collector head shall be easily removable from the pantograph frame.

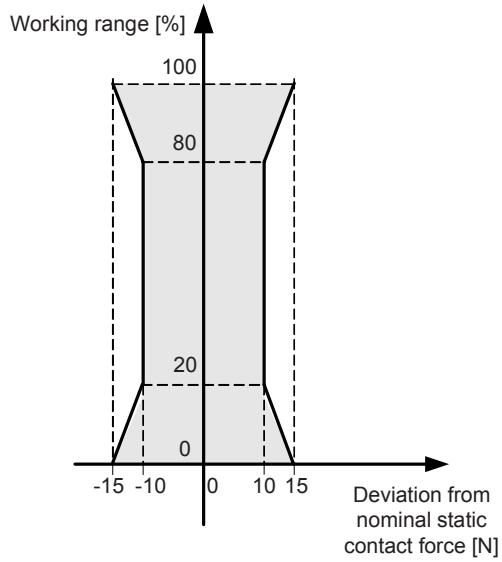
The contact strips shall be easily removable from the collector head.

The extent of the maintenance documentation shall be defined in customer specifications.

Design life and maintainability shall be demonstrated through calculation or operational experience of at least five years.

Annex A
(normative)

Static contact force tolerances



NOTE Please refer to Table 1 and Figure 1 in 3.2 for definition of “working range” and to 3.3.6 for definition of “nominal static contact force”.

Figure A.1 – Static contact force tolerances (grey area)

Annex B
(normative)

List of tests

Table B.1 – Catalogue of tests

	Routine test	Type test		Investigation test	Combined test
		Mandatory	Supplementary		
General tests (6.2)					
- visual inspection	X	X			
- weighing	.....	X			
- collector head length	X	X			
- collector head height	X	X			
- collector head width	.....	X			
- head profile	.....	X			
- length of contact strips	.....	X			
- housed height	X	X			
- maximum extension	X	X			
- electrical thickness	X	X			
- distance between mounting points.	X	X			
- identification	X	X			
- functional check of A.D.D.	X	.....	X		
Operating tests (6.3)					
- static contact force	X	X			
- checking operating system	X	X			
- operating climatic test	.....	.....	X		
Endurance tests (6.4)					
- raising/lowering operations	.....	X			
- transverse vibrations	.....	.....	X		
Resistance to shocks (6.5)	.....	.....	X		
Transverse rigidity test (6.6).....	.....	X			
Air tightness tests (6.7)					
- operating device cylinder	X	X			
- tightness climatic test	.....	X			
Measurements (6.8)					
- degrees of freedom of collector head.....	X	X			
Current collection (6.9).....	.....	.....	.....	.....	X
Heating tests (6.10)					
- at standstill	.....	.....	X		
- field tests	.....	.....	.....	.....	X

Annex C
(informative)

Items to be specified in customer specifications

Clause/Subclause

- Characteristics of the railway equipment and infrastructure 3.3
- Category of environment 3.3
- Rated voltage 3.3.1
- Rated current 3.3.2
- Maximum current 3.3.3
- Nominal static contact force 3.3.6
- Extension of the pantograph 4.2
- Electric values 4.3
- Head profiles 4.6.1
- Contact strips 4.6.2
- Electrical motor 4.7.2
- Automatic Dropping Device (A.D.D.) 4.8
- Protection against corrosion 4.10
- Supplementary type tests 6.1.2
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- Test condition for operating climatic tests 6.3.3
- Test condition for tightness climatic test 6.7.3
- Field tests 6.10.2
- Inspections 7
- Reliability specification 8.1
- Consumables design life 9.1
- Collector head design life 9.2

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