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**Economic Commission for Europe****Inland Transport Committee****World Forum for Harmonization of Vehicle Regulations****Working Party on Passive Safety****Fifty-ninth session**

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Item 17 of the provisional agenda

**Regulation No. 100 (Electric power trained vehicles)****Proposal for amendments to Regulation No. 100 (Electric Power Trained Vehicles)****Submitted by the expert from Belgium\***

The text reproduced below was prepared by the expert from Belgium to transfer additional safety provisions for electrical safety of trolleybuses from UN Regulation No. 107 (M<sub>2</sub> and M<sub>3</sub> vehicles) to UN Regulation No. 100 (Electric Power Trained Vehicles). This proposal is aimed at informing the Working Party on Passive Safety (GRSP) about the interpretation issue of the scopes of the two Regulations to cover electrical safety of trolleybuses. Moreover, the purpose of these amendments is to solve unclarity for Type Approval Authorities and Technical Service and enable manufacturers to plan the homologation of a new vehicle type. The modifications to the text of the UN Regulation are marked in bold for new or strikethrough for deleted characters.

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\* In accordance with the programme of work of the Inland Transport Committee for 2014–2018 (ECE/TRANS/240, para. 105 and ECE/TRANS/2014/26, 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

*List of Annexes,*

*Annex 6, amend to read:*

*"Annex 6*

*...*

Part 3: Essential characteristics of road vehicles or systems with chassis connected to electrical circuits.....

**Part 4: Essential characteristics of the trolleybus"**

*Text of the Regulation,*

*Insert a new paragraph 1.3., to read:*

**"1.3. Part III: Safety requirements with respect to the electric power train of road vehicles of categories M<sub>2</sub> and M<sub>3</sub>, with a maximum design speed exceeding 25 km/h, equipped with one or more traction motor(s) operated by electric power from external, overhead contact wires and temporarily from an additional internal means of propulsion, as well as their high voltage components and systems which are galvanically connected or insulated to the high voltage bus of the electric power train.**

**Part III of this regulation does not cover post-crash safety requirements of road vehicles."**

*Paragraph 2.17., amend to read:*

"2.17. "High Voltage" (voltage class "B" according to ISO 6469-3) means the classification of an electric component or circuit, if its working voltage is > 60 V and ≤ 1500 V DC or > 30 V and ≤ 1000 V AC root mean square (rms). **All other components or circuits shall be classified "Low Voltage". "**

*Insert new paragraphs 2.40. to 2.46., to read:*

**"2.40. "Trolleybus" means a vehicle, electrically driven by energy from external, overhead contact wires. For the purposes of this Regulation, it also includes such vehicles having an additional internal means of propulsion (dual mode vehicles) or having a means of temporarily external guidance (guided trolleybuses).**

**2.41. "Line voltage" means the voltage provided to the trolleybus from the overhead contact line.**

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

**2.43. "Functional insulation" means an insulation that ensures the functionality of the equipment.**

**2.44. "Basic insulation" means an insulation that protects persons from electrical hazards in systems with protective bonding.**

**2.45. "Supplementary insulation" means an insulation that protects persons from electrical hazards in systems without protective bonding.**

**2.46. "Double insulation" means a combination of basic and supplementary insulation, each individually testable by a metallized intermediate layer."**

Paragraph 5, amend to read:

- "5. Part I: Requirements of an internally supplied vehicle not permanently connected to the grid with regard to its electrical safety"

Insert a new paragraph 7, to read:

## **"7. Part III: Requirements of an externally supplied vehicle with regard to its electrical safety**

### **7.1. Operating parameters**

#### **7.1.1. 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 20 ms.

#### **7.1.2. Rated climatic conditions**

##### **7.1.2.1. Trolleybuses shall be designed to operate reliably under the following environmental conditions:**

**7.1.2.1.1. A temperature range of minus 25 °C to plus 40 °C;**

**7.1.2.1.2. A relative humidity of 98 per cent at temperatures up to 25 °C;**

**7.1.2.1.3. An atmospheric pressure range from 86.6 kPa to 106.6 kPa;**

**7.1.2.1.4. An altitude range from sea level to a maximum of 1,400 m above the sea level.**

**7.1.2.2. Special environmental conditions, beyond the rated climatic conditions specified in paragraph 1.3.1. above, shall be indicated in the type-approval documentation (Annex 6, Part 3) and communication form (Annex 6, Part 3).**

**7.1.3. "Rated insulation voltage" is the value of voltage, to which dielectric tests, clearances and creepage distances are referred.**

### **7.2. Current collection**

**7.2.1. Current shall be obtained from the contact wires by means of one or more connecting devices, normally comprising two current collectors. (A single current collector or a pantograph may be used in guided applications.) A current collector shall consist of a roof mounting (trolley base), a trolley pole, a current collector head and a replaceable contact surface insert. 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  $20^\circ$  rotation about the horizontal axis of its attachment to the trolleybus.**

**7.2.2. Trolley poles shall be made either of a 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.**

- 7.2.3. 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 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.
- 7.2.4. Each trolley pole shall be equipped with a device that automatically retracts the pole in the event of the current collector becoming accidentally detached from the contact wire (de-wired).
- 7.2.5. In the event of de-wiring, contact between the retracted poles and any part of the roof shall be prevented.
- 7.2.6. The current collector head, if disconnected from its normal position on the trolley pole, shall remain attached to the trolley pole.
- 7.2.7. Current collectors may be equipped with remote control from the driver's compartment, at least for retraction.
- 7.2.8. Provision shall be made to enable the driver to replace, if necessary, contact surface inserts while the vehicle is in operation on the road.
- 7.3. Traction and auxiliary equipment
- 7.3.1. Electrical components installed on the trolleybus shall be protected against over-voltage and short-circuit current. The protection shall preferably be assured by circuit breakers that are reset automatically, remotely or manually.
- 7.3.2. Electrical components shall be protected against commutation or atmospheric over-voltage.
- 7.3.3. Circuit breakers shall provide interruption of particular damaged circuits.
- 7.3.4. If any circuit includes a single-pole circuit breaker, it shall be installed in the positive wire of the circuit.
- 7.3.5. All electrical circuits and circuit branches of voltage Class B shall be of dual wiring. The trolleybus body 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.
- 7.3.6. Battery cases, covers and trays shall be made of non-flammable or self-extinguishing materials.
- 7.3.7. Electrical components 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 (according to ISO 20653:2013).
- 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 (according to ISO 20653:2013).

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

- 7.3.7.1. 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 be mounted with shelter from weather or be designed as umbrella insulators or insulators with drip edge or another method having equivalent effects. Silicon as material or covering is recommended. In this case, the minimum creep age 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 (see item 3.5.3. of Annex 6, Part 3).

- 7.3.7.2. 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.

- 7.3.7.3. Cables for high voltage buses which are not located within enclosures shall be identified by having an outer covering with the colour orange.

- 7.3.8. The current conducting parts of electrical components, with the exception of current collectors, surge arrestors and traction resistors, shall be protected against moisture and dust.

- 7.3.9. Means shall be provided for a periodic resistance test to be conducted on each basic and supplementary insulation of components with double insulation. With a new and dry trolleybus, the insulation resistance of electrical circuits at a test voltage of 1,000 V DC shall not be less than:

7.3.9.1. For each basic insulation: 10 MΩ

7.3.9.2. For each supplementary insulation: 10 MΩ

7.3.9.3. For the overall double insulation: 10 MΩ

- 7.3.10. Wiring and apparatus

- 7.3.10.1. Flexible wires shall be used for all circuits. The rated insulation voltage of wires to ground shall be at least the rated insulation voltage according to paragraph 7.1.3.

- 7.3.10.2. Mounted wiring should not be stressed mechanically.

- 7.3.10.3. Wiring insulation shall not propagate burning.

- 7.3.10.4. Wiring of different voltages classes shall be mounted separately.

- 7.3.10.5. 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.

- 7.3.10.6. [Reserved]
- 7.3.10.7. Wiring located under the floor of the trolleybus shall be contained in conduit that protects it against the ingress and propagation of water and dust.
- 7.3.10.8. Fastening and arrangement of wiring and cables shall be designed to prevent damage by abrasion (chafing) of insulation. Grommets of elastomeric material shall be provided at points where wiring penetrates metal structure. The bend radius of conduits containing wiring shall be at least five times the external diameter of the conduit.
- 7.3.10.9. The location of wiring in the vicinity of circuit breakers shall be designed so as to prevent arcing onto the wiring.
- 7.3.10.10. Precautions shall be taken to avoid damage of wiring from heated resistors and other electrical components. In critical areas thermo-resistant wires shall be used.
- 7.3.10.11. Wiring holders, connectors and other mounting devices shall be made of non-flammable or self-extinguishing materials.
- 7.3.10.12. 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:  $U_{Test} = 2 \times U_{Nm} + 1,500 \text{ V}$   
 Supplementary Insulation:  $U_{Test} = 1.6 \times U_{Nm} + 500 \text{ V}$

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

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

The equivalent DC test voltage is  $\sqrt{2}$  times the AC value.

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

- 7.4. Electrical safety of passengers and crew
  - 7.4.1. In a trolleybus, each circuit energized by an overhead line voltage shall have double insulation of the vehicle chassis.
  - 7.4.2. 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.
  - 7.4.3. The trolleybus shall be equipped with an onboard device for permanent monitoring of leakage current or voltage between the chassis and the road surface. The device shall automatically disconnect the high voltage circuits from the contact system (when trolleybus is stationary) if the

leakage current exceeds 3 mA or if the leakage voltage exceeds 60 V DC (according to EN 50122-1 or IEC 62128-1).

- 7.5. The driver's compartment
  - 7.5.1. In the driver's compartment, there should not be any high voltage equipment accessible by the driver.
  - 7.5.2. As a minimum, the instrument panel shall include:
    - 7.5.2.1. Indicator of voltage in the contact system;
    - 7.5.2.2. Indicator of zero voltage in the contact system;
    - 7.5.2.3. Indicator of state of main automatic line voltage circuit breaker;
    - 7.5.2.4. Indicator of charge/discharge of the batteries;
    - 7.5.2.5. Indicator of body voltage or leakage current exceeding the limits specified in paragraph 4.2. above."

*Paragraphs 7 to 12, renumber as paragraphs 8 to 13.*

*Insert a new Annex 6 - Part 3, to read:*

## "Annex 6 - Part 3

### Essential characteristics of the trolleybus

- 1. General
  - 1.1. Make (trade name of manufacturer)
  - 1.2. Type
  - 1.3. Vehicle category
  - 1.4. Commercial name(s) if available
  - 1.5. Manufacturer's name and address
  - 1.6. If applicable, name and address of manufacturer's representative
  - 1.7. Drawing and/or photograph of the vehicle
  - 1.8. Approval number of the REESS
- 2. Special environmental conditions for reliable operation:
  - 2.1. Temperature
  - 2.2. External humidity level
  - 2.3. Atmospheric pressure
  - 2.4. Altitude
- 3. Vehicle:
  - 3.1. Dimensions with locked poles
  - 3.2. Supply
    - 3.2.1. Rated voltage of overhead line (V)
    - 3.2.2. Rated line current of vehicle (A) including auxiliary drives, HVAC
  - 3.3. Performance

- 3.3.1. Maximum velocity (km/h: normal service/autonomous service)
- 3.3.2. Maximum inclination (per cent: normal service/autonomous service)
- 3.4. Description of main power circuits
  - 3.4.1. Circuit diagrams
  - 3.4.2. Protection measures (overview diagrams and drawings)
- 3.5. Insulation monitoring (if any)
  - 3.5.1. Make and type of monitoring device
  - 3.5.2. Principle of monitoring, description
  - 3.5.3. Description of insulation levels of components
- 4. Electric motor
  - 4.1. Make and type of electric motor
  - 4.2. Type (winding, excitation)
  - 4.3. Maximum hourly/continuous power (kW)
  - 4.4. Rated voltage (V)
  - 4.5. Rated current (A)
  - 4.6. Nominal frequency (Hz)
  - 4.7. Location in the vehicle
- 5. Power electronics
  - 5.1. Make and type of traction inverter
    - 5.1.1. Maximum continuous power
    - 5.1.2. Cooling system
  - 5.2. Make and type of 24V-battery charger
    - 5.2.1. Maximum continuous power
    - 5.2.2. Cooling system
  - 5.3. Make and type of 3-phase AC supply
    - 5.3.1. Maximum continuous power
    - 5.3.2. Cooling system
- 6. Power supply for autonomous service:
  - 6.1. Storage system
    - 6.1.1. Battery/supercaps
    - 6.1.2. Make and type of storage system
    - 6.1.3. Weight (kg)
    - 6.1.4. Capacity (Wh)
    - 6.1.5. Location in the vehicle
  - 6.2. Make and type of control unit
  - 6.3. Make and type of charger
    - 6.3.1. Rated voltage (V) / minimum voltage (V), end of charge voltage (V)



- 6.3.2. **Rated current (A) / max. discharge current (A), max. charge current (A)**
- 6.4. **Diagram of operation, control and safety**
- 6.5. **Characteristics of charge periods**
- 6.6. **Motor-generator unit**
  - 6.6.1. **Hourly/cont. power (kW)**
  - 6.6.2. **Make and type of unit or of motor and generator**
  - 6.6.3. **Fuel and fuel system**
  - 6.6.4. **Location in the vehicle**
- 7. **Current collector**
  - 7.1. **Make and type of current collector**
  - 7.2. **Operation of current collector"**

## II. Justification

1. Background: UN Regulation No. 36 was amended introducing an Annex with provisions for trolleybuses in 2002 (Supplement 07 to the 03 Series of Amendments). At that time the scope of UN Regulation No. 100 addressed only battery electric vehicles. The annex concerning trolley buses was then in turn added to UN Regulation No. 107, not in the 01 Series of Amendments in 2003 (the merging of UN Regulations Nos. 36, 52 and 107) but with the 02 Series of Amendments in 2006. In 2015 the concerned Annex (number 12) was then amended to align the additional safety prescriptions for electrical safety of trolleybuses with existing corresponding electrical standards (ISO).
2. A trolleybus is meant a vehicle of category M<sub>2</sub> or M<sub>3</sub> and UN Regulation No. 107 covers its general construction. A trolleybus is also an electric power trained vehicle, and therefore UN Regulation No. 100 is better suited to cover the additional safety prescriptions for electrical safety as currently listed in Annex 12 of UN Regulation No. 107.
3. Annex 12 of UN Regulation No. 107 which addresses the additional safety prescriptions for electrical safety should, therefore, be deleted by an amendment in a working document submitted to the Working Party on Passive Safety (GRSG), and transferred to UN Regulation No. 100 as proposed in this amendment.
4. Already in Annex 1 – Part 1 – Appendices 1, 2 and 3 of UN Regulation No. 107, where a list of characteristics of a trolleybus apart from the special environmental conditions was added, a reference was made to Annex 6 – Part 1 and Annex 7 of UN Regulation No. 100.
5. Open questions remain if the current text of UN Regulation No. 100 is applicable to a trolleybus in which electrical safety performance has been type approved according to the 06 series of amendments to UN Regulation No. 107. Particularly, what is meant by grid in the scope of UN Regulation No. 100 should be clarified: does grid also mean the external, overhead contact wires to which a trolleybus is mainly connected. If not, is it sufficient to make reference to item 44 of the Mutual Resolution No. 2 "Containing Vehicle Propulsion System Definitions"? If the additional internal means of propulsion is a diesel engine generator, is the trolleybus still in the scope of the UN Regulation No. 100? Finally, is a trolleybus type still within the scope if the additional internal means of propulsion is a battery or supercap?