

**Economic and Social Council**Distr.: General  
23 July 2013

Original: English

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**Economic Commission for Europe****Inland Transport Committee****World Forum for Harmonization of Vehicle Regulations****Working Party on General Safety Provisions****105<sup>th</sup> session**

Geneva, 8–11 October 2013

Item 2(a) of the provisional agenda

**Regulation No. 107 (M<sub>2</sub> and M<sub>3</sub> vehicles) –****Proposals for further amendments****Proposal for further amendments to Regulation No. 107 (M<sub>2</sub> and M<sub>3</sub> vehicles)****Submitted by the expert from Belgium\***

The text reproduced below was prepared by the expert from Belgium to align the additional safety prescriptions for trolleybuses with the corresponding electrical standards. It supersedes informal document GRSG-104-13. The modifications to the current text of the regulation are marked in bold for new and strikethrough for deleted characters.

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\* In accordance with the programme of work of the Inland Transport Committee for 2010–2014 (ECE/TRANS/208, para. 106 and ECE/TRANS/2010/8, programme activity 02.4), the World Forum will develop, harmonize and update Regulations in order to enhance the performance of vehicles. The present document is submitted in conformity with that mandate.

# I. Proposal

Annex 12

Paragraphs 1.1. to 1.2.2., amend to read:

"1.1. "Line voltage" means the voltage provided to the ~~vehicle~~ **trolleybus** from the external power supply.

Trolleybuses shall be designed to operate at a rated line voltage of either:

- (a) 600 V (a working range of 400 to 720 V, **and 800 V DC for 5 minutes**); or
- (b) 750 V (a working range of 500 to 900 V, **and 1,000 V DC for 5 minutes**); **and**
- (c) **Withstand over-voltages of 1,270 V for 20ms.**

1.2. The electrical circuits of a trolleybus are classified ~~as~~ **according to their rated voltage in the following classes:**

1.2.1. ~~"High voltage circuits" means circuits energised at line voltage~~ **"Voltage class A" means a:**

- rated voltage  $\leq 30$  V AC,**
- rated voltage  $\leq 60$  V DC.**

1.2.2. ~~"Low voltage circuits" means circuits energised at a nominal voltage of 12 V, 24 V or 42 V~~ **"Voltage class B" means a:**

- 30 V AC  $<$  rated voltage  $\leq 1,000$  V AC,**
- 60 V DC  $<$  rated voltage  $\leq 1,500$  V DC."**

Paragraph 1.2.3., shall be deleted.

Paragraphs 1.3. to 2.6., amend to read:

"1.3. ~~Rated climatic conditions~~

Trolleybuses shall be designed to operate reliably under the following ~~environmental~~ **conditions upon specification by the manufacturer for:**

1.3.1. ~~A temperature range of minus 40°C to plus 40°C:~~ **in one or more of the following classes:**

Temperature classes	Air temperature external to the vehicle (°C)
T1	-25 to +40
T2	-40 to +35
T3	-25 to +45
TX	-40 to +50

1.3.2. ~~A relative humidity of 98 per cent at temperatures up to 25°C:~~ **the following external humidity levels shall be considered:**

- (a) **Yearly average:  $\leq 75$  per cent relative humidity;**
- (b) **On 30 days in the year continuously: between 75 per cent and 95 per cent relative humidity;**

(c) **On the other days occasionally: between 95 per cent and 100 per cent relative humidity.**

1.3.3. ~~An~~ atmospheric pressure range of from ~~866~~ **86.6** kPa to ~~1066~~ **106.6** kPa;

1.3.4. ~~An~~ altitude range from sea level to a maximum of 1,000 m above the sea level: **in or more of the following classes:**

<i>Altitude classes</i>	<i>Altitude range relative to sea level (m)</i>
<b>A1</b>	<b>&lt; 1,400</b>
<b>A2</b>	<b>&lt; 1,000</b>
<b>A3</b>	<b>&lt; 1,200</b>
<b>AX</b>	<b>&gt; 1,400</b>

1.4. "Self-extinguishing material" means a material that does not continue to burn when the ignition source is removed.

1.5. "**Insulation**": there are different types of insulation:

1.5.1. **Functional insulation: ensures the functionality of the equipment;**

1.5.2. **Basic insulation: protects persons from electrical hazards in systems with protective bonding;**

1.5.3. **Supplementary insulation: protects persons from electrical hazards in systems without protective bonding;**

1.5.4. **Double insulation: combination of basic and supplementary each individually testable by a metallized intermediate layer.**

1.6. "**Rated insulation voltage**"

1.6.1. **For circuits connected to the line voltage, the rated insulation voltage ( $U_{Nm}$ ) for each part of the double insulation is the maximum line voltage according to paragraph 1.1. above; and**

1.6.2. **For circuits insulated from the line voltage, the rated insulation voltage ( $U_{Nm}$ ) is the maximum permanent voltage that occurs in the circuit."**

2. ~~Power~~ **Current** collection

2.1. ~~Electrical power~~ **Current** shall be obtained from the contact wires by means of one or more ~~power collection~~ **connecting** devices, normally comprising two ~~trolley booms~~ **current collectors**. (A single ~~trolley boom~~ **current collector** or a pantograph may be used in guided applications). A ~~trolley boom~~ **current collector** shall consist of a roof mounting (trolley base), a ~~pole~~ **trolley rod**, an ~~electrical power~~ **current collector head** (~~trolley head~~) and a replaceable contact surface insert. ~~Trolley booms~~ **Current collectors** shall be mounted so that they can turn in both horizontal and vertical directions.

**A current collector shall achieve, as a minimum, a  $\pm 55^\circ$  rotation about the vertical axis of its attachment to the trolleybus and a  $\pm 20^\circ$  rotation about the horizontal axis of its attachment to the trolleybus.**

2.2. ~~Poles~~ **Trolley rods** shall be made **either** of an ~~insulated~~ material **providing insulation** or of metal covered with insulating material **representing functional insulation to avoid short circuiting between the overhead lines in case of their detachment (de-wiring)** and shall be resistant to mechanical shocks.

2.3. ~~Power~~ **Current** collectors shall be designed to maintain adequate positive contact with the contact wires when the wires are located at between 4 and

6 metres above the ground and, ~~in the case of trolley booms,~~ to allow the longitudinal axis of the trolleybus to deviate at least 4.0 metres to either side of the mean axis of the contact wires. **Different heights of the contact wires or a different lateral deviation may be specified by the operator.**

- 2.4. ~~If the power collector becomes accidentally detached from the contact wire (de-wired), the upper end of the power collector(s) shall not be raised higher than 7.2 metres above the road, or 1 metre maximum above the contact wires at the time of de-wiring, nor lower than 0.5 metres above the roof of the trolleybus. Each trolley rod shall be equipped with a device that automatically retracts the rod in the event of the current collector becoming accidentally detached from the contact wire (de-wired).~~
- 2.5. ~~Each trolley boom shall be equipped with a device which retracts the boom automatically if the pole unwires. The trolley rod shall be equipped with mechanical stops to prevent the values specified in paragraph 2.3. being exceeded. In the event of de-wiring, contact between the retracted rods and any part of the roof shall be prevented.~~
- 2.6. ~~The trolley current collector head, if dismantled disconnected from its normal position on the pole trolley rod, shall be remain attached to the pole trolley rod and must not fall down."~~

Paragraph 2.7., shall be deleted.

Paragraph 2.8. (former), renumber as paragraph 2.7. and amend to read:

~~"2.8.2.7.~~ **Power Current** collectors may be equipped with remote control from the driver's compartment, at least for retraction."

Paragraph 2.9. (former), renumber as paragraph 2.8.

Paragraph 3.5., amend to read:

"3.5. All electrical circuits and circuit branches **of voltage class B** shall be of dual wiring. The trolleybus body ~~can be used for current earth return only for low voltage circuits~~ **may be used as a conductor for protective bonding of circuits, double insulated from the line voltage, of voltage class B. It also may be used as return connection for voltage class A circuits.**"

Paragraph 3.7., amend to read:

"3.7. Electrical components ~~energized at the line voltage shall have additional insulation from the vehicle connected to the line voltage shall have,~~ **in addition to their basic insulation, a supplementary insulation from the trolleybus body, the on-board power supply and signal interfaces.**

**For protection of current conducting parts and metallized intermediate layers inside the passenger compartment or luggage compartment, the protection degree IPXXD shall be provided.**

**For protection of current conducting parts and metallized intermediate layers in areas other than the passenger compartment or luggage compartment and not on the roof, the protection degree IPXXB shall be satisfied.**

**For protection of current conducting parts and metallized intermediate layers on the roof with protection by distance, no protection degree is required."**

Insert new paragraphs 3.7.1. and 3.7.2., to read:

- 3.7.1. External insulations, e.g. on the roof and at the traction motor with occasional conductivity and regular cleaning, shall have a minimum clearance of 10 mm.**

**They shall maintain their hydrophobic features over their lifetime. For this reason they shall be mounted with shelter from weather or be designed as umbrella insulators or insulators with drip edge. Silicon as material or covering is recommended. In this case the minimum creepage distance has to be 20 mm.**

**With other materials or designs or mountings or extreme operation conditions a greater creepage distance has to be chosen. Documentation of the layout is part of the approval.**

- 3.7.2. Voltage class B equipment shall be marked with the lightning symbol. The symbol background shall be yellow, the bordering and the arrow shall be black.**



**The symbol shall also be visible on enclosures and barriers, which when removed, expose current conducting parts of voltage class B circuits. Accessibility and removability of barriers/enclosures should be considered when evaluating the requirement for the symbol."**

Paragraphs 3.8. to 3.10.1., amend to read:

- 3.8. The current conducting parts of electrical components, with the exception of current collectors, surge arrestors and traction resistors, shall be protected against penetration of moisture and dust into the body and onto insulated and current conducting parts.**

- 3.9. Means shall be provided for a periodic resistance test to be conducted on each basic and supplementary insulation of components with double insulation. Within the rated climate conditions, With a new and dry and clean trolleybus, the insulation resistance of electrical circuits at a test voltage of 1,000 V DC, when all rotating machines and apparatus are switched on, shall not be less than:**

- |               |  |                 |
|---------------|--|-----------------|
| <b>3.9.1.</b> | <b>Body to high voltage circuits</b>                 |                 |
|               | <b>For each basic insulation:</b>                    | <b>≥ 10 MΩ;</b> |
| <b>3.9.2.</b> | <b>High voltage circuits to low voltage circuits</b> |                 |
|               | <b>For each supplementary insulation:</b>            | <b>≥ 10 MΩ;</b> |
| <b>3.9.3.</b> | <b>Body to positive pole of low voltage circuits</b> |                 |
|               | <b>For the overall double insulation:</b>            | <b>10 MΩ.</b>   |

- 3.10. Wiring and apparatus**

- 3.10.1. Only multi-core Flexible wires shall be used for high voltage all circuits. All high voltage DC wiring shall have insulation rated for 3,000 V DC or AC. The rated insulation voltage of wires to ground shall be at least the rated insulation voltage according to paragraph 1.6."**

Paragraphs 3.10.4. and 3.10.5., amend to read:

- "3.10.4. Wiring of different voltage **classes** shall be mounted separately.
- 3.10.5. Wiring conduits shall be made of non-flammable **or self-extinguishing** material. **Conduits inside the passenger compartment of voltage class B shall be closed and be made of metal. Metallic conduits shall be connected to the vehicle chassis."**

Paragraph 3.10.12., amend to read:

- "3.10.12. ~~All electrical circuits shall undergo an excess voltage test. The test voltage shall be AC with a frequency of 50 Hz and approximately sinusoidal form. The time of application of the test voltage shall be 1 min.~~

**Each of the insulations of voltage class B equipment on-board the trolleybus shall be tested with an AC power supply at test frequency of 50 - 60 Hz for 1 minute.**

**The test voltage (U<sub>Test</sub>) for wiring and components at the trolleybus shall be:**

<b>Basic Insulation:</b>	$U_{\text{Test}} = 2 \times U_{\text{Nm}} + 1,500 \text{ V}$
<b>Supplementary Insulation:</b>	$U_{\text{Test}} = 1.6 \times U_{\text{Nm}} + 500 \text{ V}$

**The values for basic and supplementary insulations may be reversed.**

**For circuits double insulated from overhead line voltage, the test voltage (U<sub>Test</sub>) shall be at least 1,500 V, or:**

<b>Basic Insulation:</b>	$U_{\text{Test}} = 2 \times U_{\text{Nm}} + 1,000 \text{ V}$
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**The equivalent DC test voltage is  $\sqrt{2}$  times the AC value.**

**Components that have already been tested at their time of manufacture shall be excluded. The factory tests may be performed with the voltages or durations according to EN/IEC product standards.**

**Reinforced insulation in trolleybuses is not allowed for circuits directly connected to overhead line."**

Paragraphs 3.10.12.1. and 3.10.12.2., shall be deleted.

Paragraphs 3.11. to 3.11.2., amend to read:

- "3.11. **The trolleybus shall undergo an EMC-test suited for vehicles supplied from overhead conducting lines.**

- 3.11.1. **Measuring conditions:**

**Lateral distance of antenna to the middle of the test track: 10 m**

**Vertical distance of antenna to the ground:**

**H-field antenna: 1 – 2 m**

**E-field antenna: 2.5 – 3.5 m**

**Measuring time: 50 ms**

**Frequency range / bandwidth: see limit diagrams of paragraph 3.11.3.**

**Detection mode: see reference limits diagrams of paragraph 3.11.3.**

- 3.11.2. **Operating conditions of the vehicle for measuring**

**The trolleybus shall be tested while stationary and at slow moving speed. During the stationary test, the auxiliary converters shall operate (it is not inevitably under maximum load conditions that the maximum emission**

level is produced) and the traction converter shall be under voltage but not operating.

For the slow moving test, the speed shall be low enough to avoid arcing at or bouncing of the sliding contact and high enough to allow for electric braking. The recommended speed range is  $20 \pm 5$  km/h. When passing the antenna the vehicle shall accelerate or decelerate with approximately 1/3 of its maximum tractive effort within the given speed range."

Insert a new paragraph 3.11.3., to read:

**"3.11.3. Reference limits for emission of the vehicle for type approval are as specified in the following diagrams:**

- (a) **Vehicle broadband reference limits**  
**Antenna vehicle - overhead contact line separation 10 m**

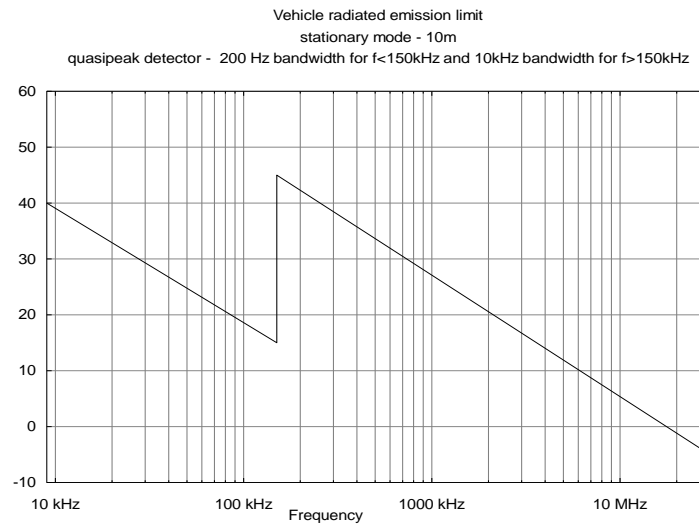
**Limit H (dBμA/m) at frequency F (MHz):**

**0.009 – 0.150 MHz**

**0.150 – 30 MHz**

$$H = 40 - 20.46 \cdot \log ( F / 0.009 )$$

$$H = 45 - 21.73 \cdot \log ( F / 0.15 )$$

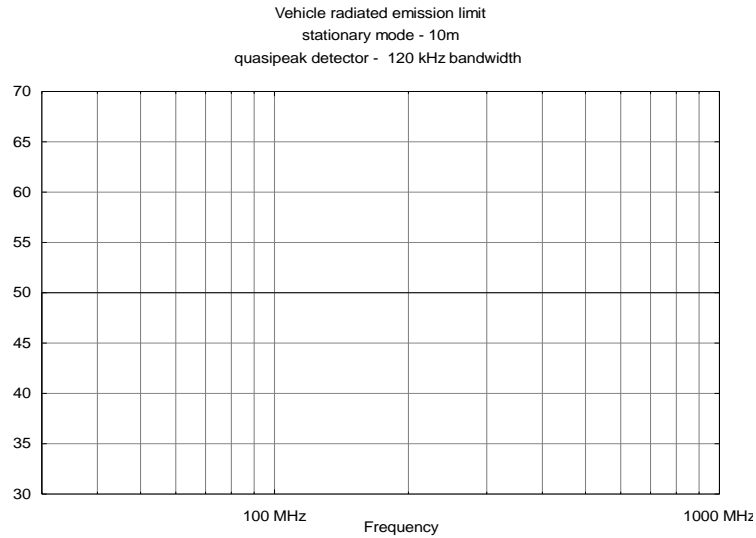


**(b) Vehicle broadband reference limits**  
**Antenna vehicle - overhead contact line separation 10 m**

**Limit E (dBμV/m) at frequency F (MHz):**

**30 – 1000 MHz**

**E = 50**



**(c) Vehicle broadband reference limits**  
**Antenna vehicle - overhead contact line separation 10 m**

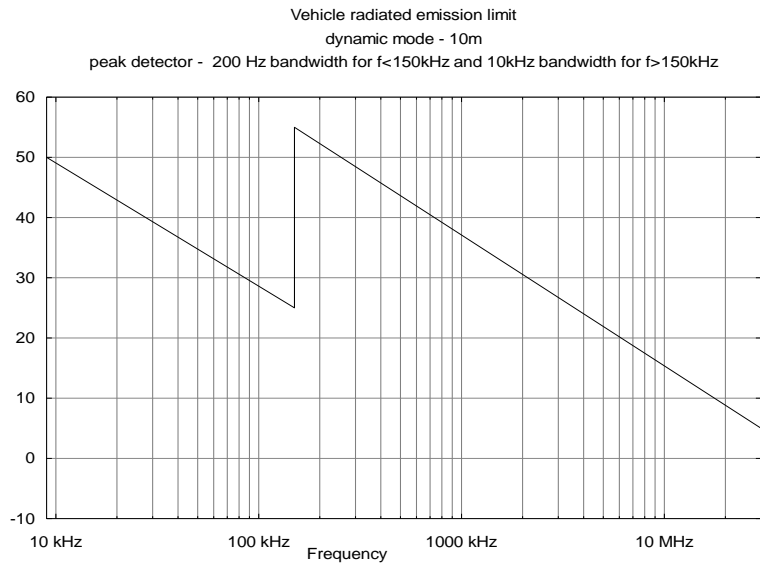
**Limit H (dBμA/m) at frequency F (MHz):**

**0.009 – 0.150 MHz**

**0.150 – 30 MHz**

**H = 50 – 20.46 · log ( F / 0.009 )**

**H = 55 – 21.73 · log ( F / 0.15 )**



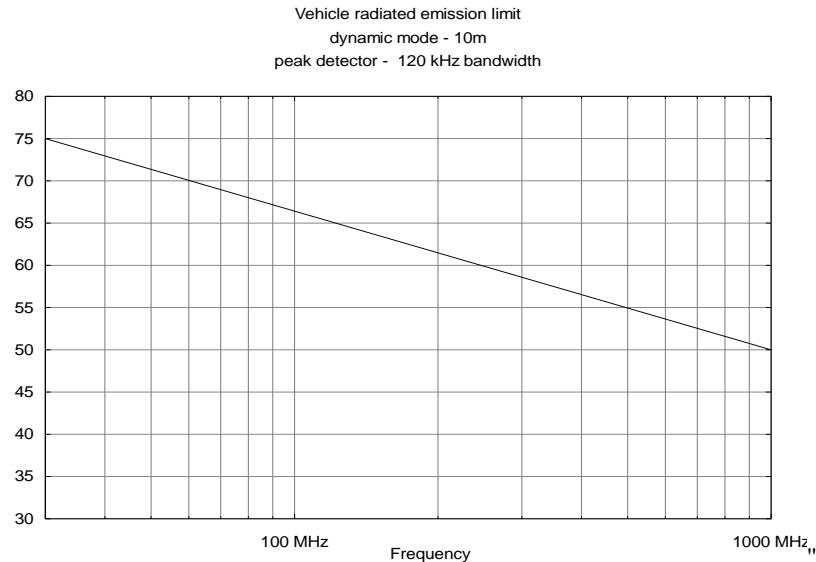


(d) **Vehicle broadband reference limits**  
**Antenna vehicle - overhead contact line separation 10 m**

**Limit E (dB $\mu$ V/m) at frequency F (MHz)**

**30 – 1000 MHz**

$$E = 75 - 16.42 \cdot \log ( F / 30 )$$



*Paragraphs 4.1. to 4.3., amend to read:*

- "4.1. **In a trolleybus, each circuit energized by overhead line voltage shall have double insulation to vehicle chassis.**
- 4.2. **The influence of dynamic charge currents, caused by capacitive couplings between voltage class B equipment and electric chassis, shall be reduced by the protective impedance of insulating materials used in entrance areas. Stanchions and handrails at doorways, door panels and handles, mobility aid ramps and the first steps shall be made of insulating material, or covered with mechanical durable insulation or insulated from the trolleybus body.**
- 4.3. **If specified by the operator, trolley buses may be equipped with an automatic monitoring device, i.e. a leakage detector. The device shall give an optical and/or acoustic alarm signal when the insulating resistance, between the circuits fed at line voltage and the trolleybus body, decreases to a value less than that specified in paragraph 3.9.**

**When the above-mentioned limit value is reached the leakage detector may, when the trolleybus is stationary, effect both the opening of the line contactor circuit breaker and the automatic lowering of the current collector.**

**The leakage detector, or at least the relevant optical and/or acoustic alarm device, if any, shall be mounted in a location to permit it to be easily visible or audible, as appropriate, to the driver."**

*Paragraphs 4.4. to 4.7., shall be deleted.*

*Paragraph 5.2.5., shall be deleted.*

## II. Justification

1. Reference paragraph 1.1.

The definition of line voltage is updated with reference to EN50163/IEC60850 Railway applications – Supply voltages of traction systems.

2. Reference paragraph 1.2.

The classification of voltage classes is updated with reference to EN50153/IEC61991: Railway applications – Rolling stock – Protective provision relating to electrical hazards.

Note: In France and Italy different limits apply because of legal prescriptions. Because voltage band II does not appear in new electrical road vehicles, voltage band II is combined with band III. In accordance to ISO6469-3, band I is renamed class A and the combination of Bands II and III is renamed class B.

3. Reference paragraph 1.2.3.

Definition of three phase circuits can be deleted, as this is not used.

4. Reference paragraph 1.3.

The conditions for operation, which the manufacturer has to specify, are updated with reference to EN50125 Railway applications – Environmental conditions for equipment / IEC60077 Railway applications – Electrical equipment for rolling stock / IEC60721.

The mentioned values are part of the prescriptions for normal service conditions of IEC60077-1, referring to IEC60721-3-5: 5Z1, 5K2, 5B2, 5C2, 5S2

5. Reference paragraph 1.5.

The definitions for insulations are added with reference to EN50153/IEC61991 Railway applications – Rolling stock – Protective provisions relating to electrical hazards.

6. Reference paragraph 1.6.

The definition of rated insulation voltage is added with reference to EN50124-1 Railway applications – Insulation coordination – Clearances and creepage distances for all electrical and electronic equipment. Annexes A and D.

7. Reference paragraph 2.

Current is new wording for (electrical) power.

8. Reference paragraph 2.1.

New wording for the current collector and parts thereof replaces the old wording with reference to TS50502 Railway applications – Rolling stock Electric equipment in trolley buses – Safety requirements and connection systems.

9. Reference paragraph 2.2.

The prescription for the trolley rod is updated with reference to TS50502 Railway applications – Rolling stock Electric equipment in trolley buses – Safety requirements and connection systems.

10. Reference paragraph 2.3.

The prescription for the current collector is added with reference to TS50502 Railway applications – Rolling stock Electric equipment in trolley buses – Safety requirements and connection systems.

11. Reference paragraph 2.7.

This paragraph should be deleted. For the insulation resistances of the current collector see new wording of paragraph 3.10.12.

12. Reference paragraph 3.5.

The prescription for the electrical circuits is updated with reference to TS45545 Railway applications – Fire protection on railway vehicles and EN50343 Railway applications – Rolling stock – Rules for installation of cabling. Electrical power installations shall be separated by firewalls from passenger compartment or air ducts to the passenger compartment. Power cabling shall be halogen free and self-extinguishing.

13. Reference paragraph 3.7.

New wording with reference to EN50153/IEC61991 Railway applications – Rolling stock – Protective provisions relating to electrical hazards.

14. Reference paragraph 3.7.1.

The prescription for outside insulations is added with reference to EN50124-1 Railway applications – Insulation coordination.

15. Reference paragraph 3.8.

New wording with reference to EN60529 Degrees of Protection provided by enclosures (IP Code) and to EN60322/IEC 60322 Railway applications – Electrical equipment for rolling stock – Rules for power resistors of open construction.

16. Reference paragraph 3.9.

Note: In Italy and Switzerland, the test periods are fixed by legal prescriptions.

17. Reference paragraph 3.10.1.

The prescription for all circuits is updated with reference to EN50343 Railway applications – Rolling stock – Rules for installation of cabling.

18. Reference paragraph 3.10.4.

New wording with reference to TS45545 Railway applications – Fire protection on railway vehicles

19. Reference paragraph 3.10.5.

The prescription for wiring conduits is updated with reference to EN45545 Railway applications – Fire protection on railway vehicles, which includes the trolley bus.

20. Reference paragraph 3.10.12.

New wording with reference to EN60077/IEC60077: Railway applications – Electrical equipment for rolling stock; this includes auxiliary power supplies as well as batteries and motor-generator units. Reinforced insulation with reference to EN50153/IEC61991.

21. Reference paragraph 3.11.

The requirements for shock and vibration should be deleted (because there is no direct link with the safety of the trolleybus) and replaced by requirements for electromagnetic compatibility (EMC).

22. Reference paragraph 4.1.

This requirement could be deleted as this is covered by new paragraph 3.9.3.; instead a new requirement on double insulation is added.

23. Reference paragraph 4.2.

New wording with reference to IEC60479-1: Effects of current on human beings and livestock.

24. Reference paragraphs 4.3. to 4.6.

The measurements in paragraphs 4.3. to 4.6. were not specified completely: neither the test voltage nor the condition dry or wet are specified. These measurements, and the insulation itself, always create problems. The original paragraphs 4.3. to 4.6. can be waived because of complete double insulation is now mentioned in paragraph 4.1. The protective impedances have lower requirements than for each insulation of the double insulation and only their existence should be checked. More important is the choice of non-conducting material and, for steps, internal water tightness to avoid contact of a water-film with chassis in wet conditions.

25. Reference paragraph 4.7.

This paragraph should be deleted, because single insulated equipment connected to the line voltage is not allowed with reference to EN50153/IEC61991 Railway applications – Rolling stock – Protective provision relating to electrical hazards.

26. Reference paragraph 5.2.5.

Because of modification of paragraph 4.2, this paragraph is optional and should be deleted.

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