

# 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

<https://standards.iteh.ai/catalog/standards/sist/e3d5dadd-7fff-47bf-9987-13>



## THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2013 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester.

If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de la CEI ou du Comité national de la CEI du pays du demandeur.

Si vous avez des questions sur le copyright de la CEI ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de la CEI de votre pays de résidence.

IEC Central Office  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland

Tel.: +41 22 919 02 11  
Fax: +41 22 919 03 00  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://www.iec.ch)

### About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

### About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

#### Useful links:

IEC publications search - [www.iec.ch/searchpub](http://www.iec.ch/searchpub)

The advanced search enables you to find IEC publications by a variety of criteria (reference number, text, technical committee,...).

It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)

Stay up to date on all new IEC publications. Just Published details all new publications released. Available on-line and also once a month by email.

Electropedia - [www.electropedia.org](http://www.electropedia.org)

The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary (IEV) on-line.

Customer Service Centre - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: [csc@iec.ch](mailto:csc@iec.ch).

### A propos de la CEI

La Commission Electrotechnique Internationale (CEI) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

### A propos des publications CEI

Le contenu technique des publications de la CEI est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

#### Liens utiles:

Recherche de publications CEI - [www.iec.ch/searchpub](http://www.iec.ch/searchpub)

La recherche avancée vous permet de trouver des publications CEI en utilisant différents critères (numéro de référence, texte, comité d'études,...).

Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

Just Published CEI - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)

Restez informé sur les nouvelles publications de la CEI. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

Electropedia - [www.electropedia.org](http://www.electropedia.org)

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 30 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (VEI) en ligne.

Service Clients - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: [csc@iec.ch](mailto:csc@iec.ch).

# 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**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

COMMISSION  
ELECTROTECHNIQUE  
INTERNATIONALE

PRICE CODE  
CODE PRIX

U

ICS 45.060

ISBN 978-2-8322-1090-1

**Warning! Make sure that you obtained this publication from an authorized distributor.  
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

## CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	7
2 Normative references .....	7
3 Terms and definitions, symbols and abbreviations .....	8
3.1 General.....	8
3.2 Design.....	8
3.3 General characteristics.....	10
3.4 Symbols and Abbreviations .....	10
4 Technical requirements .....	11
4.1 Gauge .....	11
4.2 Extension of the pantographs .....	11
4.3 Electric values.....	11
4.4 Static contact force tolerances .....	11
4.5 Transverse rigidity.....	11
4.6 Collector head.....	11
4.6.1 Head profiles.....	11
4.6.2 Contact strips.....	11
4.7 Operating system .....	12
4.7.1 General .....	12
4.7.2 Electric motor .....	12
4.8 Automatic dropping device (ADD).....	12
4.9 Pantograph mass and force on the roof.....	12
4.10 Protection against corrosion.....	12
5 Marking .....	12
6 Tests.....	12
6.1 Categories of tests .....	12
6.1.1 Overview .....	12
6.1.2 Type tests .....	13
6.1.3 Routine tests .....	13
6.1.4 Investigation tests .....	13
6.1.5 Combined tests .....	13
6.2 General tests.....	13
6.2.1 Visual inspection (routine test).....	13
6.2.2 Weighing (type test) .....	14
6.2.3 Dimensions.....	14
6.2.4 Identification (routine test).....	14
6.2.5 Functional check of ADD (routine test).....	14
6.3 Operating tests.....	15
6.3.1 Measurement of static contact force at ambient temperature (routine test).....	15
6.3.2 Checking of the operating system of the pantograph (routine test).....	15
6.3.3 Operating climatic test (supplementary type test) .....	15
6.3.4 Measurement of mean static contact force at ambient temperature (investigation test).....	16
6.4 Endurance tests .....	16

6.4.1	Raising/lowering operations (type test)	16
6.4.2	Resistance to vibrations	16
6.5	Resistance to shocks (supplementary type test)	17
6.6	Transverse rigidity test (type test)	17
6.7	Air tightness tests	18
6.7.1	General	18
6.7.2	Air tightness tests on pantograph mounted pneumatic equipment (routine test)	18
6.7.3	Air tightness climatic test (type test)	18
6.8	Measurement of degrees of freedom of collector head (routine test)	18
6.9	Current collection tests (combined test)	19
6.10	Current heating tests	19
6.10.1	Heating tests: rated and maximum current, vehicle at standstill (supplementary type test)	19
6.10.2	Heating test: simulation of running vehicle (supplementary type test)	19
6.10.3	Field tests (combined test)	19
7	Inspection plan	20
8	Reliability	20
8.1	General	20
8.2	Specification	20
8.3	In-service reliability demonstration	20
9	Maintenance	20
9.1	Structure	20
9.2	Collector head structure	21
9.3	Maintainability	21
Annex A (normative)	Static contact force tolerances	22
Annex B (normative)	List of tests	23
Annex C (informative)	Items to be specified in customer specifications	24
Annex D (informative)	Static contact force tolerances in Japan	25
	Bibliography	26
	Figure 1 – Pantograph terminology	9
	Figure 2 – Test principle	17
	Figure A.1 – Static contact force tolerances (grey area)	22
	Table 1 – Design definitions	8
	Table 2 – Lateral deviation of the collector head	11
	Table 3 – Transverse rigidity	18
	Table B.1 – Catalogue of tests	23
	Table D.1 – Static contact force tolerances in Japan [N]	25

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

**Part 2: Pantographs for metros and light rail vehicles**

**FOREWORD**

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

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;

– 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,
- withdrawn,
- replaced by a revised edition, or
- amended.

**ITEH STANDARD PREVIEW**  
**(standards.iteh.ai)**

[IEC 60494-2:2013](https://standards.iteh.ai/catalog/standards/sist/e3d5dadd-7fff-47bf-9987-ca638da313e3/iec-60494-2-2013)

<https://standards.iteh.ai/catalog/standards/sist/e3d5dadd-7fff-47bf-9987-ca638da313e3/iec-60494-2-2013>

## 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.

## **iTeh STANDARD PREVIEW** **(standards.iteh.ai)**

[IEC 60494-2:2013](https://standards.iteh.ai/catalog/standards/sist/e3d5dadd-7fff-47bf-9987-ca638da313e3/iec-60494-2-2013)

<https://standards.iteh.ai/catalog/standards/sist/e3d5dadd-7fff-47bf-9987-ca638da313e3/iec-60494-2-2013>



# 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

IEC 60494-2:2013

<https://standards.iteh.ai/catalog/standards/sist/e3d5dadd-7ff-47bf-9987->

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*

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

### 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]

STANDARD PREVIEW  
(standards.iteh.ai)

#### 3.2 Design

**Table 1 – Design definitions**

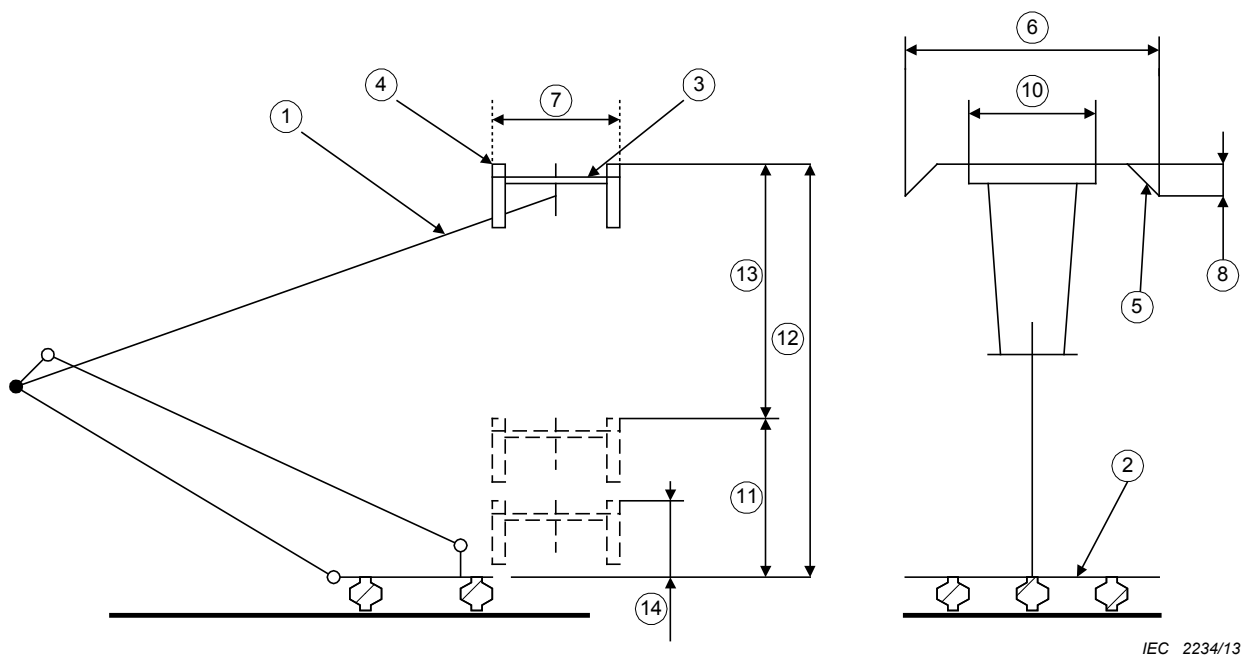
IEC 60494-2:2013

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

<sup>1</sup> EN 50317 is under consideration at the IEC and will be published as IEC 62846.

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.



IEC 2234/13

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**

### 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
$\Gamma$	Acceleration at collector head pivot

## 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

**iTeh STANDARD PREVIEW**  
(standards.iteh.ai)

### 4.3 Electric values

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

[IEC 60494-2:2013](#)

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.

## 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;

- 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:*