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Item 2(a) of the provisional agenda

Regulation No. 107 (M₂ and M₃ vehicles) –**Proposals for further amendments****Proposal for amendments to Regulation No. 107 (M₂ and M₃ vehicles)****Submitted by the expert from Belgium ***

The text reproduced below was prepared by the Belgium to align the additional safety prescriptions for trolleybuses with the corresponding electrical standards. It supersedes ECE/TRANS/WP.29/GRSG/2013/16 and informal document GRSG-104-13 (see report ECE/TRANS/WP.29/GRSG/84, para. 8). The modifications to the current text of UN Regulation No. 107 are marked in bold for new or strikethrough for deleted characters.

* In accordance with the programme of work of the Inland Transport Committee for 2012–2016 (ECE/TRANS/224, para. 94 and ECE/TRANS/2012/12, 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; and**
- 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; and**
- 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
- 1.3.1. Trolleybuses shall be designed to operate reliably under the following environmental conditions:**
- 1.3.1.1. A temperature range of minus ~~40~~ 25 °C to plus 40 °C;**
 - 1.3.1.2. A relative humidity of 98 per cent at temperatures up to 25°C;**
 - 1.3.1.3. An atmospheric pressure range of from ~~866~~ 86.6 kPa to ~~1066~~ 106.6 kPa;**
 - 1.3.1.4. An altitude range from sea level to a maximum of ~~1,000~~ 1,400 m above the sea level.**
- 1.3.2. Trolleybuses may be designed for special environmental conditions, which exceed the rated climatic conditions on the request of the type approval authority. Those special environmental conditions shall be indicated in the type-approval documentation (Annex 1, Part 1, Appendices 1 to 3) and certification (Annex 1, Part 2, Appendices 1 to 3).**
- 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~~ **a 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 **least** 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.
- 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. 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 ~~dismounted~~ **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 the 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 onboard 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 shall be 20 mm.

With other materials or designs or mountings or extreme operation conditions, a greater creepage distance shall 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 the trolleybus 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:**
- 3.9.1. ~~Body to high voltage circuits~~
For each basic insulation: $\geq 10 \text{ M}\Omega$;
- 3.9.2. ~~High voltage circuits to low voltage circuits~~
For each supplementary insulation: $\geq 10 \text{ M}\Omega$;
- 3.9.3. ~~Body to positive pole of low voltage circuits~~
For the overall double insulation: $\geq 10 \text{ M}\Omega$.
- 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 voltages **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 onboard the trolleybus shall be tested with an AC power supply at test frequency of 50 - 60 Hz for 1 minute.

The test voltage (U_{Test}) for wiring and components at the trolleybus shall be:

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

The values for basic and supplementary insulations may be reversed.

For circuits double insulated from overhead line voltage, the test voltage (U_{Test}) shall be at least 1,500 V, or:

Basic Insulation:

$$U_{\text{Test}} = 2 \times U_{\text{Nm}} + 1,000 \text{ V}$$

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., shall be deleted.

Paragraphs 4.1. to 4.3., amend to read:

"4.1. **In a trolleybus, each circuit energized by an overhead line voltage shall have double insulation of the 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. **On trolleybuses with no means of connection to the protective conductor of the fixed installation when stationary, all electrical equipment shall be double insulated. Any failure of either level of insulation shall be detectable either by procedure or by the use of monitoring devices.**

Under extreme environmental conditions, it is convenient to take additional measures. Other measures are: separation of insulations, higher insulations, larger insulation distances, shelter of insulations, more frequent procedures or the combination of procedures and the use of monitoring devices.

For this combination the values to be monitored are the insulation resistance between circuits fed at the line voltage and the chassis, the leakage current or the leakage voltage between chassis and road surface.

The monitoring device shall give an optical and/or acoustic alarm signal when the insulating resistance is less than 500 k Ω , the leakage current exceeds more than 3 mA or the leakage voltage exceeds more than 40 V.

When the above-mentioned limit values are reached the monitoring device 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 monitoring device, 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.

Annex 1, Part 1, Appendices 1, 2 and 3, insert new items 6 to 6.6.2. to read:

"6.	Special provisions for trolleybuses
6.1.	Special environmental conditions for reliable operation:
6.1.1.	temperature
6.1.2.	external humidity level
6.1.3.	atmospheric pressure
6.1.4.	altitude
6.2.	Vehicle
6.2.1.	dimensions with locked poles
6.2.3.	supply
6.2.4.	rated voltage of overhead line (V)
6.2.5.	rated line current of vehicle (A) including auxiliary drives, HVAC
6.2.6.	performance
6.2.7.	maximum velocity (km/h: normal service/autonomous service)
6.2.8.	maximum inclination (%: normal service/autonomous service)
6.2.9.	description of main power circuits
6.2.10.	circuit diagrams
6.2.11.	protection measures
6.2.12.	insulation monitoring (if any)
6.2.13.	make and type of monitoring device
6.2.14.	principle of monitoring, description
6.2.15.	description of insulation levels of components
6.3.	Electric motor
6.3.1.	make and type of electric motor
6.3.2.	type (winding, excitation)
6.3.3.	maximum hourly/continuous power (kW)
6.3.4.	rated voltage (V)
6.3.5.	rated current (A)
6.3.6.	nominal frequency (Hz)
6.3.7.	location in the vehicle
6.4.	Power electronics
6.4.1.	make and type of traction inverter
6.4.2.	maximum continuous power
6.4.3.	cooling system
6.4.4.	make and type of 24V-battery charger
6.4.5.	maximum continuous power

6.4.6.	cooling system
6.4.7.	make and type of 3-phase AC supply
6.4.8.	maximum continuous power
6.4.9.	cooling system
6.5.	Power supply for autonomous service:
6.5.1.	storage system
6.5.2.	battery/supercaps
6.5.3.	make and type of storage system
6.5.4.	weight (kg)
6.5.5.	capacity (Ah)
6.5.6.	location in the vehicle
6.5.7.	make and type of control unit
6.5.8.	make and type of charger
6.5.9.	rated voltage (V) / minimum voltage (V), end of charge voltage (V)
6.5.10.	rated current (A) / max. discharge current (A), max. charge current (A) .
6.5.11.	Diagram of operation, control and safety
6.5.12.	Characteristics of charge periods
6.5.13.	motor-generator unit
6.5.14.	hourly/cont. power (kW)
6.5.15.	make and type of unit or of motor and generator
6.5.16.	fuel and fuel system
6.5.17.	location in the vehicle
6.6.	Current collector
6.6.1.	make and type of current collector
6.6.2.	operation of current collector

Annex 1, Part 2:

Appendix 1, insert new items 1.13. to 1.13.1.4. to read:

"1.13	Trolleybuses
1.13.1.	Special environmental conditions for reliable operation:
1.13.1.1.	temperature
1.13.1.2.	external humidity level
1.13.1.3.	atmospheric pressure
1.13.1.4.	altitude

Appendix 2, insert new items 1.9. to 1.9.1.4. to read:

"1.9.	Trolleybuses
1.9.1.	Special environmental conditions for reliable operation:
1.9.1.1.	temperature
1.9.1.2.	external humidity level
1.9.1.3.	atmospheric pressure
1.9.1.4.	altitude

Appendix 3, insert new items 1.5. to 1.5.1.4. to read:

"1.5	Trolleybuses
1.5.1	Special environmental conditions for reliable operation:
1.5.1.1.	temperature
1.5.1.2.	external humidity level
1.5.1.3.	atmospheric pressure
1.5.1.4.	altitude

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.
3. 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.
4. Reference paragraph 1.2.3. - The definition of three phase circuits can be deleted, as it is not used.
5. Reference paragraph 1.3. - We refer to IEC60077-1 for the rated climatic conditions for temperature, humidity and altitude. Classes of special environmental conditions are given in EN50125-1, which the technical authority can request depending on the service location of the operator. Temperature and altitude according to EN50125-1 shall be indicated in the type-approval documentation and certification.
6. It was experienced that the altitude effects on cooling and clearances will start at 1,800 m to 2,000 m. Thus, the limit of 1,400 m given in IEC60077-1 is sufficient as a limit and there is no need for different altitude classes.

7. 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.
8. 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.
9. Reference paragraph 2. - Current is the new wording for (electrical) power.
10. 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.
11. 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.
12. 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. Operational height shall be at least from 4 m to 6 m for type approval.
13. 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.
14. 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.
15. Reference paragraph 3.7. - New wording with reference to EN50153/IEC61991 Railway applications – Rolling stock – Protective provisions relating to electrical hazards. The driver's compartment is included in the passenger's compartment (see UN Regulation No. 100).
16. Reference paragraph 3.7.1. - The prescription for outside insulations is added with reference to EN50124-1 Railway applications – Insulation coordination.
17. 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.
18. Reference paragraph 3.9. - Note: In Italy and Switzerland, the test periods are fixed by legal prescriptions.

19. 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. The rated voltage of cables should be determined and stated by the manufacturer. Since reflection can increase the voltage amplitude of switched outputs (up to 100 per cent) the rated insulation voltage may be too low, but 3 kV is too much. Additionally, the insulation is stressed by switched AC-voltages which reduces its lifetime.
20. Reference paragraph 3.10.4. - New wording with reference to TS45545 Railway applications – Fire protection on railway vehicles
21. 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.
22. 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.
23. 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 electro-magnetic compatibility which will be submitted for amendment to UN Regulation No. 10 in an informal document to the Working Party on lighting and light-signalling (GRE).
24. 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.
25. Reference paragraph 4.2. - New wording with reference to IEC60479-1: Effects of current on human beings and livestock.
26. Reference paragraphs 4.3. to 4.6. - The measurements in paragraphs 4.3. to 4.6. are not specified completely: neither the test voltage nor the dry or wet condition are specified. These measurements, and the insulation itself, always create problems. The original paragraphs 4.3. to 4.6. can be waived because 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 the chassis in wet conditions.
27. Reference paragraph 4.3. - Reference to EN50153/IEC61991: double insulation with procedure or monitoring devices. Safety is established by the double insulation. For a monitoring device without control by procedure a safety analysis shall be carried out. Disconnection of supply as a single measure is only allowed in EN61140 with a protective conductor, which is missing in a trolleybus.
28. 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.
29. Reference paragraph 5.2.5. - Because of the modification of paragraph 4.2., this paragraph is optional and should be deleted.

30. Reference Annex 1 – Part 1 – Appendices 1, 2 and 3 - A list of characteristics of a trolleybus apart from the special environmental conditions, referring to Annex 6 – Part 1 and Annex 7 of UN Regulation No. 100, is added.
