
Železniške naprave - Vozna sredstva - Električna oprema v trolejbusih - Varnostne zahteve in povezovalni sistemi

Railway applications - Rolling stock - Electric equipment in trolley buses - Safety requirements and connection systems

Bahnanwendungen - Fahrzeuge - Elektrische Ausrüstung in O-Bussen – Sicherheitsanforderungen und Verbindungssysteme

Applications ferroviaires - Matériel roulant - Equipement électrique des trolleybus - Exigences de sécurité et systèmes de connexion

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Railway applications - Rolling stock - Electric equipment in trolley buses - Safety requirements and current collection systems

Applications ferroviaires - Matériel roulant - Equipement électrique des trolleybus - Exigences de sécurité et systèmes de connexion

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EN 50502:2015 (E)

European foreword

This document (EN 50502:2015) has been prepared by CLC/SC 9XB "Electromechanical material on board rolling stock" of the Technical Committee CENELEC TC 9X "Electrical and electronic applications for railways".

The following dates are fixed:

- latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2016-03-30
- latest date by which the national standards conflicting with this document have to be withdrawn (dow) 2018-03-30

This document supersedes CLC/TS 50502:2008.

EN 50502:2015 includes the following significant technical changes with respect to CLC/TS 50502:2008:

- Clause 1: a more detailed scope (guided vehicles) in reference to other electric vehicles;
- 5.6.1: insulation resistance and separate source applied voltage tests for voltage band I components is waived with respect to other electric vehicles and with reference to ECE R100;
- Table 5: test voltages for components intended to break a current which are used with open contacts for supplementary or basic insulation;
- 6.4.2: specification of periodical checks additional to insulation resistance tests;
- 6.2.5, Table 6: electrical tests of the insulation of entrance areas are waived, visual inspection is added;
- 6.5: extension of description and test of different leakage detectors;
- A.3: description of special requirements for external insulations;
- A.13, A.14: addition of energy storage systems and fuel cells;
- B.2.4.6: equipment for switch operation of overhead contact line.

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

1 Scope

This European Standard applies to electrical systems on board of vehicles of the type trolley bus, as defined in 3.1, fed with a nominal line voltage (U_n) between 600 V d.c. and 750 V d.c.

This European Standard defines the requirements and constructional hints, especially to avoid electrical danger to the public and to staff. Where special requirements are existing for trolley buses, hints are given for mechanical and functional safety as well as for protection against fire.

This European Standard covers vehicles intended for public transport of persons. This Standard applies to:

- trolley buses,
- buses with current rail for guidance in the road surface,
- guided buses with bipolar roof current collector.

This European Standard does not apply to:

a) electric driven vehicles with only internal power supply:

- 1) hybrid vehicles,
- 2) diesel - electric vehicles,
- 3) fuel - cell vehicles,
- 4) battery vehicles,

b) vehicles with safe protective bonding:

- 1) rubber tyred commuter trains,
- 2) guided buses with supply by a separate current rail,
- 3) rail guided buses with unipolar roof current collector,

c) vehicles operated outside publicly accessible areas:

- 1) electric driven lorries on motorways

Guidance and current rails are special solutions and at this time are not under standardization like trolley bus current collectors and overhead contact lines (OCL).

It refers mainly to earthed networks, but reference is made also to galvanically insulated networks.

Annex A is related to detailed design features for trolley buses.

Annexes B and C are related to the current collection systems. The detailed scope of these annexes is given in Annex B.

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.

EN 45502 (all parts), *Active implantable medical devices*

EN 45545-5, *Railway applications — Fire protection on railway vehicles — Part 5: Fire safety requirements for electrical equipment including that of trolley buses, track guided buses and magnetic levitation vehicles*

EN 50110 (all parts), *Operation of electrical installations*

EN 50110-1:2013, *Operation of electrical installations — Part 1: General requirements*

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EN 50119, *Railway applications — Fixed installations — Electric traction overhead contact lines*

EN 50121 (all parts), *Railway applications — Electromagnetic compatibility*

EN 50122-1, *Railway applications — Fixed installations — Electrical safety, earthing and the return circuit — Part 1: Protective provisions against electric shock*

EN 50124-1, *Railway applications — Insulation coordination — Part 1: Basic requirements — Clearances and creepage distances for all electrical and electronic equipment*

EN 50125-1, *Railway applications — Environmental conditions for equipment — Part 1: Rolling stock and on-board equipment*

EN 50153, *Railway applications — Rolling stock – Protective provisions relating to electrical hazards*

EN 50155, *Railway applications — Electronic equipment used on rolling stock*

EN 50163, *Railway applications — Supply voltages of traction systems (IEC 60850)*

EN 50178, *Electronic equipment for use in power installations*

EN 50215:2009, *Railway applications — Rolling stock — Testing of rolling stock on completion of construction and before entry into service*

EN 50264 (all parts), *Railway applications — Railway rolling stock power and control cables having special fire performance*

EN 50272-3, *Safety requirements for secondary batteries and battery installations — Part 3: Traction batteries*

EN 50306 (all parts), *Railway applications — Railway rolling stock cables having special fire performance — Thin wall*

EN 50343, *Railway applications — Rolling stock — Rules for installation of cabling*

CLC/TS 50457 (all parts), *Conductive charging for electric vehicles*

EN 50500, *Measurement procedures of magnetic field levels generated by electronic and electrical apparatus in the railway environment with respect to human exposure*

EN 60034 (all parts), *Rotating electrical machines (IEC 60034, all parts)*

EN 60077 (all parts), *Railway applications — Electrical equipment for rolling stock (IEC 60077, all parts)*

EN 60146 (all parts), *Semiconductor converters (IEC 60146, all parts)*

EN 60322, *Railway applications — Electrical equipment for rolling stock — Rules for power resistors of open construction (IEC 60322)*

EN 60349 (all parts), *Electric traction — Rotating electrical machines for rail and road vehicles (IEC 60349, all parts)*

EN 60445, *Basic and safety principles for man-machine interface, marking and identification — Identification of equipment terminals, conductor terminations and conductors (IEC 60445)*

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

EN 60721-3-5, *Classification of environmental conditions — Part 3: Classification of groups of environmental parameters and their severities — Section 5: Ground vehicle installations* (IEC 60721-3-5)

EN 61111, *Live working — Electrical insulating matting* (IEC 61111)

EN 61287-1, *Railway applications — Power converters installed on board rolling stock — Part 1: Characteristics and test methods* (IEC 61287-1)

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

EN 61557-2, *Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. — Equipment for testing, measuring or monitoring of protective measures — Part 2: Insulation resistance* (IEC 61557-2)

EN 61557-8, *Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. — Equipment for testing, measuring or monitoring of protective measures — Part 8: Insulation monitoring devices for IT systems* (IEC 61557-8)

EN 61851 (all parts), *Electric vehicle conductive charging system* (IEC 61851, all parts)

EN 61881 (all parts), *Railway applications — Rolling stock equipment — Capacitors for power electronics* (IEC 61881, all parts)

EN 62196-1, *Plugs, socket-outlets, vehicle connectors and vehicle inlets — Conductive charging of electric vehicles — Part 1: General requirements* (IEC 62196-1)

IEC 60479 (all parts), *Effects of current on human beings and livestock*

ISO 6469-3, *Electrically propelled road vehicles — Safety specifications — Part 3: Protection of persons against electric shock*

ISO 10099, *Pneumatic fluid power — Cylinders — Final examination and acceptance criteria*

ISO 16750-2, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 2: Electrical loads*

ISO 16750-3, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 3: Mechanical loads*

ISO 23273, *Fuel cell road vehicles — Safety specifications — Protection against hydrogen hazards for vehicles fuelled with compressed hydrogen*

3 Terms and definitions

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

3.1

trolley bus

vehicles with rubber tyres (with limited lateral operating range or guided) without safe protective bonding of the chassis, which operate with an electrical drive in the public area accessible for persons and galvanically externally powered by a supply line (overhead contact line, current rail)

Note 1 to entry: The two poles of the supply line are either both galvanically insulated from earth or one insulated and the other earthed. This can take place at a central point or at every feed (substation).

3.2**current collection system**

whole of the components, generally mounted on the vehicle roof, having the task of taking the current from the overhead contact lines to supply the equipment of the vehicle, both in standing and in running conditions

3.3**mass**

conductive part of an electrical component which is accessible and which is not energized in normal conditions, but may become energized in fault conditions

Note 1 to entry: The equipment defined in 5.6.1 as normal bus vehicle components are not included in this term.

Note 2 to entry: The conductive parts of the chassis and of the bodywork are defined as the vehicle mass.

3.4**intermediate mass**

conductive part between two insulating parts of a double insulated equipment (protection, enclosure, etc.), which shall not be accessible to the public

3.5**basic insulation**

insulation for personal safety between the electric parts which are subject to be energized and the intermediate mass, to provide basic protection against electric shock

3.6**supplementary insulation**

insulation for personal safety between the intermediate mass and the vehicle mass

3.7**double insulation**

insulation comprising both basic insulation and supplementary insulation

Note 1 to entry: According to EN 60077-1 the basic and supplementary insulation may also be interchanged (refer also to Table 5).

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3.8**functional insulation**

insulation not for personal safety, with lower requirements, that ensures the function of the plant

Note 1 to entry: To some extent, the design is specified in the product standards.

3.9**nominal voltage U_n**

designated value for a system to which the general characteristics are referred

3.10**rated voltage range U_{Ne}**

voltage range which, together with rated current, defines the use of the equipment and to which the applicable tests and the utilization categories are referred

3.11**highest permanent voltage U_{max1}**

maximum voltage value likely to be present indefinitely

3.12**rated insulation voltage U_{Nm}**

value to which the dielectric test voltages and the creepage distances are referred and which can in no cases be lower than U_{Ne}

Note 1 to entry: When no value is defined by the purchaser for U_{Nm} , the maximum operating voltage U_{max1} , given by EN 50163 is due to be assumed.

3.13**power frequency withstand voltage U_a**

r.m.s. a.c. voltage which does not cause an insulation fault according to specified test conditions

3.14**highest non-permanent voltage $U_{\max 2}$**

maximum voltage value likely to be present for a limited period of time

3.15**overvoltage**

voltage having a peak value exceeding the corresponding peak value of maximum steady-state voltage at normal operating conditions

3.16**long term overvoltage**

overvoltage higher than $U_{\max 2}$ lasting typically for more than 20 ms, due to low impedance phenomena, for example a rise in substation primary voltage

3.17**highest long term overvoltage $U_{\max 3}$**

voltage defined as the highest value of the long term overvoltage for $t = 20$ ms

3.18**maximum current**

maximum current value which the current collection system is able to carry

3.19**maximum speed**

maximum speed the vehicle can reach, to be taken into account for the current collection system to guarantee a proper operation of the same

3.20**static contact force**

value of force F (see Figure B.8) applied by the slipper on the contact line, as measured with standing vehicle

Note 1 to entry: This value is referred to the mean height of the contact lines (see Figure B.2, dimension "d"), without displacement of the vehicle from the lines axis.

3.21**dewirement**

sudden and permanent detachment of the trolley of one or both poles from the overhead contact line(s) with running trolley bus

3.22**overhead contact line****OCL**

contact line which is placed above or beside the upper limit of the vehicle gauge and which supplies traction units with electrical energy via roof-mounted current collection equipment

Note 1 to entry: The characteristics of the overhead contact line are due to be made known to the manufacturer, together with the type of service, the environmental conditions and the road profile. Mechanical properties are given in EN 50119, minimum heights are given in EN 50122-1.

3.23**trolley bus displacement from OCL**

allowed displacement of the vehicle axis from the longitudinal contact lines axis in both transversal directions as indicated in dimension “g” of Figure B.2

Note 1 to entry: The minimum displacement is referred to the height “d” (see Figure B.2) and represents the allowed excess of the gauge in respect to the gauge normally allowed by the legislation.

3.24**involved parties**

- manufacturer: who actually is responsible for the design and the manufacture of the vehicle;
- supplier: who acts as selling partner in a contract;
- purchaser: who acts as purchasing partner in a contract;
- operator: the final entity which is entitled to use the vehicles for public service

3.25**main contactor**

remote controlled, two pole circuit breaker to connect/disconnect the entire downstream installation in normal service mode and emergency situations

Note 1 to entry: Design also is possible with a single pole circuit breaker for one polarity combined with a single pole follower contactor for the other polarity or a two pole fuse combined with a two pole follower contactor.

4 Voltages and classification of the voltage bands**4.1 Voltages****4.1.1 General**

The voltage definitions used in this European Standard are those of EN 50163 and EN 50124-1, where the following applies to direct voltage networks in compliance with EN 50163.

4.1.2 Operating voltages

The equipment shall operate at voltages of the overhead contact line system specified in EN 50163:

- U_n	Nominal voltage	600 V	750 V
- U_{Ne}	Rated voltage range ($0.67 U_n$ to $1.2 U_n$)	400 V to 720 V	500 V to 900 V
- U_{max1}	Maximum permanent voltage	720 V	900 V
- U_{max2}	Highest non permanent voltage	800 V	1 000 V < 5 min

NOTE In France, Belgium and the United Kingdom different national regulations (EN 50163) apply, which, however, do not apply to trolley buses.

For vehicle wash plants, according to EN 50122-1 the max. allowed voltage is 120 V d.c (Voltage band II). In this case, the vehicle wash plant is not part of the workshop where the max. allowed voltage is 60 V d.c (voltage band I).

4.1.3 Insulation voltages and test voltages

Insulation according to EN 50124-1 shall be designed and tested with reference to the following voltages:

- U_n	Nominal voltage	600 V	750 V
- U_{Nm}	Rated insulation voltage ($\geq U_{max1}$)	≥ 720 V	≥ 900 V
- U_a	Power frequency withstand voltage	refer to Table 5	

4.1.4 Overvoltages

The equipment shall withstand overvoltages of the overhead contact line system specified in EN 50163:

- U_N	Nominal voltage	600 V	750 V
- $U_{\max 3}$	Highest long-term overvoltage	1 270 V	1 270 V

4.2 Classification of the voltage bands

According to EN 50153, the voltage bands applicable to trolley buses are in accordance with Table 1.

Table 1 — Voltage bands for trolley buses

Band	Nominal voltage	
	a.c. V	d.c. V
I	$U_N \leq 25$	$U_N \leq 60$
II	$25 < U_N \leq 50$	$60 < U_N \leq 120$
III	$50 < U_N \leq 1,000$	$120 < U_N \leq 1,500$

In France different limits apply because of special national conditions.

Table 2 — Voltage bands for France

Band	Nominal voltage	
	a.c. V	d.c. V
I	$U_N \leq 25$	$U_N \leq 60$
II	$25 < U_N \leq 50$	$60 < U_N \leq 120$
III	$50 < U_N \leq 500$	$120 < U_N \leq 750$
IV	$U_N > 500$	$U_N > 750$

In Italy different limits apply because of legal regulations.

Table 3 — Voltage bands for Italy (Decree D.P.R. 547: 1955, Law 191:1974)

Band	Nominal voltage	
	a.c. V	d.c. V
I	$U_N \leq 25$	$U_N \leq 50$
III	$25 < U_N \leq 400$	$50 < U_N \leq 600$
IV	$U_N > 400$	$U_N > 600$

In ISO 6469-3 different limits apply.

Table 4 — Voltage bands for electric plants on road vehicles

Band	Nominal voltage	
	a.c. V	d.c. V
A	$U_N \leq 30$	$U_N \leq 60$
B	$30 < U_N \leq 1\,000$	$60 < U_N \leq 1\,500$

5 Trolley bus construction

5.1 Protection and electrical safety criteria

5.1.1 Protection criteria against direct and indirect contacts

The best criteria and arrangements shall be adopted in the design and in the manufacture of trolley buses to avoid, or at least minimize to a non-dangerous level, all touch voltages and in particular the voltage differential between mass and earth potentials and to detect leakages before the associated voltages reach a dangerous level.

Limit values for touch voltages are specified in EN 50122-1. Limit values for shock currents are specified in the IEC 60479 series.

NOTE Different limit values for touch voltages apply in Switzerland (SR 734.2).

The requirements of EN 50153 shall apply wherever applicable.

Since the highest hazard potential is present when touching the outside of the vehicle, the requirements of EN 50153 of a verifiable double insulation are supplemented by a third insulation in the area of the doors, where passengers would be most likely to come into contact with voltages.

If possible, the double insulation should be designed such that a fault cannot bridge both paths at the same time.

Layout of insulation distances depending on material and degree of pollution is carried out according to EN 50124-1.

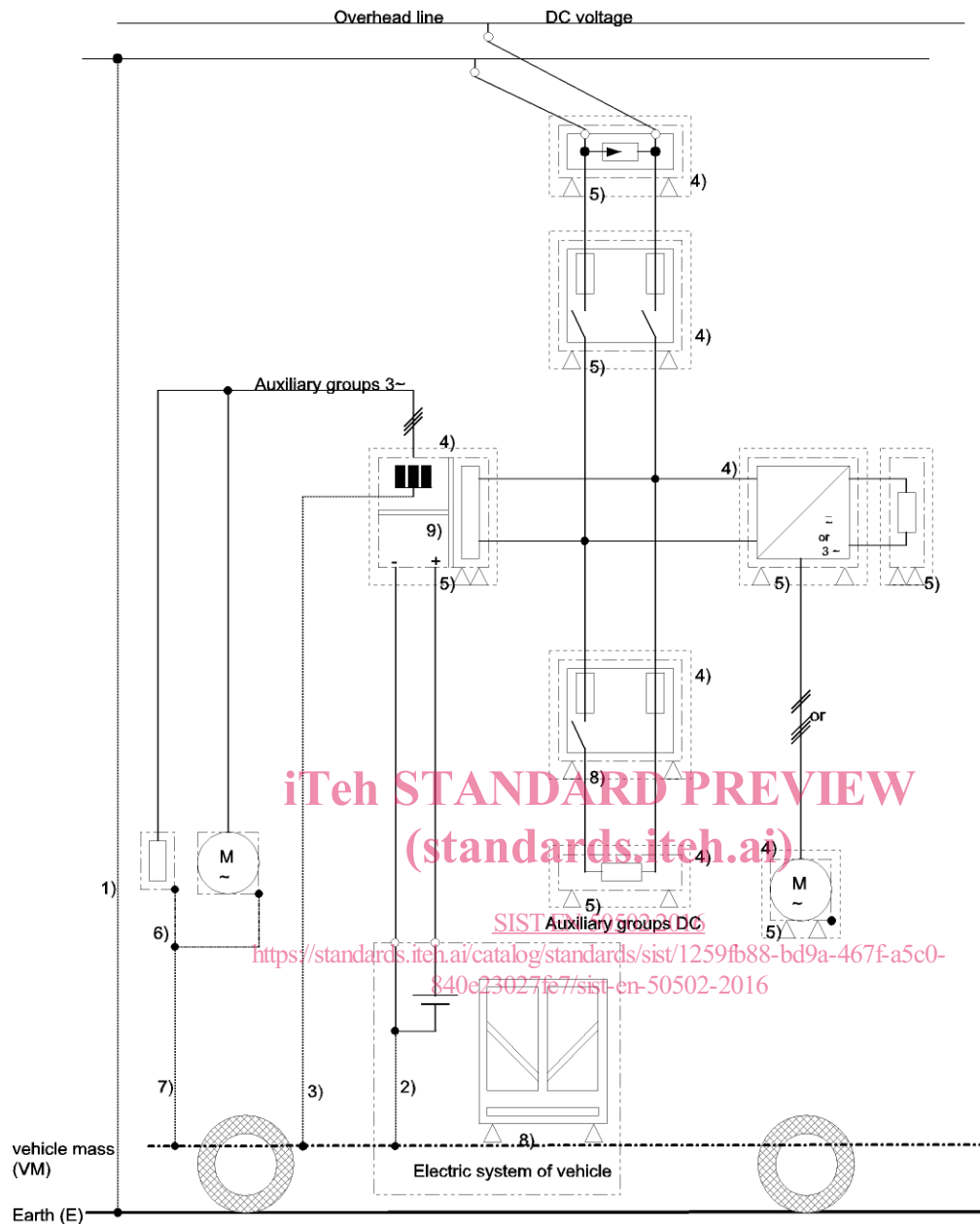
Always make sure for external insulation that part of the insulation remains protected from moisture or dirt. If this is not possible, greater distances and/or other materials shall be selected because of the higher minimum insulation resistances in systems with no protective bonding (see Table 6).

Figure 1 provides an overview of the double insulation requested for this vehicle type in EN 50153 as well as of the third insulation of the doors.

The expansion of the basic insulation to double insulation always applies to all three types of interfaces of the component:

- Supplementary insulation of the mechanical mounting;
- Supplementary insulation of the power supply module;
- Supplementary insulation of the signal interfaces.

The marking by warning signs of installation spaces containing circuits with voltages of bands II and III or power circuits of band I shall comply with EN 50153.



Key:

- 1) Conducting connection of substation output to earth if applicable
- 2) Conducting connection of DC- on board power supply to vehicle mass if applicable
- 3) Conducting connection between neutral point of transformer of static converter and vehicle mass as protective conductor if applicable (see also 7)
- 4) Protection of direct contact of all intermediate masses (enclosure, roof installation, underfloor installation)
- 5) Supplementary insulation for implementation of the double insulation. Basic- or functional insulation are represented by enclosures, double insulation of cables is not depicted.
- 6) Conducting connection of all enclosures of three phase AC loads (protective bonding if applicable).
- 7) Conducting connection of all enclosures of three phase AC loads and vehicle mass as protective conductor (see also 3)
- 8) Supplementary insulation of entrance areas (doors, access platforms, push buttons) if applicable
- 9) Double insulation inside devices (depicted only for static converter)

Figure 1 — Insulation overview — Trolley buses