IEC 60494-2

Edition 2.0 2013-09

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Railway applications – Rolling stock – Pantographs – Characteristics and tests – Part 2: Pantographs for metros and light rail vehicles

Applications ferroviaires – Matériel roulant – Pantographes – Caractéristiques et essais – Partie 2: Pantographes pour métros et tramways

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INTERNATIONAL
ELECTROTECHNICAL
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INTERNATIONALE

PRICE CODE
CODE PRIX U

ICS 45.060

ISBN 978-2-8322-1090-1

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

RAILWAY APPLICATIONS – ROLLING STOCK – PANTOGRAPHS – CHARACTERISTICS AND TESTS –

Part 2: Pantographs for metros and light rail vehicles

FOREWORD

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International Standard IEC 60494-2 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

This standard is based on EN 50206-2.

This second edition cancels and replaces the first edition issued in 2002 and constitutes a technical revision.

The main technical changes with regard to the previous edition are as follows:

– simplification and standardization of the tolerances for static contact force (Annexes A and B);
– adjustment of terms (static contact force instead of static force);
– deletion of Clause 10;

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– new Annex D "Static contact force tolerances in Japan".

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

FDIS	Report on voting
9/1822/FDIS	9/1846/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.

A list of all parts in the IEC 60494 series, published under the general title *Railway applications – Rolling stock – Pantographs – Characteristics and tests*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
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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.

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RAILWAY APPLICATIONS – ROLLING STOCK – PANTOGRAPHS – CHARACTERISTICS AND TESTS –

Part 2: Pantographs for metros and light rail vehicles

1 Scope

This part of IEC 60494 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 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 IEC 62497-1 may be used.

This Standard does not apply to pantographs used on main line vehicles: these pantographs are considered in IEC 60494-1.

This 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 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.

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

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

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

IEC 60850, *Railway applications – Supply voltages of traction systems*

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

IEC 62278 (all parts), *Railway applications – Specification and demonstration of reliability, availability, maintainability and safety (RAMS)*

IEC 62486, *Railway applications – Current collection systems – Technical criteria for the interaction between pantograph and overhead line (to achieve free access)*

IEC 62498-1, *Railway applications – Environmental conditions for equipment – Part 1: Equipment on board rolling stock*

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EN 50317, *Railway applications – Current collection systems – Requirements for and validation of measurements of the dynamic interaction between pantograph and overhead contact line*[1]

3 Terms and definitions, symbols and abbreviations

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 for collecting current from one or more contact wires, formed of a hinged device designed to allow vertical movement of the pantograph head

[IEC 60050-811:1991, 811-32-02]

3.2 Design

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

[1] EN 50317 is under consideration at the IEC and will be published as IEC 62846.

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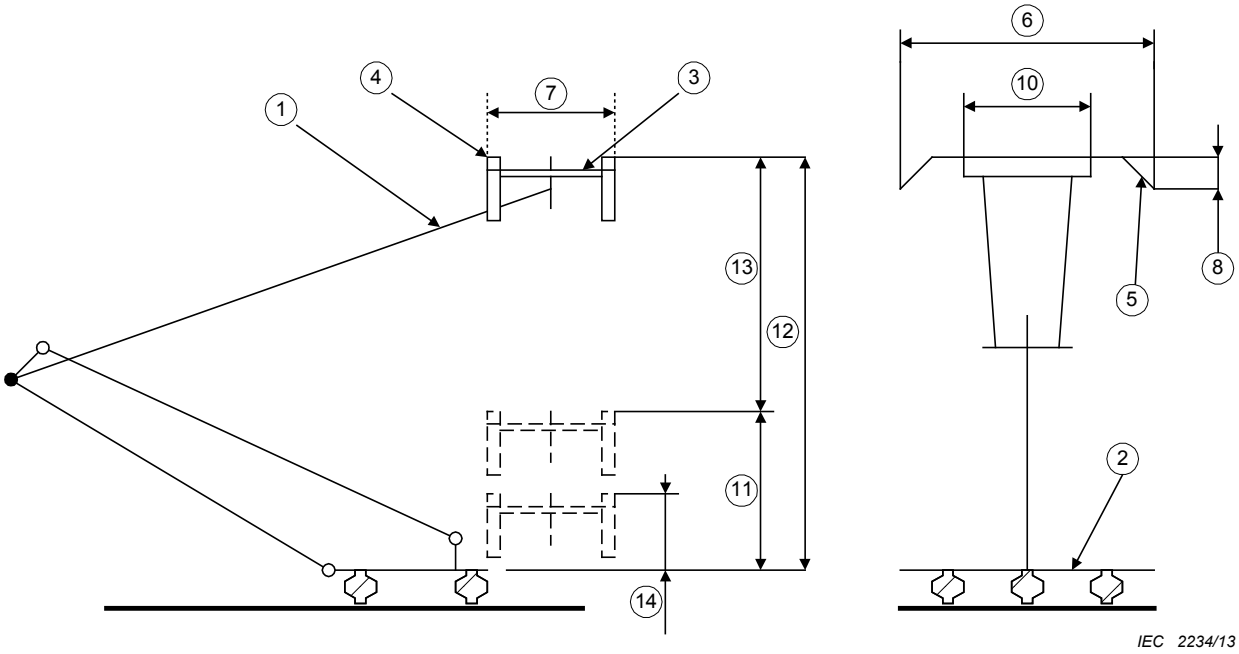
Def. No.	Term	Item No.	Definition
3.2.10	length of contact strips	10	total length of wearable material intended for normal interaction measured transversely in relation to the vehicle
3.2.11	height at "lower operating position"	11	vertical distance between the pantograph mounting plane on the top of 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
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 (vertical distance between the pantograph mounting plane on the top of insulators and the upper surface of contact strips, 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 (vertical distance between the pantograph mounting plane on the top of insulators and the upper surface of contact strips)
3.2.19	Automatic dropping device	19	Device that lowers the pantograph in the event of pantograph head failure or damage of the pantograph head.
NOTE The definitions in Table 1 are related to Figure 1, except items 9, 15, 16, 17, 18, and 19.			



NOTE 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

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3.3 General characteristics

All general characteristics are given in the customer specifications. Unless otherwise specified, environmental conditions are defined in IEC 62498-1. 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

Note 1 to entry: 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 $\frac{F_r + F_l}{2}$

3.3.8
target static contact force
upward force measured at the standard working height of the pantograph when the pantograph is raised at 0,05 m/s under the same conditions as in actual use.

3.4 Symbols and abbreviations

ADD Automatic dropping device

E Extension range

F_0 Natural transverse frequency

F_r Force during raising the pantograph

F_l Force during lowering the pantograph

MDBF Mean distance between failure

Γ Acceleration at collector head pivot

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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 lateral deviation of the collector head trajectory from the vertical line over the working range shall be in accordance with Table 2.

Table 2 – Lateral deviation of the collector head

Extension range m	Maximum lateral deviation from vertical line mm
$E < 1$	10
$1 \leq E < 2$	20
$E \geq 2$	30

4.3 Electric values

The supply voltages of traction systems are specified by IEC 60850.

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

Unless larger tolerances are agreed between user and supplier, 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 IEC 62486 can be considered.

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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 IEC 62498-1, the electrical motor shall be in accordance with the requirements of IEC 60077-1 and IEC 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 IEC 60529.

4.8 Automatic dropping device (ADD)

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

The ADD 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 or without insulators. Any additional forces applied by the operating system at standstill 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;
- month and year of production.

6 Tests

6.1 Categories of tests

6.1.1 Overview

There are four categories of tests:

- type tests;
- routine tests;

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- 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 International 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:

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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 ADD (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 ADD shall be released by simulating a damage.

Test acceptance criteria:

The ADD shall react and no damage shall occur to the pantograph.

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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.

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.

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.

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6.3.4 Measurement of mean static contact force at ambient temperature (investigation test)

If a damper is fitted, the test described in 6.3.1 shall be repeated with the damper in place.

6.4 Endurance tests

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 (air or electric) is at the minimum value indicated in IEC 60077-1 and IEC 60077-2.

If the customer specification requires a different number of operations, then the test and the acceptance requirement shall be the subject of agreement between customer and supplier.

NOTE The number of 10 000 was derived from assumptions about average figures of life time, days of operation per year and number of raising and lowering operations per day.

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 and any attached component (electrical and/or pneumatic) shall be capable of withstanding the vibration and shock given by the test requirements of IEC 61373.

6.4.2.2 Measurement of natural transverse frequency of the pantograph (F_0)

The natural transverse frequency (F_0) shall be measured. 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 in accordance with customer requirements, for an extension equal to 75 % of the upper operating position.

Test acceptance criteria:

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