IEC 60494-1

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

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Railway applications – Rolling stock – Pantographs – Characteristics and tests – Part 1: Pantographs for main line vehicles

Applications ferroviaires – Matériel roulant – Pantographes – Caractéristiques et essais – Partie 1: Pantographs pour véhicules grandes lignes

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

Part 1: Pantographs for main line vehicles

FOREWORD

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International Standard 60494-1 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

This standard is based on EN 50206-1.

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);
– definition of a new investigation test "Measurement of mean static contact force at ambient temperature" (6.3.4);
– deletion of combined test "Total contact force" (6.11);

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– definition of a new combined test "Check of operating system at maximum speed" (6.13);
– 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
9/1821/FDIS	9/1845/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- withdrawn,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.

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INTRODUCTION

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

The contact strips of the pantograph which slide along the contact wire facilitate the transmission of power.

The pantograph and the overhead contact line system 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 1: Pantographs for main line vehicles

1 Scope

This part of IEC 60494 specifies the general assembly characteristics which are to be applied to pantographs, to enable current collection from the overhead contact line system. It also specifies the tests the pantographs have to perform, excluding insulators.

This Standard is not applicable 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 is not applicable to pantographs used on isolated metros and light rail systems. These pantographs are considered in IEC 60494-2.

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 (all parts), *Railway applications – Electric equipment for rolling stock*

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

IEC 60913:2013, *Railway applications – Fixed installations – Electric traction overhead contact lines*

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*

IEC 62499, *Railway applications – Current collection systems – Pantographs, testing methods for carbon contact strips*

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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 contact line system
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 uppermost 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

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

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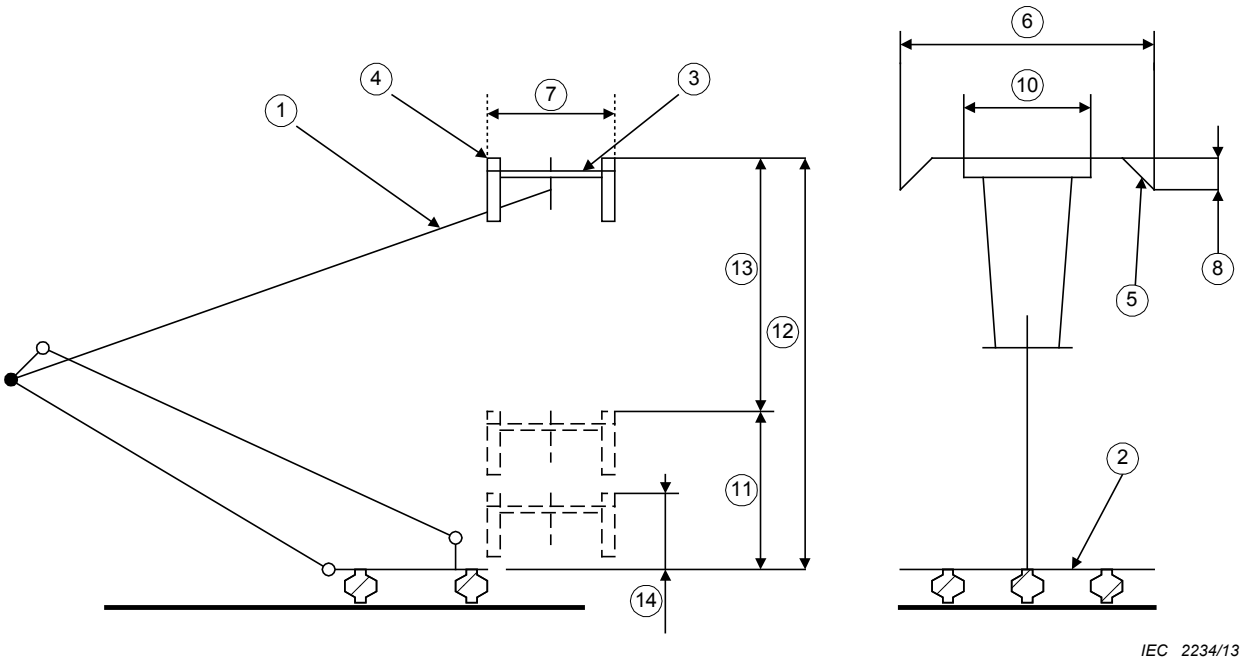
Def. No.	Term	Item No.	Definition
3.2.11	height at "lower operating position"	11	vertical distance between the pantograph mounting plane on the top of insulators and the upper surface of contact strips, the pantograph being raised to the lowest level at which it is designed to collect current
3.2.12	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	limited maximum extension	18	reduced extension allowed by intermediate mechanical stops (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 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

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 that current withstood for 30 min by the pantograph at standstill

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

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 contact line system at standstill

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

3.3.9
total mean uplift force
vertical force measured at the collector head, the latter not touching the contact wire

Note 1 to entry: It is equal to the sum of static contact force and the aerodynamic force caused by the air at the considered speed for a given collector height, the results being referred to zero ambient wind conditions.

3.3.10
total contact force
total force between collector head and contact wire while running

3.3.11
housing force
force applied vertically to the collector head to maintain the whole pantograph in housed position

3.4 Symbols and abbreviations

AC Alternating current

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ADD	Automatic dropping device
DC	Direct current
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

4 Technical requirements

4.1 General

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.

4.2 Gauge

The pantograph, at housed position and operating position, shall comply with the gauge specified in the customer specifications or shall be in accordance with IEC 62486.

4.3 Extension of the pantograph

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 within a range of ± 50 mm in the longitudinal direction, and ± 10 mm in the lateral direction in relation to the vertical line.

4.4 Electrical values

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

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

Values defined in 3.3.2 to 3.3.4 shall be given in the customer specifications.

4.5 Force requirements

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.

Operating requirements for static contact force, total mean uplift force and total contact force shall follow the requirements in IEC 62486 if not specified in the customer specifications.

4.6 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.

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4.7 Collector head

4.7.1 Length

If not specified in the customer specification, lengths defined in IEC 62486 shall be used.

4.7.2 Width

The collector head width shall be defined according to the type of suspension, the number of wear strips and the system characteristics of the overhead contact line system.

4.7.3 Head profiles

If not specified in the customer specification, the collector head outline profiles and maximum allowable tilt defined in IEC 62486 shall be used.

4.7.4 Contact strips

When not specified in IEC 62486 wear strip material, maximum current at standstill and under running conditions shall be specified in the customer specifications. If applicable, testing methods according to IEC 62499 are recommended.

4.8 Operating system

The installation and the definition of the operating system shall be provided by the supplier.

If not specified by the customer, the operating system shall be designed to ensure, at standstill and up to the maximum speed of the traction unit, a break from the contact wire, within 3 s, over the minimum insulation distance.

The housing force shall prevent the pantograph from raising from the housed position at all speeds up to maximum speed of the vehicle.

The housing force may be agreed between the customer and the supplier. Alternatively, provision may be made for the fitting of a holding down device.

4.9 Automatic dropping device (ADD)

The automatic dropping device has to be mounted only when the customer so requires. Impact or damage occurring to contact strips liable to cause subsequent damage to overhead contact line system shall be detected by ADD. Impacts or damages to other parts of the collector head like horns can be included in the ADD, if specified by the customer.

When designing, the following characteristics shall be taken into account:

- ADD reaction time;
- ADD failure to safe condition;
- ADD self-test in workshop;
- ADD reliability;
- pantograph integrity after work of ADD.

The ADD system shall be designed to ensure that minor damage to the contact strips as may be experienced in daily service shall not cause operation of ADD system.

The ADD shall not cause additional damage to the pantograph.

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4.10 Pantograph mass and force on the roof

The supplier shall specify the mass of the pantograph with or without insulators and the maximum force at every fixing point. In addition the supplier shall specify all relevant parameters to enable the calculation of the maximum efforts at every fixing point.

4.11 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 shall be considered to be covered by the existing relevant type tests. This is provided that any such changes can be demonstrated to be at least equal to the basic design through calculation or operational experience of at least two years on operational lines, and with technical requirements at least equal to those for which the basic model was designed.

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.

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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.

The acceptance of the apparatus shall not rely on the results of those investigation tests.

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 contact line system defined in the customer specifications.

These tests apply to both basic and derived pantograph models.

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 4.11).

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 4.10.

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);

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- housed height (routine test);
- maximum extension (routine test);
- limited 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 (type test)

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

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

After the pantograph is raised to the considered extension, the ADD shall be released by simulating damage. The simulation shall be carried out with the same physical signal as in real operation. The reaction time shall be measured from generating the signal to 20 cm below the considered extension.

Test acceptance criteria:

The reaction time shall be less or equal to 1 s. There shall be no damage on the pantograph structure.

6.2.6 Functional check of ADD (routine test)

The pantograph shall be raised to the extensions described in 6.2.5 and then the ADD shall be released by simulating a damage.

Test acceptance criteria:

The ADD shall operate.

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:

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The measured forces shall comply with 4.5.

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 electrical operating system.

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 movement from any height in the working range shall operate with a rapid commencement.

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 tests (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 values of air pressure or voltage specified in the customer specifications.

Test acceptance criteria:

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

6.3.4 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

6.4.1 Raising/lowering operations (type test)

6.4.1.1 Operation between housed position and upper operating position

The pantograph fitted with a collector head which has the largest mass designed for that pantograph, shall be 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 (air or electricity) supply is at the minimum value indicated in IEC 60077 series. 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.

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Test acceptance criteria:

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

There shall be no abnormal wear. The pantograph shall meet the requirements of 6.3.1 and 6.3.2.

There shall be no distortions or fractures.

6.4.1.2 Operation within working range

The pantograph with a collector head in the same conditions as described in 6.4.1.1 shall be submitted to 75 000 raising and lowering consecutive operations within the working range at a speed of 0,1 m/s (if damper is fitted this shall be disconnected).

NOTE The number of 75 000 was derived from assumptions about "up and down movement" along the contact wire during the life time of the pantograph.

Test acceptance criteria:

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

There shall be no abnormal wear. The pantograph shall meet the requirements of 6.3.1 and 6.3.2.

There shall be no distortions or fractures.

6.4.2 Collector head suspension (type test)

The collector head suspension shall be subjected to $1{,}2 \times 10^6$ consecutive cycles throughout its design operating range. This test shall be carried out at a minimum frequency of 0,5 Hz.

NOTE The number of 0,5 Hz was derived from assumptions about the speed of the pantograph and the span of the contact line.

Test acceptance criteria:

There shall be no abnormal wear: the pantograph shall meet the requirements of 6.3.1 and 6.3.2.

There shall be no distortions or fractures.

6.4.3 Resistance to vibrations

6.4.3.1 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.

6.4.3.2 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.

6.4.3.3 Transverse vibration tests (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

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