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Foreword

This project of European Standard was prepared by SC9XB, Electromechanical material on board rolling stock, of Technical Committee CENELEC TC9X, Electrical and electronic applications for railways

The document is released for approval procedures.

Annexes designated “normative” are part of the body of the standard.

Annexes designated “informative” are given for information only.

In this standard, annexes A, B and C are normative.

Contents

1 GENERAL

1.1 Scope

The standard applies to electrical systems on board trolley buses, as defined in 1.2.01, fed with a nominal line voltage (U_n) between 600 V d.c. and 750 V d.c.

The standard defines the requirements and constructional hints, especially to avoid danger of electrical kind to the public and to the personnel.

The standard covers vehicles intended for public transport of persons.

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

1.2 Normative references

This European Standard incorporates by dated or undated references, provisions from other publications. These normative references are cited at the appropriate place in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 50119	Railway applications – Fixed installations – Electric traction overhead contact lines
EN 50121 s.	Railway applications – Electromagnetic Compatibility
EN 50124 s.	Railway applications – Insulation coordination
EN 50153	Railway applications – Rolling stock – Protective provision relating to electrical hazard
EN 50155	Railway applications – Electronic equipment used on rolling stock
EN 50163 s.	Railway applications – Supply voltage of traction systems
EN 50207	Railway applications – Electronic power converters for rolling stock
EN 50215	Railway applications – Testing of rolling stock after completion of construction and before entry into service
EN 50264 s.	Railway applications – Railway rolling stock cables having special fire performance – Standard wall
EN 50272-3	Safety requirements for secondary batteries and battery installations – Part 3: Traction batteries
EN 50306 s.	Railway applications – Railway rolling stock cables having special fire performance – Thin wall

EN 50343	Railway applications – Rolling stock – Rules for the installation of cables
EN 60077 s.	Railway applications – Electrical equipment for rolling stock
EN 60322	Railway applications – Electrical equipment for rolling stock – Rules for power resistors of open construction
EN 60349 s.	Electric traction – Rotating electrical machines for rail and road vehicles
EN 60373	Railway applications – shock and vibration tests
ISO EN 9001	Quality management systems - Requirements
ISO 10099 s.	Pneumatic fluid power – Cylinders – Final examination and acceptance
EEC 2001/85	Special requirements for public transport vehicles having more than eight seats in addition to the seat of the driver

1.3 Definitions

For the purpose of this standard the following definitions apply:

1.3.1
trolleybus
rubber tyred vehicle, connected to a direct current overhead contact line, driven by one or more electrical motors. The conductors of the overhead contact line are either both insulated or one insulated and one earthed.

1.3.2

current collection system

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

1.3.3
mass
the conductive part of an electrical component which is accessible and which is not energized in normal conditions, but may become energized in fault conditions; the equipment defined in 2.6.01 as normal bus vehicle components are not covered in this definition. The conductive parts of the chassis and of the bodywork are defined as the vehicle mass.

1.3.4
intermediate mass
the conductive part comprised between two insulating parts of a double insulated equipment (protection, enclosure, etc.), which shall be in any case not accessible to the public.

1.3.5
main insulation
the insulation between the electric parts which are subject to be energized and the intermediate mass.

Note: In 50124-1 this insulation is named “basic insulation” and is defined as the insulation applied to live parts to provide basic protection against electric shock.

1.3.6
supplementary insulation
the insulation between the intermediate mass and the vehicle mass.

1.3.7
double insulation
an insulation comprising both main (basic) insulation and supplementary insulation.

1.3.8

nominal voltage U_n

the voltage value with which the system or one part of the same is nominated and which the general characteristics are referred to.

1.3.9

rated voltage U_{Ne}
the voltage which, together with rated current, defines the use of the equipment and which the applicable tests and the use categories are referred to.

1.3.10

rated insulation voltage U_{Nm}
the value the dielectric test voltages and the creepage distances are referred to. In no cases this value can be lower than U_{Ne}. When no value is defined by the purchaser for U_{Nm}, the maximum operating voltage U_{max1}, given by EN 50163 shall be assumed.

1.3.11

power frequency withstand voltage U_a
the r.m.s. a.c. voltage which does not cause an insulation fault according to specified test conditions.

1.3.12

highest non-permanent voltage U_{max2}
The maximum value of the voltage likely to be present for maximum 5 min.

1.3.13

maximum current

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

1.3.14

maximum speed

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

1.3.15

static contact force

the value of force $\vec{F}$ (see Figure B.7) applied by the slipper on the contact line, as measured with standing vehicle. 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.

1.3.16

dewirement

the accidental and permanent detachment of the trolley of one or both poles from the overhead contact line(s) with running trolleybus.

1.3.17

overhead contact lines (OHL)

the fixed equipment intended to supply the power to the vehicle. The characteristics of the OHL shall be made known to the tenderer, together with the type of service, the environmental conditions and the road profile.

1.3.18

trolleybus displacement from OHL

the 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.

The minimum displacement is referred to the height "d" (see 3.9) and represents the allowed excess of the gauge in respect to the gauge normally allowed by the legislation.

1.3.19

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.

1.4 Voltages

The voltage definitions used in the standard are those of EN 50163 and EN 50124-1, where:

• U_n	nominal voltage	600 V d.c.	750 V d.c.
• U_N	rated voltage (0,67 U_n to 1,2 U_n)	402÷720 V d.c.	502,5÷900 V d.c.
• U_{Nm}	rated insulation voltage (≥ U_{max1})	≥ 720 V d.c.	≥ 900 V d.c.
• U_{max2}	maximum applicable voltage	800 V d.c.	1000 V d.c.
• U_a	power frequency withstand voltage	see Table 2	

1.5 Classification of the voltage bands

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

Table 1 – Voltage bands for trolleybuses

Band	Rated voltage	
	a.c. (V)	d.c. (V)
I	$U_N \leq 25$	≤ 60
II	$25 < U_N \leq 50$	$60 < U_N \leq 120$
III	$50 < U_N \leq 1000$	$120 < U_N \leq 1500$

Note: In France and Italy different limits apply because of legal prescriptions.

2 TROLLEYBUS CONSTRUCTION

2.1 Protection and electrical safety criteria

2.1.1 Protection criteria against direct and indirect contacts

The best criteria and arrangements shall be adopted in the design and in the manufacture of trolleybuses to avoid, or at least minimise to a non-dangerous level, all contact voltages and in particular the voltage differential between mass and earth potentials and to detect leakages before the associated voltages reach a dangerous level. As reference, the requirements of EN 50153 apply for similar features .

2.1.2 Steps, handrails, slopes and access platforms

Steps and handrails facing all doors shall be insulated from vehicle mass or made of insulating material. Slopes and access platforms intended to assist handicapped people, shall be insulated from the vehicle mass. Alternatively when it is not insulated from mass the operation shall be interlocked with opening the main line contactor.

2.1.3 Doors

All door shutters and relevant accessories, except for control equipment not accessible to the public, shall be insulated from the vehicle mass or made of insulating material.

2.1.4 Cabling layout

Canalisation of cables fed at voltages of band III shall be segregated from those containing cables fed at voltages of bands I and II; band III canalisations shall be easily detectable by means of suitable markings. In case of double insulation canalisation of band III cables being part of different circuits shall be segregated.

2.1.5 Open door interlocking

Traction equipment shall be provided with an interlock to prevent the vehicle from starting while the doors are open. This interlock device shall include a push button or a similar padlocked device enabling the driver to exclude the feature. EEC 2001/85 shall be complied.

2.1.6 Leakage detector

When the feature is applicable, trolleybuses shall be equipped with an automatic safety device, defined as leakage detector. The device gives an optical/acoustic alarm signal when the insulating resistance, between the circuits fed at line voltage and the vehicle mass, decreases down to unacceptable limits such as those mentioned in EN 50153 or the vehicle body potential reaches the limits given in EN 50122-1.

When the above mentioned limit value is reached, the device actuates, when the vehicle is standing, the line contactorcircuit breaker to open and the contact rods to lower automatically, when this feature is possible.

The leakage detector or at least the relevant acoustic/optic alarm device, if any, shall be mounted at the driving place, in a location easily visible by the driver.

The device, when required and supplied, shall be provided with self-checking means and shall satisfy intrinsic safety criteria; an authorized third party shall verify, in this case, the characteristics.

2.1.7 Intermediate mass insulation detector

In case of a leakage detector is provided, a device suitable to detect the insulation level of the various parts energised towards the relevant intermediate masses and towards the vehicle mass shall be provided on request. This device may be combined with the leakage detector described in 2.1.6. The intermediate masses shall be electrically insulated among themselves (see Table 2); it is allowed that, exceptionally and for justified constructional reasons, some intermediate masses of functionally homogeneous equipment are connected.

2.1.8 Capacitors

The capacitors fed with voltages within band III shall be provided with discharge resistances in parallel. To achieve the best safety conditions, steps shall be taken to avoid that personnel have access unintentionally to parts with harmful voltages. In this connection reference shall be made to the requirements given by EN 50153.

2.1.9 Equipotential connections

In case of articulated trolleybus or connected coaches, these elements of the vehicle shall be electrically interconnected, in order to have vehicle masses at the same potential. These connections shall be easily found and suitably marked.

2.1.10 Electromagnetic compatibility (EMC)

The electrical and electronic equipment on board shall not cause or suffer in the vehicle and in the surrounding ambient interferences of electrical, magnetic or electromagnetic origin at such a level as to endanger the correct operation of the control, calibration, safety, radio-transmission devices etc., due to emissions conducted, induced or radiated.

Reference shall be made to EN 50121 series.

2.2 Electrical components in band III voltage (high voltage)

2.2.1 General

The electrical components fed at a voltage of band III and connected to the OHL shall be specifically made for electric traction, suitable for use in trolleybus service, with the pole terminals isolated from intermediate mass.

For the electrical and mechanical characteristics the specific standards for the specific product apply.

2.2.2 Current collection system

See Annex B.

2.2.3 Cables

Cable shall have characteristics for fire of non-propagating flame, reduced smoke, toxic and corrosive gases emissions. They shall comply with the CENELEC standards (see EN 50343,

EN 50264 and EN 50306) as applicable for these types of traction cables when applied on trolleybuses.

2.2.4 Auxiliary groups

The auxiliary groups fed at the line voltage, e.g. the auxiliary motors for driving the compressor, the fans, the hydroguide pump, etc., the auxiliary generators, the static converters, and so on, shall have a double insulation in respect to the vehicle mass.

The equipment supplied through circuits galvanically insulated from the line may be mounted without the double insulation.

Protective provisions against electrical hazard shall be in accordance with EN 50153 for insulated supply systems

2.2.5 Climatisation devices

When space heaters or air conditioning equipment, for different uses, imply components supplied by band III voltages, the requirements given in 2.2.4 apply. Ventilation ducts, if made of conducting material, shall be connected to the vehicle mass.

2.3 Electric traction equipment

2.3.1 General

The electrical traction equipment mainly comprises the traction motor(s), the driving equipment for the operation and the braking, the resistor, if any, for starting and braking.

The control and the calibration equipment are considered part of the traction equipment on the functional point of view.

2.3.2 Traction motors

For the traction motors EN 60349 series apply.

The motors shall be arranged to have a double insulation both in respect to the fixing to the chassis and to the connection to the transmission outputs.

2.3.3 Traction and braking drive

EN 50207 applies to the electronic power equipment.

EN 60077 series applies in case of electromechanical drive.

EN 50155 applies to electronic control equipment

The equipment shall be installed in body compartments or enclosures, suitably ventilated and accessible only to the personnel attending the trolleybuses. All the live parts shall have double insulation in respect to the vehicle mass, except for those galvanically insulated from the line voltage, and shall be in any case protected from undue accidental contacts when excited.

2.3.4 Starting and braking resistors

EN 60322 applies to the electrical resistors. They shall be mounted in order to have the live parts with double insulation against the vehicle mass and with suitable barriers or arrangements for protection from undue accidental contacts when excited.

When the heat produced by the resistors is used for heating the ambient, the relevant conduits, if made of conducting material, shall be electrically connected to the vehicle mass.

2.4 Emergency running equipment (independent from OHL)

2.4.1 General

Trolleybuses may be equipped with an equipment for running with an auxiliary source of electrical energy, differing from the overhead contact line.

This equipment may be an electro generating thermal engine, a group of batteries or other equivalent mean suitable to supply the traction motor(s).

As far as the control and safety systems are concerned, they can remain in use as in normal running,.

2.4.2 Independence of emergency equipment and insulation requirements

All electrical components for specific use for the operation in independent running shall have the same characteristics as required for equipment fed at the same voltage band.

Except for special features, any electrical connection between overhead contact line and the electrical source for independent running shall be excluded without the need of lowering the contact rods. In this case double insulation is not required, but intermediate test connection has to be defined between purchaser and supplier.

The equipment under 2.3.1 may be used for feeding the traction motor(s).

2.5 Electrical components in band II voltage (medium voltage)

2.5.1 General

The electrical components supplied at a voltage of band II shall be two-pole and insulated from the vehicle mass. They shall be protected by means of fuses or automatic breakers having a suitable breaking capacity and they shall be suitable for the use on trolleybuses. When there is the need of having on the vehicle components fed at voltages pertaining to different bands, suitable arrangements shall be taken for an effective electrical segregation.

Protective provisions against electrical hazards shall be according EN 50153 for insulated supply systems.

2.5.2 Cables

The cables for the circuits at a voltage of band II shall be of the type non-propagating flame, at low emission of smokes and toxic or corrosive gases. The cables shall comply with the EN standards for traction cables of the above-mentioned characteristics for use on trolleybuses (see EN 50343, EN 50264 and EN 50306).

2.5.3 Separation from other voltage band circuits

The circuits related to the components under 2.5.1, which are mounted on the same structures with cables for voltages of bands I and III, shall be designed for a suitably segregated installation. The connection points, if any, of cables for voltages in band II and apparatus at voltages in bands I and III, shall be carefully designed in respect to distance, mechanical protection and insulation between voltages.

2.6 Electrical components in band I voltage (low voltage)

2.6.1 General

Protective provisions against electrical hazards shall be according to EN 50153 for insulated supply systems.

The electrical components supplied at a voltage of band I are shared between two groups as follows:

- **Trolleybus components:** components specifically designed for trolleybuses, such as the traction control, the auxiliary services, etc. for which it is possible also the presence of circuits fed with voltages of band III. The components having a simple insulation against the line voltage shall be two-pole and fed through a galvanic separation device suitable for an insulation equal to that between intermediate mass and vehicle mass of the line fed equipment (see Table 1). An intermediate connection for insulation check has to be agreed between purchaser and supplier.

  Electronic components used in connection with band II and III equipment can be handled as required in the following Item "normal bus components".

- **Normal bus components:** components used in any bus, such as the internal and external lighting systems, signalling, diesel engines for driving the vehicle and APU and relevant starters. These may be single-pole with the return connected to the trolleybus mass directly or indirectly (cabled negative), according to the requirements and to the constructional needs.

They shall be protected by means of fuses or automatic breakers having a suitable breaking capacity and they shall be suitable for the use on trolleybuses. When there is the need of having on the vehicle components fed at voltages pertaining to different bands, suitable arrangements shall be taken for an effective electrical segregation.

2.6.2 Cables

The application of the requirements under 2.5.2 is subject to agreement between purchaser and supplier. See also EEC and EN 45

2.6.3 Separation from other voltage band circuits

See 2.5.3.

3 CHECKS AND TESTS

3.1 General

The requirements contained in this clause concern the dielectric tests to be carried out specifically on trolleybus equipment. Test on components are specified in the relevant product standards and applied.

The additional applicable tests according to this Standard are listed in Table 2.

Checking of the insulation shall be carried out at least at two month intervals from 7 500 km to 10 000 km (as stated by the operator) of operation, considering the limit firstly encountered between the two given above. These limits can be shortened in case the pre-alarm device mentioned in A.10 is present and the readings suggest frequent insulation checks.

Hereafter the limit values for the insulation are given for a new trolleybus, for an overhauled trolleybus and for a trolleybus during normal service.

3.2 New trolley-vehicles

3.2.1 Design and construction verification

The compliance of the vehicle to the requirements of clause 2 shall be carefully verified, particularly in respect to the insulation of the equipment having voltages in band III, especially those circuits fed by the OHL with double insulation.

The design shall list and show the various intermediate masses, on which the electrical tests below specified shall be carried out.

3.2.2 Separate source applied voltage tests on circuits and components fed at voltages of the band III

Circuits and electrical components at the line voltage and those fed at voltages of the band III, with double insulation against the vehicle mass, shall be submitted to voltage tests, carried out on new material when the vehicle is commissioned.

The test is carried out:

a) after having excluded the motors and those components supplied at voltages of band III which could be damaged or could disturb the test and having connected all remaining circuits, belonging to one insulation level of band III. A list of such components shall be given as well as documentation of a separate test carried out by the manufacturer;

b) having connected to earth all remaining circuits and components of the electrical equipment of the trolleybus;

c) by applying gradually during 10 s a test voltage U_a a.c., sinusoidal, at a frequency of 50 Hz and keeping this value for a duration of 60 s; U_a is shown in Table 2;

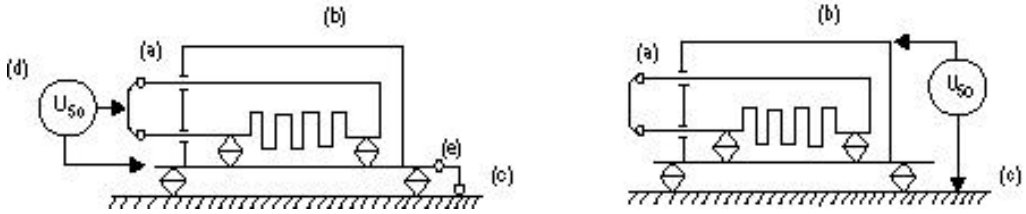
d) by carrying out the test between the above mentioned circuits and components and the intermediate masses connected together and to the vehicle mass (see Figure 1);

e) by repeating the test between the intermediate masses connected and the vehicle mass (see Figure 2).

f) By repeating the test between the intermediate masses kept insulated.

The circuits and the components fed at voltages of band III, but not fed directly by the voltage of the line and not provided with double insulation towards mass, shall be tested as above, at a voltage U_a (see Table 2), applied between the concerned circuits and the vehicle mass.

If a dielectric test failed the second test after repair shall be carried out at 85 % of U_a.



LEGENDA

(a)	circuit or electrical component	**(d)**	voltage generator
(b)	intermediate mass	**(e)**	equipotential connection
(c)	vehicle mass		

Figures 1 and 2 – Test circuits

3.2.3 Separate source applied voltage tests on circuits and components fed at voltages of the band II

The circuits and the components supplied at voltages of band II shall be submitted to voltage test, on new material, when the vehicle is commissioned according to EN 50215.

The test is carried out:

a) after having excluded those components supplied at voltages of band II which could be damaged or could disturb the test and having connected all remaining circuits, belonging to one insulation level of band II;

b) having connected to earth all remaining circuits and components of the electrical equipment of the trolleybus;

c) by applying gradually during 10 s a test voltage U_a a.c., sinusoidal, at a frequency of 50 Hz and keeping this value for a duration of 60 s, between said circuits and components and the vehicle mass; U_a is shown in Table 2.

3.2.4 Separate source applied voltage tests on circuits and components fed at voltages of the band I

Circuits and electrical components supplied at voltages of the band I shall be submitted to voltage tests, carried out on new material when the vehicle is commissioned.

The test is carried out:

a) after having excluded the components supplied at voltages of band I which could be damaged or could disturb the test and having connected all remaining circuits, belonging to one insulation level of band I;

b) having connected to earth all remaining circuits and components of the electrical equipment of the trolleybus;

c) by applying gradually during 10 s a test voltage U_a a.c., sinusoidal, at a frequency of 50 Hz and keeping this value for a duration of 60 s between the concerned circuits and the vehicle mass; U_a is shown in Table 2.

The circuits and the components fed at voltages of band III, but not fed directly by the voltage of the line and not provided with double insulation towards mass, shall be tested as above, at a voltage U_a (see Table 2), applied between the concerned circuits and the vehicle mass.

Table 2 – Test voltages U_a based on rated insulation voltage U_{Nm}

Subject	Industrial frequency applied voltage U_a (V)				
	Rated insulation voltage U_{Nm}				
	≤ 36	**>36 ≤60**	**>60 ≤300**	**>300 ≤660**	**>660 ≤1200**
For components with single insulation, dielectric test shall be carried out across any circuit supplied to a given voltage and the mass, to which all the remaining circuits shall be connected	750	1000	2000	2500	$2U_{Nm}$+1500
For components with double insulation, the dielectric test shall be made: • across intermediate masses connected and the vehicle mass and across each pair of intermediate masses when insulated			1500	1500	$1,6U_{Nm}$+500
• across an electrode put in contact to platform, doors or handicapped people ramps and vehicle mass • across the circuits and the intermediate masses connected to the vehicle mass			2000	2500	$2U_{Nm}$+1500
Note: For electronic equipment with U_{Nm} < 36 V the dielectric test voltage is reduced to 500 V					

3.2.5 Insulation resistance values for circuits and components supplied at the line voltage

The following insulation resistance measurements shall be effected:

a) between the vehicle mass and all the interconnected circuits and components supplied at the line voltage (see Figure 3);

b) between each intermediate mass and all the interconnected circuits and components supplied at the line voltage (see Figure 4);

c) between the vehicle mass and each intermediate mass (see Figure 5);

d) between each intermediate mass and all other intermediate masses.

The tests, to be performed with the modalities shown in 3.2.6 (dry conditions), are considered successful when the insulation resistance, measured and expressed in Megaohms, satisfies the condition:

$$R \geq 4 + U_{Nm}/300$$

Note: Internal regulations (e.g. in Switzerland) may impose tests relating to wet conditions.

3.2.6 Insulation resistance test modalities for circuits and components supplied at the line voltage

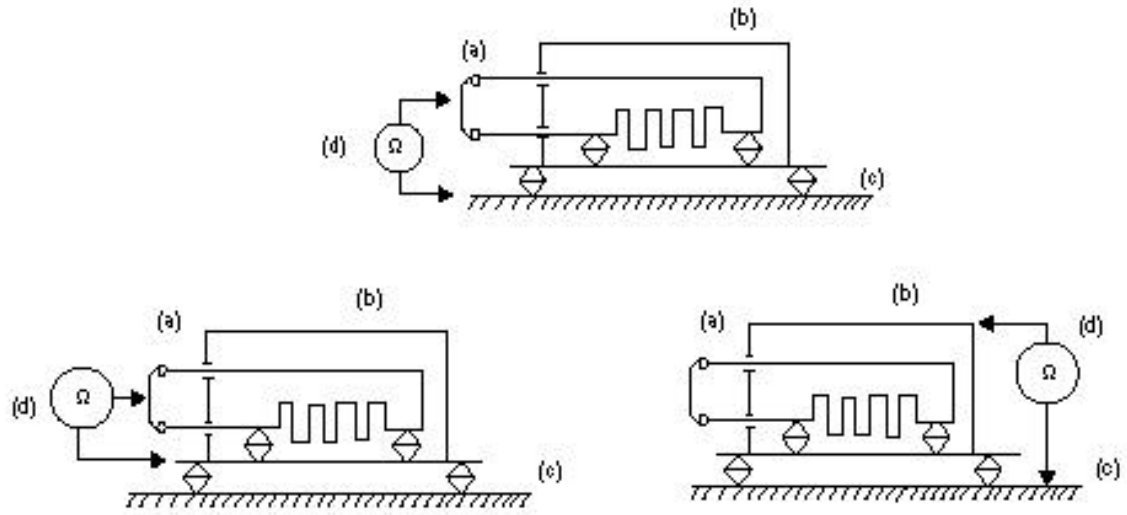
The insulation tests shall be made with the vehicle dry. Referring to the tests under a) and b) of 3.2.5, all circuits and electrical components shall be connected; therefore, considering the electrical diagram of the vehicle equipment, all switches and contactors concerned shall be in

the position to put all parts of the electrical installation directly supplied at the line voltage energised during the test.

Before testing, the mass connection of the leakage detector (see 2.1.6) shall be removed.

The measure shall be carried out with a megaohmmeter with a generator (part of the instrument) for 1 000 V d.c.

According to the measurement type the megaohmmeter shall be connected as indicate in Figures 3, 4 or 5.



LEGENDA

(a) circuit or electrical component

(b) intermediate mass

(c) trolleybus mass

(d) measuring instrument

Figures 3, 4 and 5 – Megaohmmeter connection

3.2.7 Insulation resistance values for circuits and components supplied at a band III voltage differing from the line voltage

These circuits and electrical components shall be submitted to the measurement of the insulation resistance against the vehicle mass. The test is considered successful when the insulation resistance, measured in dry conditions and expressed in Megaohms, satisfies the condition:

$$R \geq 4 + U_{Nm}/300$$

Note: Internal regulations (e.g. in Switzerland) may impose tests relating to wet conditions.

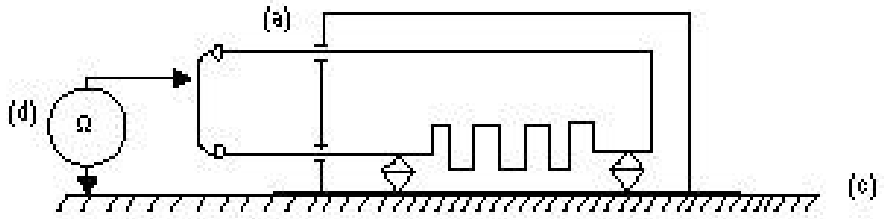
When an intermediate mass is present for constructional reasons in these installations, the criteria shown in 3.2.5 b) and c) apply. The resistance values for these intermediate masses shall satisfy the above-mentioned condition.

The insulation tests shall be made with the vehicle dry. All circuits and electrical components shall be connected; therefore, considering the electrical diagram of the vehicle equipment, all concerned switches and contactors shall be in the position to put all parts of the electrical installation supplied at the voltage of band III energised during the test.

Before testing, the mass connection of the leakage detector (see 2.1.7) shall be removed.

The measure shall be carried out with a megaohmmeter with a generator (part of the instrument) for 1 000 V d.c.

The megaohmmeter shall be connected as indicated in Figure 6.



LEGENDA

(a) circuit or electrical component

(c) trolleybus mass

(d) measuring instrument

Figure 6 – Megaohmmeter connection

When intermediate masses are present, the instrument shall be connected as shown in Figures 4 and 5.

Depending on the provisions (according EN 50153) to prevent electrical hazards, if applicable, the insulation test can be included in the periodical insulation test.

3.2.8 Insulation resistance values for circuits and components supplied at a voltage of band II

The insulation resistance between the vehicle mass and all the interconnected circuits and components supplied at a voltage of band II shall be measured.

The test, to be performed according the modalities shown in 3.2.9 is considered successful when the insulation resistance, measured and expressed in Megaohms, is equal to or exceeding 4 MΩ.

3.2.9 Insulation resistance test modalities for circuits and components supplied at a voltage of band II

The insulation tests shall be made with the vehicle dry. All circuits and electrical components shall be connected; therefore, considering the electrical diagram of the vehicle equipment, all concerned switches and contactors shall be in the position to put all parts of the electrical installation supplied at the voltage of band II energised during the test.

Before testing, the mass connection of the leakage detector (see 2.1.7) shall be removed.

The measure shall be carried out with a megaohmmeter with a generator (part of the instrument) for 1 000 V d.c.

The megaohmmeter shall be connected as indicated in Figure 6.

Depending on the provisions (according EN 50153) to prevent electrical hazards, if applicable, the insulation test can be included in the periodical insulation test.

3.2.10 Insulation resistance values for circuits and components supplied at a voltage of band I

The insulation resistance between the vehicle mass and all the interconnected circuits and components supplied at a voltage of band I shall not be measured unless specifically required by the operator.

The test, to be performed according modalities shown in 2.3.9, is considered successful when the insulation resistance, measured and expressed in Megaohms, is equal or exceeding 4 MΩ.

Depending on the provisions (according EN 50153) to prevent electrical hazards, if applicable, the insulation test can be included in the periodical insulation test.

3.2.11 Insulation resistance values for the parts concerned with the accesses to the vehicle

The parts concerned with the accesses of the vehicle (see 2.1.3 and 2.1.4) shall be tested for insulation resistance between the same and the vehicle mass.

The measurements shall be carried out with a megaohmmeter having a generator, being part of the instrument, with a voltage of 1 000 V d.c.; the test is considered successful if the insulation resistance of every part is equal to or larger than 6 MΩ in dry and clean conditions.. In wet conditions the limit measure shall be 0,3 MΩ when the entrance flooring is immersed in local drinking water, contact area wiped with shoes so that there is no visible film of water at the test point.

3.3 Overhauled trolley-vehicles

3.3.1 Tests and verification of the electrical equipment

Upon new commissioning of the overhauled vehicle, the verifications required under 3.2.1 to 3.2.4 shall be repeated with reduced values of 85% of U_a.

3.3.2 Measurements and value of the insulation resistance

The insulation tests described in 3.2.5, 3.2.7, 3.2.8, 3.2.10 and 3.2.11 shall be carried out with reference to the portion of electric installation revised and the voltage band associated.

The tests are considered successful when the insulation resistance is at least 1/3 of the values required for a new vehicle; this is applicable also to the access parts under 2.1.3 and 2.1.4.

3.3.3 Insulation test modalities

See the requirements in 3.2.6 and 3.2.9..

3.4 On-duty trolley vehicles (periodical checks)

3.4.1 Insulation decay and provisions required

During service, the insulation can suffer a decay, due to several external causes (mud, rain, etc.), gradual wear or fault; this decay, beyond a given limit, shall be revealed by the leakage detector (see 2.1.6). To grant a suitable safety margin of the insulation level of the vehicle to kind of provisions are necessary:

- verifications and periodical checks according 3.4.2 and 3.4.3; when the verified insulation resistance results to be equal or lower than indicated in Table 4, the vehicle shall be immediately submitted to maintenance before being put in service again;
- verification of the efficiency of the leakage detector, if any,, as per 3.5.3; when the verified insulation resistance value results to be equal or lower than what required in

3.5.2, the vehicle shall be immediately submitted to maintenance before being put in service again.

3.4.2 Periodical checks and tests of the insulation during maintenance

Basing on the maintenance plan stated by the user or after a fault, verifications on the insulation of the electrical equipment of the vehicle or on part of the same.

These verifications shall be preceded by a sight examination, to evaluate the absence of evident deteriorations, such to prevent operation and safety.

Successively the intermediate masses shall be individually checked using the device under 2.1.7 and, if suitable, measuring the insulation resistance of the electrical equipment, of the systems or of the sub-systems concerned, using the specific terminal board described in A.9, if any.

The supplier of the maintenance shall submit to the purchaser a short description of the procedure he intends to adopt.

3.4.3 Periodical checks and tests of the insulation prescribed by law

The law in some countries prescribes annual visits, checks and tests on the rolling stock. For trolleybuses, when theses events occur, the insulation resistance measurements shall be carried out according 3.2.5, 3.2.7, 3.2.8, 3.2.10 and 3.2.11.

Test modalities shall be those described in 3.2, and the value of the insulation resistance shall be limited to 1/3 of the value prescribed for a new vehicle; this value applies also to the access parts (see 2.1.3 and 2.1.4).

3.5 Leakage detectors

3.5.1 Operation and alarm of the detector

As indicated in 2.1.6, the leakage detector, if any, shall give an alarm signal, optical and acoustical, at the intervention level (threshold) specified in 3.5.2.

The apparatus shall disregard temporary interventions.

In case the threshold is reached, the vehicle shall be immediately removed from service, according to the procedures stated by the Operator, for undergoing the verifications and repairs according 3.4.2.

3.5.2 Calibration of the detector

The minimum insulation resistance R_{min}, which represents the threshold (calibration) for actuating the detector signal, is given by the formula:

$$R_{min} = U_n / 3000$$

where R_{min} is expressed in MΩ and U_n in V.

The minimum calibration values of the insulation resistance, expressed in Megaohms, are the following:

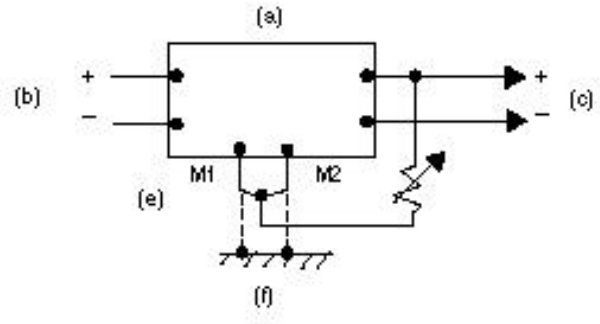
Table 3 – Calibration of the insulation resistance

Nominal line voltage (U_n) [V d.c.]	**Calibration of the insulation resistance R_{min} [MΩ]**
600	0,200
750	0,250

The leakage detecting apparatus shall operate correctly also in the range 0,67 U_n to 1,20 U_n referred to the line nominal voltage (see 1.1); the same in the range 0,70 U_n' to 1,25 U_n' when the apparatus is supplied by the battery for auxiliary services (see 2.6) having the nominal voltage U_n'.

3.5.3 Periodical efficiency checks

Particular care shall be given to ascertain that the leakage detector, if any, is permanently efficient and that the calibration remains in the values required in 3.5.2. Such verifications shall be carried out not only with a new or overhauled vehicle, but also periodically in accordance with the maintenance plan of the Operator and in any case before putting in service the vehicle after a repair work caused by insulation deficiency. Criteria for the efficiency verification are given in Figure 7.



LEGENDA
(a) leakage detector
(b) battery voltage
(c) line voltage
(d) disconnect from vehicle mass and short-circuit
(e) R_{min} = variable leakage resistance externally applied
(f) vehicle mass

Figure 7 – Typical efficiency verification criteria for the leakage detector

Table 4 – Summary of electric tests

Voltage band	New vehicle	Overhauled vehicle	On duty vehicles
Band I	• Test voltage U_a based on U_{Nm} (see Table 2) • Insulation $R \geq 4$ MΩ (instr. 500 V d.c.) (if required)	• Insulation ≥ 1/3 R (MΩ) (instr. 500 V d.c.) (for trolleybus components) (if required)	• Insulation ≥ 1/3 R (MΩ) (instr. 500 V d.c.) (for trolleybus components) (if required)
Band II	• Test voltage U_a based on U_{Nm} (see Table 2) • Insulation $R \geq 4$ MΩ (instr. 1000 V d.c.)	• Insulation ≥ 1/3 R (MΩ) (instr. 1000 V d.c.)	• Insulation ≥ 1/3 R (MΩ) (instr. 1000 V d.c.)
Band III	• Test voltage U_a based on U_{Nm} (see Table 2) • Insulation $R \geq 4$ MΩ + $U_{Nm}/300$ (instr. 1000 V d.c.)	• Insulation ≥ 1/3 R (MΩ) (instr. 1000 V d.c.)	• Insulation ≥ 1/3 R (MΩ) (instr. 1000 V d.c.)
Doors, steps, handrails, slopes, platforms, etc.	• Insulation $R \geq 6$ MΩ (instr. 1000 V d.c.)	• Insulation ≥ 1/3 R (MΩ) (instr. 1000 V d.c.)	• Insulation ≥ 1/3 R (MΩ) (instr. 1000 V d.c.)
Note: The manufacturer shall supply for each group of components of the same voltage band, the relative insulation voltage U_{Nm} in order to assess the test voltage U_a given in Table 2.			

Annex A

(Normative)

CONSTRUCTIONAL DETAILED PROVISIONS

A.1 General

Considering the specific characteristics of a trolleybus vehicle, it is considered necessary to recall the following points, which shall be carefully considered during the design and in the manufacture.

A.2 Attachement of the connection system

The current connection system and the rods to the base shall be fitted and secured in order to prevent disconnection or loosing of parts, taking into account shocks due to miscarriages of the trolley.

A.3 Insulations

The insulating covers, the interposed insulations, clearance in air and the protection against water penetration shall be adequately designed and cared.

A.4 Ventilation

The compartments housing contactors or switching devices suitable to have an arc during breaking shall be adequately ventilated to avoid accumulation of ionised air. The same precautions shall be used for compartments containing batteries.

A.5 Accessibility

The arrangement of the individual equipment and of cabling shall be made taking into account the need of accessibility and inspection needs: the cables shall not create an obstacle to accede to parts to be calibrated or subject to wear and tear.

A.6 Location of the main breaker

Mounting of the main protection equipment shall ensure that, particularly in faulty conditions, the arc chute sparks do not reach flammable parts.

A.7 Income and outlet points of cables

The income and outlet points through the vehicle body and from the conduits under the chassis shall be protected against penetration of water or mod and against the formation of moisture.

A.8 Cabling

Particular care shall be given to the routing, anchoring location and spans of cables, to avoid dangerous loosing or vibrations, considering, if any, passages in proximity of metallic edges.

A.9 Test terminal board

In order to facilitate the checks and measurements of the electrical insulation, it is advisable to provide the vehicle of a terminal board to which all intermediate masses are connected together with other components suitable to be verified.

A.10 Pre-alarm leakage detecting device

To be on the watch for the insulation decay, in particular in conjunction of adverse climatic conditions, to support a preventive action of the maintaining team in support of the safety and the regularity of the operation, it is suggested to have on board a device for the determination of the insulation having a value, agreed with the operator, to be considered a threshold of pre-

alarm. This device may be considered a complement of the terminal board under A.9 or of the device under 2.1.8.

A.11 Equipment connected to different voltage band circuits

In case of connection to circuits supplied with band I and II voltages, having components supplied with band III voltages, the cabling shall be made particularly cared for sturdiness of terminals and clearance. When necessary additional clamps and protections shall be added, suitable to avoid contacts of different voltage bands, even in case of detachment of the terminals.

A.12 Segregation of band III circuits

The compartments containing electrical components at band III voltages, placed inside the vehicle, shall be firmly closed and protected from external agents and from undue access.

A.13 Batteries

When an operation with the vehicle disconnected from the line, through batteries, is foreseen, these batteries should be selected among those commonly used in traction and road vehicles. This selection shall be made taking into consideration the safety of personnel and passengers and, in any case the standards applying to the kind of battery selected shall apply. (See also EN 50272-3 and EN 60077-1).

Annex B
(normative)

Trolleybuses

Connection system to overhead contact lines

B.1 SCOPE

This Annex applies to trolleybuses.

It defines the main characteristics of the connection system to the overhead contact lines, with a rated voltage between 600 V d.c. and 750 V d.c., which is mounted on the roof of trolleybuses.

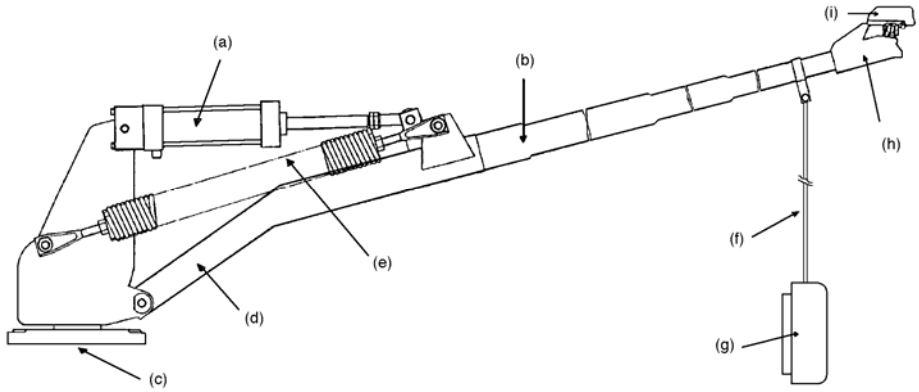
The Standard covers mainly automatic lowering and rising of the trolley rods. Nevertheless the Standard may be used also for manually operated rods systems for those parts which are not specifically intended for that feature.

B.2 GENERAL CHARACTERISTICS

B.2.1 General

The typical fundamental parts of the connection system, in their most common arrangement, are shown in Figure B.1 and listed here below.

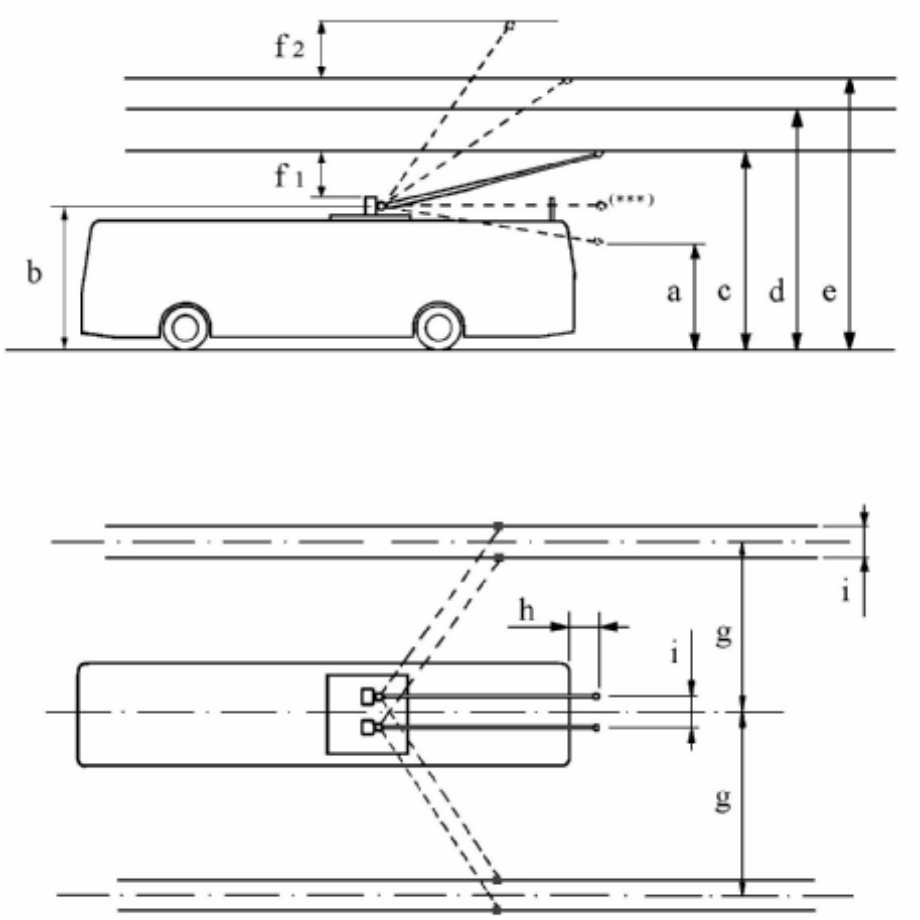
The dimensional characteristics of the system, as well as the limit geometry of the trolleybus are given in Figure B.2.



LEGEND

a) ACTUATOR	b) ROD
c) BASE SUPPORT	d) ROD FOOT
e) LIFTING SPRING	f) ROPE
g) WINDING DEVICE	h) CURRENT COLLECTOR HEAD
i) TROLLEY	

Figure B.1 – General characteristics of a typical trolley



Dimensions in mm

Minimum height from ground	Height of pivot ([1])	Height from ground of the overhead contact line			Safety distance under c	Safety distance over e	Minimum displacement of the vehicle at height d ([2])		Maximum protruding of rod system	OHL gauge
		Min.	Norm.	Max.			g			
a	b	c	d	e	f_1	f_2	g_1	g_2	h	i
to be agreed Suggested 2700	3100÷3500	Preferred 4700 Admitted: 3800	5600	Preferred 6500 Admitted 7200	≥200	≤800	4500	4000	≤1200	600÷700

[1] The distance b of the pivot from ground (vertical rotation) is to be intended for any load condition of the vehicle.

[2] g_1 and g_2 are respectively referred to rod systems long 6200 mm and 5500 mm

[3] rod locked in stand still position

Figure B.2 – Preferred excursion of trolley poles versus distances of contact lines to ground

B.2.3 Rod assembly

The equipment comprising all devices ensuring the connection with the overhead contact lines and the rotation of the parts. The length of the rod assembly is the distance of the vertical axis of rotation on the base support and the vertical rotation axis of the trolley, as measured

with blocked rods in lowered position, as shown in Figure B.2. It is mainly composed by the following devices.

B.2.3.1 Base support

The base support, together with the rod foot is the rotation centre of the system, allowing lateral displacements of the vehicle, in respect to the OHL axis, and height variations of "d", as shown in Figure B.2.

The base support shall be electrically insulated from the underbase (see B.2.4.1) or, as an alternative, the underbase shall be electrically insulated from the vehicle mass. Then the base support is an intermediate mass.

Dimensional requirements for mounting the base support on the underbase are given in Figure B.3.

B.2.3.2 Rod

Tube structure, generally metallic or of materials of equivalent strength, with various diameters, having one hand fitted on the rod foot, and the other hand supporting the current collector head.

The rod may be bended near the trolley head.

The rod shall be insulated from the base support and from the rod foot. Alternatively the support base may be double insulated and the rod not insulated. In such a case the direct contact with the vehicle roof shall be prevented.

The rod foot shall allow ± 55 ° rotation on the horizontal plane.

When the rod is used as the electrical connection, it shall be covered by an insulation sufficient to grant the first stage of a composite insulation, and in those vehicle locations which can become in contact with the rods, it shall have an insulation particularly cared. The manufacturer shall declare (among other constructional data) the maximum allowable force $\vec{F}_P$ applied to the free end of the rod, when it is simply engaged and there is no risk of permanent distortions.

B.2.3.3 Current collector head

Support structure allowing the trolley to rotate both vertically and horizontally.

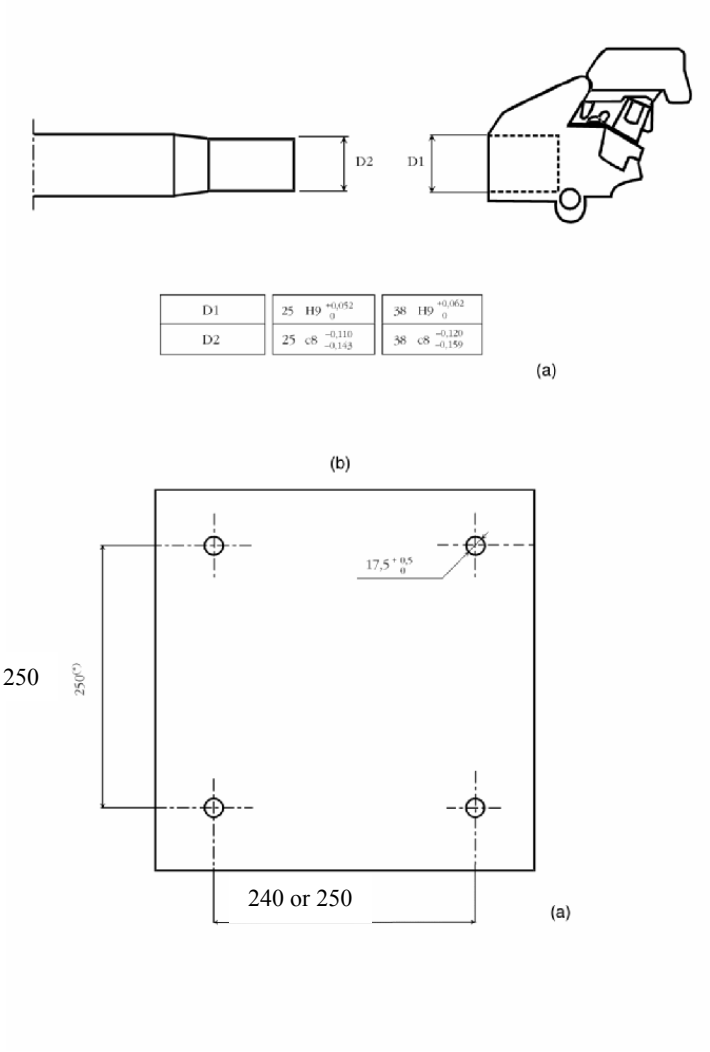
It shall allow a ± 55 ° rotation on the horizontal plane and a ± 20 ° (minimum) on the vertical plane, in any case suitable to keep the trolley horizontal both at the minimum and maximum height of the line, in order to avoid abnormal consumptions at the edges of the slipper.

The current collector head shall have a smoothed profile to avoid sticking on the line components, so damaging the same.

If applicable, the manufacturer shall declare the maximum allowable force $\vec{F}_t$ supported by the current collector head in case of engagement to the OHL. Beyond said force the current collector head shall slip off the rod.

A device suitable to limit consequences of the collector head slipping off the rod shall be provided.

Figure B.3 shows the dimensional characteristics of the coupling with the end of the rod.



LEGEND

a) DIMENSIONS IN MILLIMETRES

b) FITTING OF SUPPORT BASE

Figure B.3 – Example of coupling of rod with this head and underbase

B.2.3.3.1 Trolley

Metallic support to the slipper; in some conditions it is in direct contact with some components of the fixed installation (switches, crossings, bends, etc.) slipping on the same; Figure B.4 shows the detail of this situation.

The material used shall be sufficiently hard to limit wearing and tearing of the fixed installation component encountered. It shall withstand the electrical and mechanical stresses occurring during the passage in switches, in crossings and in case of dewirement.

It shall allow an easy and quick replacement of the slipper, also granting a correct positioning in different operating conditions.

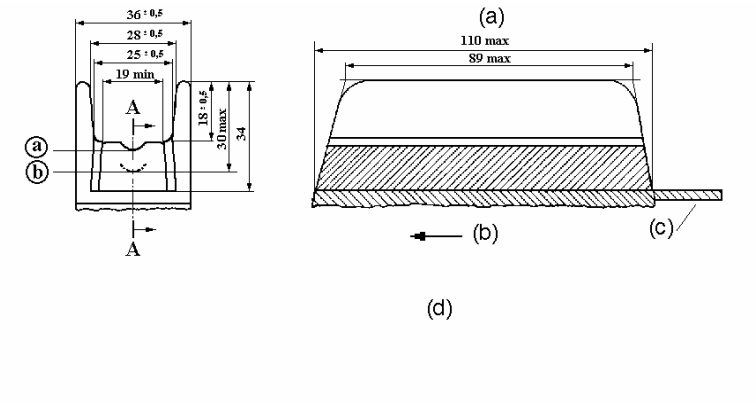
Suitable low-resistance links shall be provided for the electrical connection between the rod end and the trolley. The same shall grant the maximum moving freedom of the current collector head.

B.2.3.3.2 Slipper

Consumable element, described in Figure B.4 and B.5, providing the direct contact with the OHL, through which the current necessary for supplying the electrical equipment on board the trolley bus and the electrical braking (in case of energy recovery scheme) flows.

The selection of the correct slipper type shall consider the characteristics of the environment, of the operation and of the fixed installation.

These requirements may be disregarded when specific requirements of the operator are given due to previous installations



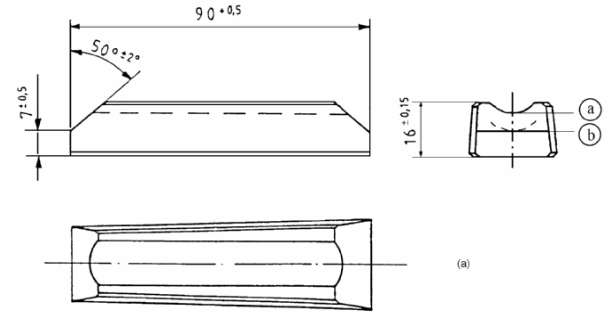
LEGEND:

(a) SLIPPING PLANE WITH NEW SLIPPER (b) SLIPPING PLANE WITH SLIPPER WORN OUT

a) SECTION A – A b) FORWARD MOTION c) ARC ESTINGUISHER

Material of trolley: Copper alloy Gc-Al 9 Fe 3 or material in conformity with that of the fixed installation.

Figure B.4 – Typical trolley



The dimensions shall be such to guarantee the correct coupling to the trolley

THE FOLLOWIING CHARACTERISTICS SHALL BE AGREED BETWEEN PURCHASER AND SUPPLIER:

- TYPE OF MATERIAL: E.G. COOL (HARD OR AMORPHOUS), ELECTROGRAPHITE
- MAX. CURRENT FOR ANY CONTACT POINT
- SPECIFIC RESISTANCE
- MAX. ADMITTED TEMPERATURES
- SHORE
- DENSITY
- STRENGTH TO FLECTION

Figure B.5 – Typical slipper

B.2.3.4 Electrical connection cable

The conductor allowing the connection between the current collector head and the vehicle equipment.

The cable shall be suitable for use on trolleybuses and have specific electromechanical characteristics which better fit the application.

B.2.3.5 Lifting spring

Lifting spring or, alternatively, an equivalent device, shall grant, statically and dynamically and in the various height conditions of the lines, that the force $\vec{F}_r$ applied by the slipper to the line is as constant as possible, without sensible difference from the contact force indicated.

The spring shall be adjustable to obtain values of $\vec{F}_r$ at least comprised between 80 N and 130 N; adjusting device shall be easily operated.

B.2.3.6 Moving system of rod assembly

This may be required for lowering and lifting the rods. It may have three configurations:

- automatic lowering, manual lifting through the operating and guiding devices in 4.2;
- automatic lowering and lifting;
- Manual actuation of lifting and/or lowering rods.

It shall be safely operated, granting lowering of rods, or at least giving a signal at the driving desk, in case of incorrect operation of the system as:

- loss of supply voltage;
- failure of the relevant electronic equipment;
- insufficient air pressure.

B.2.3.6.1 Moving system through automatic lowering and manual lifting

The fundamental components for such a system are:

B.2.3.6.1.1 Actuator

It is a pneumatic cylinder, or an equivalent device, which performs the lowering of the rod assembly.

It is automatically controlled by the device under B.2.3.6.1.2 in case of:

- dewirement or other emergency condition requiring safe positioning of the rods, for standing vehicle;
- control signal actuated from the driving desk.

B.2.3.6.1.2 Control-command device

It is the device, if any, responsible for the lowering of the rod assembly, which, in case of dewirement, shall occur as quick as possible.

The device is supplied with a nominal voltage of band I and its operation shall be correctly performed with the supply voltage in the range 0,7 to 1,25 U_{Ne}.

B.2.3.6.2 Moving system through automatic lowering and lifting

In case this configuration is used, suitable slabs may be mounted on the OHL to facilitate the engagement of the trolley during lifting.

The main components for allowing this movement are:

B.2.3.6.2.1 Actuator

It is a cylinder with pneumatic motion, or equivalent device, which operates lifting and lowering the rod assembly.

The device is automatically actuated by the control device in B.2.3.6.2.2:

- for lowering, in case of dewirement and/or in other conditions requiring to put the vehicle in safety conditions for standing vehicle;
- for lowering or lifting the poles following a control signal actuated from the driving desk.

B.2.3.6.2.2 Control-command device

For lowering the rod assembly see B2.3.6.1.2.

For lifting the rod assembly, the device shall drive the correct positioning of the current collector head on the OHL and avoid that the fixed installation is damaged.

The device is supplied with a nominal voltage of band I and its operation shall be correctly performed with the supply voltage in the range 0,7 to 1,25 U_{Ne}.

B.2.4 Recovering and actuating mechanisms

They shall be adequately dimensioned on the mechanical point of view and, when necessary, have electrical insulation characteristics suitable to ensure safety for the personnel driving or maintaining the vehicle in all operation conditions.

B.2.4.1Rope

If any, is the connection and operating element for rod manual operation.

Three types of ropes are identified:

- **Operating rope:** is the portion of rope that is wound on the winding device; its length shall be determined taking into account the height of the OHL and the lateral displacement admitted for the vehicle.
- **Rod rope:** is the short rope between the operating rope and the rod head.

Its presence is required to grant the necessary electrical insulation for the operating rope against the line voltage, if existing in any part of the rod, as necessary for the operating personnel.

It may be replaced by suitable insulating means, which, however, shall not cause damages to persons or goods in case of dropping for breakage of the rope.

- **Safety rope:** is a very short piece of rope which keeps the current collector head in case of slipping off the rod.

All types of rod shall have a traction breaking load not less than 10 kN.

B.2.4.2 Foil and other devices

Tool made of insulating material for the manual operation of the rod assembly in case of necessity. This tool is compulsorily required in case of absence of the rope.

B.2.4.3 Winding device

When required, it is the device for collecting and housing the necessary rope length. May be additionally equipped with a mechanical equipment for the recovery of the rod assembly in case of dewirement. Provisions to avoid mechanical hazards have to be taken.

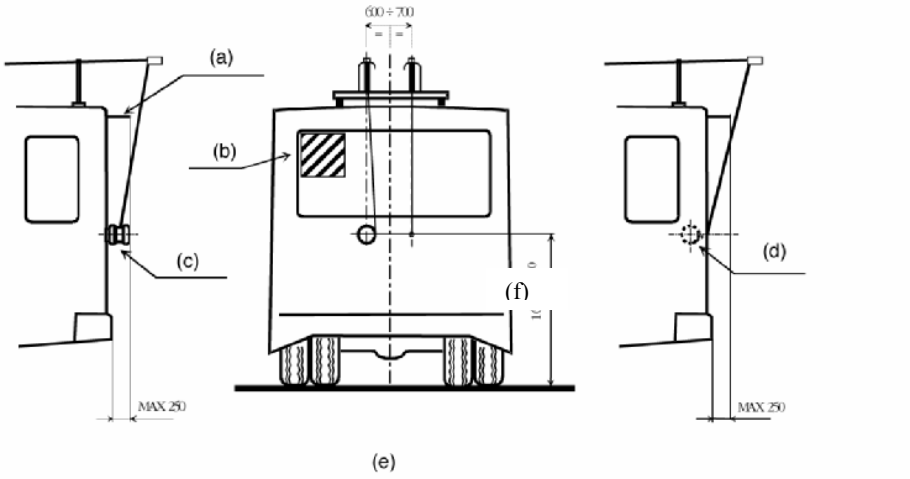
Dimensions and location are indicated in Figure B.6.

B.2.4.4 Automatic aligning device

An automatic aligning device shall be provided, if required, for automatically aligning the rod assembly, parallel to the major vehicle axis; this device shall operate in the following cases:

- dewirement;
- putting in safety conditions (e.g. operation of the leakage detector, central emergency command);
- control signal actuated from the driving desk.

In addition, this device may be used for maintaining the rod assembly aligned during automatic lifting.



LEGEND:

a) ROPE EXCURSION LIMITING DEVICE

b) INDICATING PANEL FOR PROTRUDING LOADS (REQUIRED IN SOME COUNTRIES)

c) TYPE A WINDING DEVICE

d) TYPE B WINDING DEVICE

e) DIMENSIONS IN MILLIMETRES

f) TO BE AGREED BETWEEN PURCHASER AND SUPPLIER

The rear projection for type A winding device and rope excursion limiting device shall be not more than 0,25 m; these devices shall not be considered in the vehicle length if complying with the present standard; they shall be provided with red and white stripes of reflecting material.

The panel shall have a minimum surface of 0,25 m^2 and shall be fitted on the rear of the vehicle.

Figure B.6 – Devices (if any) for recovering and excursion limiting of rod ropes position, overall dimensions and signalling

B.2.5 Additional elements

These elements complete the installation of the rod assembly on the roof, for a correct use.

B.2.5.1 Underbase

The underbase is the structure mounted on the vehicle roof to fix the support base. It shall be constructed able to withstand the stresses due to dewirements or to eventual sticking on components of the fixed installation.

Therefore the connection system to the OHL shall be designed together with the general design of the trolleybus.

The underbase may be mounted on dampers against vibrations, considering however that dampers are not considered as electrically insulating elements.

B.2.5.2 Rod displacement limiters

If required suitable arrangements shall be used to avoid the possibility that the current collector head can reach a height from ground less than 2,70 m, also in dynamic conditions.

B.2.5.3 Rope length limiter

This device, mounted on the back wall of the vehicle, shall limit the rope length (when this feature is provided) to avoid that the limit gauge of the vehicle, mainly in case of lateral displacement of the vehicle in respect , is exceeded.

B.2.5.4 Locking equipment for the rods in stand still conditions

This equipment shall block, in a way easily visible from ground, the rods on the vehicle roof. Locking may be manually or automatically operated. In case of automatic locking a signal shall appear on the driving desk. Locking equipment shall be insulated.

B.3 MARKING

The following system components shall be permanently marked:

- support base, together with actuating, control and command devices;
- winding device.

This marking shall allow to identify:

- the manufacturer;
- the serial number;
- the component type.

The other components may be identified through the above mentioned criteria.

B.4 CHECKS AND TESTS

B.4.1 Test categories

Three categories of tests are foreseen:

- type tests;
- routine tests;
- functional tests.

The required tests are listed in Table B.1.

Table B.1 – Summary of tests and checks

Subclause	Subject	Type test	Routine test	Functional test
B.4.2.1	Visual inspection		X	
B.4.2.2	Weighting	X		
B.4.2.3	Dimensional checks		X	
B.4.2.3.1	Displacement of rod system			X
B.4.2.3.2	Minimum height of the rods from ground			X
B.4.2.4	Identification		X	
B.4.3.1	Contact force			X
B.4.3.2	Slipping during rear motion			X
B.4.3.4	Climatic tests	X		
B.4.3.5	Air tightness test of the pneumatic cylinder	X		
B.4.3.6	Air tightness test of the pneumatic plant			X
B.4.4	Check on the slipping off of the current collector head	X		
B.4.5.1	Power frequency withstand voltage test		X	
B.4.5.2	Measure of the insulation resistance			X
B.4.6	Shock and vibration test	X		

B.4.1.1 Type tests

The type tests are intended to assess the conformity of the complete system to the technical characteristics and to the performances of the complete vehicle; they shall follow a sampling plan and the purchaser and the supplier shall state the criteria for the lot acceptance.

When the design or the manufacturing techniques are changed after the tests, the influence of such modifications on the system performances shall be evaluated and the purchaser and the supplier shall agree the need of the repetition of one or more type tests.

B.4.1.2 Routine tests

Routine tests shall be carried out on all the components of the supply. For some components, the purchaser and the supplier may agree to perform the tests on samples.

B.4.1.3 Functional tests

Functional tests require the complete erection of the complete system on board the trolleybus, with availability, when necessary, for the supply of the operator fixed installation.

B.4.2 General checks

B.4.2.1 Visual inspection (routine test)

The current collecting system, before being completely assembled with all components foreseen in the design, shall be carefully inspected; it shall show no physical defects and the various materials shall have the indication of the surface treatment received, according to the design or to particular requirements of the operator.

B.4.2.2 Weighting (type test)

Masses shall be verified, to be in accordance with the characteristics declared by the manufacturer when tendering the complete system and the various components, except for those weights which are of strict competence of the vehicle manufacturer.

B.4.2.3 Dimensional checks (routine test)

The dimensions and relevant tolerances given in the manufacturing drawings (and part of the contractual documentation) shall be verified.

B.4.2.3.1 Displacement of rod system (functional test)

Once the rod system has been completely mounted on the trolleybus, the compliance with the dimensions given in Annex A shall be verified. When purchaser and supplier agree for the need of the check, this verification shall be carried out in dynamic conditions.

B.4.2.3.2 Minimum height of the rods from ground (functional test)

For the static verification, the rod is manually lowered down to the lower limit allowed by the limiting device under 4.4.2; this test shall be repeated for both rods and for different positions within distance "g" given in Annex A, but protruding the vehicle lateral walls.

The measured height over ground shall not be less than the stated dimension "a" of Figure B.2.

For the verification simulating dynamic conditions, in order to avoid damages to the rods, in the less favourable position obtained with static test, 90 % of the force $\vec{F}_P$ declared by the manufacturer is vertically applied.

In these conditions too, distance "a" of Figure B.2 shall be respected.

B.4.2.4 Identification (routine test)

The component marking (see clause B.3) shall be verified.

B.4.3 Functional checks

B.4.3.1 Contact force (functional test)

The contact force $\vec{F}_r$ in the conditions of Figure B.7 shall be verified with the vehicle completely assembled. The value of the contact force shall be declared by the manufacturer.

B.4.3.2 Slipping during rear motion (functional test)

The correct behaviour of the system, particularly in respect to the current collector head and its components, shall be verified during rear movement of the vehicle, on a straight path and at a speed agreed between purchaser and operator.

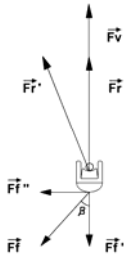
B.4.3.3 Lowering (functional test)

A dewirement at the height "c-d-e" and at the displacements indicated in Figure B.7 shall be simulated. The time delay between the moment the rod is left and that in which it reaches 0,1 m below this point shall be measured.

This time delay shall not exceed 2 s.

Thereafter, the current collector head shall further lower at least 0,2 m below the minimum OHL level, given by EN 50119.

B.4.3.4 Climatic tests (type test)



LEGEND:

$\overline{F}f$: FORCE APPLIED ON THE ROPE	$\overline{F}v$: VERTICAL FORCE ONTO THE CURRENT COLLECTOR HEAD
$\overline{F}f'$: VERTICAL COMPONENT OF THE ABOVE FORCE	$\overline{F}r'$: FORCE APPLIED BY THE CURRENT COLLECTION HEAD
$\overline{F}f''$: HORIZONTAL COMPONENT OF THE SAME	$\overline{F}r$: VERTICAL COMPONENT OF THE ABOVE FORCE

Determination of the contact force $\vec{F}r$				
	Trolleybus displacement from the OHL			
Height from ground of OHL (Annex A)	**In axis**	**2500 mm**	**4000 mm (5500 mm rod)**	**4500 mm (6200 mm rod)**
4700 mm	cos β =1 $\vec{F}f =$ $\vec{F}r =$	cos β =0,869 $\vec{F}f =$ $\vec{F}r =$	cos β =0,740 $\vec{F}f =$ $\vec{F}r =$	cos β =0,699 $\vec{F}f =$ $\vec{F}r =$
5600 mm	cos β =1 $\vec{F}f =$ $\vec{F}r =$	cos β =0,913 $\vec{F}f =$ $\vec{F}r =$	cos β =0,814 $\vec{F}f =$ $\vec{F}r =$	cos β =0,780 $\vec{F}f =$ $\vec{F}r =$
6500 mm	cos β =1 $\vec{F}f =$ $\vec{F}r =$	cos β =0,933 $\vec{F}f =$ $\vec{F}r =$	cos β =0,852 $\vec{F}f =$ $\vec{F}r =$	cos β =0,822 $\vec{F}f =$ $\vec{F}r =$

Figure B.7 – Composition of forces when handling rope is adopted

These tests are intended to check the correct operation of the components at different temperature and humidity conditions. When the operator does not specify special values, these tests shall be performed at temperatures of – 25 °C and + 40 °C with relative humidity of 95 % at 40 °C without temperature variations.

B.4.3.5 Air tightness test of the pneumatic cylinder (type test)

All pneumatic cylinder of the actuator (see 4.2.6.2.1), shall be submitted to an air tightness test at ambient temperature. The test shall be made in accordance with ISO 10099.

B.4.3.6 Air tightness test of the pneumatic plant (functional test)

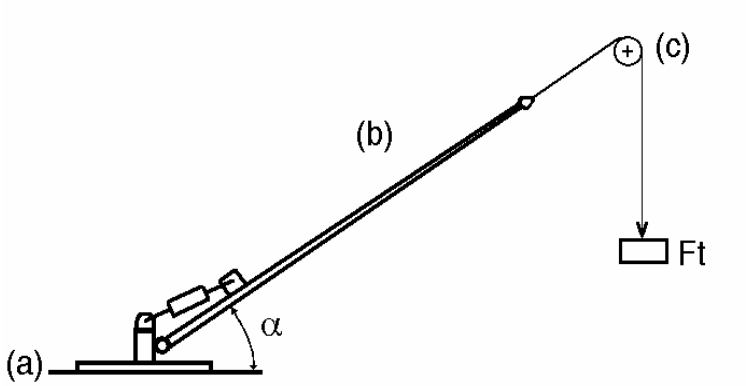
A tightness test shall be carried out on the pneumatic plant of the current collecting system. The test shall be made as agreed between operator and manufacturer

B.4.4 Check on the slipping off of the current collector head (type test)

The test, if required, shall be made with a rod system completely assembled for the essential parts, at normal ambient temperature and with the rod positioned to form an angle α corresponding to that formed by the rod system when mounted on the vehicle and in contact with OHL at the height "d" shown in Figure B.2. A force $\vec{F}_t$ shall be gradually applied as shown in Figure B.8.

At the end of the test, the current collector head shall slip off at the declared force, with a tolerance of ± 10 %, and no deformations, breakages or other faults of any component, with particular attention to the connection components and to the safety rope.

Purchaser and supplier may agree further specific tests.



LEGEND

a) BASE SUPPORT	b) ROD
c) PULLEY	d) $\vec{F}_t$

Figure B.8 – Scheme of the verification of the slipping off of the current collector head

B.4.5 Electrical tests

B.4.5.1 Power frequency withstand voltage test (routine test)

It is effected by applying gradually during 10 s an a.c. r.m.s. voltage U_a, at 50 Hz, keeping the value for 60 s.

The value of U_a is given in Table 2.

B.4.5.2 Measure of the insulation resistance (functional test)

With the current collection assembly completely mounted on a vehicle roof, the insulation resistance is measured according to the requirement of this Standard.

B.4.5 Shock and vibration tests

Shock and vibration test shall be carried out in accordance to EN 61373.

B.5 INSPECTIONS

In accordance with EN ISO 9001 and EN ISO 9002 inspections may be required, according to the requirements of the contract.

B.6 ELECTROMAGNETIC COMPATIBILITY

The system described in this standard shall comply with the requirements of EN 50121 series.

ANNEX C

(normative)

CONSTRUCTIONAL HINTS FOR CONNECTION SYSTEMS

C.1 General

In view of the importance of the current collection system described in this Standard, both in respect to the mobile part (vehicle) and to the fixed installation (OHL and supports), the following points shall be particularly cared by the designer of the vehicle and the manufacturers of the various parts.

C.2 Material of the rods

The rods will be made of materials suitable to be straightened cold, to facilitate maintenance.

C.3 Current connections

The best current conduction shall be achieved between the collector and the electric cable, avoiding phenomena such as sticking of the head on the rod end, due to galvanic migration of material.

C.4 Joints

Lubrication of the articulated joint shall not be necessary: e.g. suitable antifriction linings.

C.5 Cable insulation

The ends of the electric cable, which may be affected by water, shall be suitably protected to avoid the progress of the water between the core and the cover of the cable.

C.6 Abnormal line height

The operation of the equipment described in this Standard shall be assured even in case the height of OHL from ground is lower than the distance “c” shown in Figure B.2.