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## **Global Registry**

**Created on 18 November 2004, pursuant to Article 6 of the Agreement concerning the establishing of global technical regulations for wheeled vehicles, equipment and parts which can be fitted and/or be used on wheeled vehicles (ECE/TRANS/132 and Corr.1) done at Geneva on 25 June 1998**

## **Addendum 20: Global technical regulation No. 20**

### **Global Technical Regulation on Electric Vehicle Safety (EVS)**

Established in the Global Registry on 14 March 2018

#### **Proposal and report pursuant to Article 6, paragraph 6.2.7. of the Agreement**

- Proposal for establishing two informal working groups addressing the safety and environmental requirements for electric vehicles to enhance regulatory cooperation including developing global technical regulations in the framework of the 1998 Agreement (ECE/TRANS/WP.29/AC.3/32)
- Final report on the development of Global Technical Regulation No. 20 on Electric Vehicle Safety (EVS) (ECE/TRANS/WP.29/2017/139, adopted by AC.3 at its fifty-second session (ECE/TRANS/WP.29/1137, para. 134)



UNITED NATIONS

## **Proposal for establishing two informal working groups addressing the safety and environmental requirements for electric vehicles to enhance regulatory cooperation including developing global technical regulations in the framework of the 1998 Agreement**

### **I. Introduction**

1. The proposal for setting up two informal working groups on electric vehicles<sup>1</sup> (EVs) was initiated by the European Commission, DG Enterprise and Industry, the National Highway Traffic Safety Administration and the Environmental Protection Agency in the United States and the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) in Japan. These will act as technical co-sponsors of the EVs and of potential UN GTRs to be developed. The intention of setting up the groups was announced during the WP.29 plenary session in June 2011.
2. Through this initiative, the co-sponsors aim to:
  - (a) Exchange information on current and future regulatory requirements for electric vehicles in different markets;
  - (b) Minimize the differences between these regulatory requirements, with a view toward facilitating the development of vehicles to comply with such requirements;
  - (c) Where possible, develop common requirements in the form of one or more UN GTRs.
3. Both working groups should be established under the 1998 Agreement to create the basis for the possible development of a UN GTR. All global partners are invited to join the groups and share experiences on setting relevant regulatory requirements as well as from the market.
4. The groups aim to replicate the successful approach of the Working Group on Hydrogen and Fuel Cell Vehicles, including the safety (HFCV-SGS) and environmental (HFCV-SGE) subgroups. This working group facilitated an exchange of information among participants when each party was developing domestic regulatory requirements for hydrogen and fuel cell vehicles. This working group now aims to develop a UN GTR setting up global safety requirements for hydrogen and fuel cell vehicles.
5. Electric propulsion technology is fairly mature, but recent advances in energy storage (batteries, capacitors, flywheels) have largely improved electric vehicles' performance and made them a valid choice for consumers. There is a considerable potential for further developments in automotive energy storage. Electric vehicles, like hydrogen and fuel cell vehicles, represent a promising technology in terms of addressing climate change, improving air quality and cutting oil dependency. The current regulatory pressure to lower CO<sub>2</sub> and pollutant emissions is helping to drive an increasing market penetration of electric vehicles. Furthermore, many governments support the development and deployment of

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<sup>1</sup> The term and the work in the groups will cover both battery electric (BEV) and hybrid electric vehicles (HEV) (including plug-in hybrids (PHEV)).

electric vehicles by financing research or offering incentives for consumers. Consequently, the automotive industry is investing in research and development, as well as the production capacity for electric vehicles, at a scale not seen in the past.

6. Together with support measures for industry development, many governments have already started to define their regulatory framework for electric vehicles, mostly in order to ensure their safety and thus gain consumer confidence, but also in consideration of environmental performance measures.

7. Because of the relatively small volume of electric vehicles and their components currently produced, any degree of convergence between regulatory obligations can result in economies of scale and cost reductions for automotive manufacturers – critical in the context of economic recovery and the general cost-sensitiveness of the industry. The new informal working groups seek regulatory convergence on a global scale, via the framework of the 1998 Agreement. This avenue of cooperation is particularly interesting considering that the regulatory structure for electro-mobility technologies is currently being developed on both sides of the Atlantic and in Asia and a unique opportunity exists to develop common approaches.

8. It is also important to note that while electric vehicles are currently on the market and regulators are moving forward with setting applicable technical requirements, the technology is still evolving. This ongoing technology development necessitates a flexible yet solid regulatory framework, one that is performance-oriented, based on the best available data and scientific research and analysis. Cooperation with relevant researchers and technical experts will be a prerequisite for successful operation of the group.

## **II. Areas of work in two informal working groups**

9. The two key topics for the informal working groups are safety requirements and environmental performance of electric vehicles.<sup>2</sup> Two separate structures, reporting to the Working Party on Passive Safety (GRSP) and to the Working Party on Pollution and Energy (GRPE) respectively, will facilitate organization of the work as well as the nomination of experts and chairs of the meetings.

### **1. Informal working group on Electric Vehicles Safety (EVS)**

10. The aim of this working group is to sponsor an effort to develop one UN GTR (or more, if appropriate) to address the safety of EVs.<sup>3</sup> The gtr would attain equivalent levels of safety for electric vehicles as for conventional gasoline powered vehicles. The UN GTR would address the unique safety risks posed by EVs and their components, taking into account the actual use in the market. It would be performance-based to the extent possible so as not to restrict future technologies. It should be preceded by an exchange of information on current and future planned regulatory safety requirements for electric vehicles, including the underlying scientific and technical basis and research.

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<sup>2</sup> The results of the informal working group on Quiet Road Transport Vehicles, expected early 2012, are also acknowledged and will be taken into consideration, if appropriate.

<sup>3</sup> The work already accomplished under the 1958 Agreement could be an important basis, notably the Regulation Nos. 100, 12, 94 and 95 and the results of the Rechargeable Energy Storage System (REESS) group of interested parties which has been operating since November 2010 and which is scheduled to deliver the results early 2012. Importantly, the start of the work under the 1998 Agreement will not pre-empt any further work on REESS under the 1958 Agreement.

11. Given that electric vehicle technology is advancing and vehicle manufacturers are planning to produce EVs at higher production volumes in the near future, it is necessary to ensure that the occupants are protected, while in normal use, and during and after a crash event, from electric shocks associated with the high voltage circuits of EVs and from potential hazards associated with lithium-ion batteries and/or other REESS (in particular, containing flammable electrolyte).

12. The UN GTR would also set provisions and test protocols to ensure that the vehicle system and/or electrical components perform safely, are appropriately protected, and are electrically managed while recharging from external electricity sources, at a residence or other charging location.

13. The UN GTR will cover high voltage electrical safety, electrical components such as electric connectors and receptacles, and REESS in particular, containing flammable electrolyte. In addition, the EVS will investigate design, development and production of lithium-based battery technology. The safety provisions will address the safety of electric vehicles, both in-use and post-crash. The key items would be as follows:

- (a) In-use:
  - (i) Occupant protection: protection against electric shock;
  - (ii) Charging requirements including electric receptacle and connector;
  - (iii) Safety requirements for REESS, including battery safety (battery management system, thermal shock, thermal cycling, mechanical shock, overcharge/isolation resistance, over-charge, vibration, fire resistance and short circuit, etc.);
- (b) Post-crash:
  - (i) Electrical isolation: protection against electric shock;
  - (ii) Battery integrity: battery management system, robustness and survivability;
  - (iii) Best practices or guidelines for manufacturers and/or emergency first responders; and
  - (iv) Battery discharge procedures.

14. To the extent possible, the experts of the subgroup will develop the UN GTR using the following processes:

- (a) Identify potential safety risks specific to EVs taking account of the actual use in the market;
- (b) Develop and evaluate the requirements by reviewing analyses and evaluations conducted to justify the requirements;
- (c) Develop and validate test procedures based on existing evaluations and research; and
- (d) Avoid design-restricted requirements and provisions that are not technically justified.

15. Finally, this group could also consider the different standards for electro-mobility (e.g. vehicle inlets for which the United States of America and European Union industries have expressed interest in a transatlantic standard), based on relevant expertise. Such standards, which are in principle voluntary, could potentially be transformed into regulatory requirements or represent a de facto product requirement and could also impact safety.

Standards are a factor of competitiveness, and harmonized or common standards would likely result in cost savings for industry and society.

16. Another area for consideration by the group is the standardization of vehicle-to-grid communication, potentially enabling intelligent charging and energy storage on board of the vehicle. At the same time, regulators could look into opportunities offered by meters that could be installed on board of the vehicles. While those standards go outside the scope of the automotive regulations, they may influence some technical requirements (e.g. on REESS) and could therefore be considered by the group.

## **2. Informal Working Group on Electric Vehicles and Environment (EVE)**

17. The informal working group on Electric Vehicles and the Environment would be an open structure which would enable the exchange of information and experience on relevant policies and regulations. The general consensus on environmental performance is that electric vehicles have superior environmental performance to conventional vehicles, but the exact method of measurement of emissions and energy efficiency has yet to be defined under the 1998 Agreement (although there is ongoing work on test-cycle for hybrid electric vehicles in WLTP and HDH groups). While this area is less likely to provide grounds for a UN GTR, it is important to provide a forum for sharing information about developing techniques for such important considerations such as measuring the energy efficiency of future electric vehicles, battery durability, cold start performance and recharging performance. Furthermore, application of fuel economy standards to electric vehicles and measurement of upstream emissions could be discussed as well.

18. Moreover, while investigating the potential for future regulatory action, the informal working group can discuss the related research priorities, current projects and experience in order to foster mutual learning and possibly encourage development of common research projects and definitions. Among the important considerations regarding the environmental aspects of electric vehicles to be examined for potential UN GTR or other appropriate action might include the methods and procedures necessary to determine the operational, recharging performance of the electric drive system in any given vehicle and end-of-life battery approaches.

19. With the continuing efforts to foster the development of electro-mobility, there will also be opportunities to share information on issues such as infrastructure build-up, standards for charging infrastructure, support for battery manufacturing, battery recycling and second-life usage, thus bringing together dispersed competences within the global context of WP.29.

20. All of these considerations of environmental performance aspects and other issues should be reviewed in the context of the existing work already being conducted by the worldwide harmonized light vehicles test procedure (WLTP), Heavy Duty Hybrids (HDH) and Environmentally Friendly Vehicles (EFV) informal working groups. This will enable a clear and discrete development of the terms of reference for the new informal working group on environmental performance of EVs.

## **III. Existing regulations and directives:**

21. Currently, there are no regulations concerning electric vehicle safety in the Compendium of Candidates. Consideration of regulations, voluntary standards and guideline documents during development of the UN GTR regarding safety of electric vehicles should include, but not be limited to, the following:

### **Regulations and directives:**

- United States -- FMVSS 305 – Electric-Powered Vehicles: Electrolyte Spillage and Electrical Shock Protection
- UN Regulation No. 12 – Uniform Provisions Concerning The Approval Of Vehicles With Regard To The Protection Of The Driver Against The Steering Mechanism In The Event Of Impact
- UN Regulation No. 94 – Uniform Provisions Concerning The Approval Of Vehicles With Regard To The Protection Of The Occupants In The Event Of A Frontal Collision
- UN Regulation No. 95 -- Uniform Provisions Concerning The Approval Of Vehicle With Regard To The Protection Of The Occupants In The Event Of A Lateral Collision
- UN Regulation No. 100 – Uniform Provisions Concerning The Approval Of Vehicles With Regard To Specific Requirements for Electric Power Train
- Japan -- Attachment 101 – Technical Standard for Protection of Occupants against High Voltage in Fuel Cell Vehicles
- Japan -- Attachment 110 – Technical Standard for Protection of Occupants against High Voltage in Electric Vehicles and Hybrid Electric Vehicles
- Japan -- Attachment 111 – Technical Standard for Protection of Occupants against High Voltage after Collision in Electric Vehicles and Hybrid Electric Vehicles
- Japan – Circular notice for test procedures with Hard-In-the-Loop Simulator system to measure fuel efficiency and emission in Electric Hybrid Heavy-duty Vehicles (H19.3.16, KOKU-JI-KAN No.281)
- China -- GB/T 24548-2009 Fuel cell electric vehicles – terminology
- China -- GB/T 24549-2009 Fuel cell electric vehicles – safety requirements
- China -- GB/T 24554-2009 Fuel cell engine – performance - test methods
- Canada -- CMVSS 305 – Electric Powered Vehicles: Electrolyte Spillage And Electrical Shock Protection
- Korea -- Motor Vehicle Safety Standard, Article 18-2 – High Voltage System
- Korea -- Motor Vehicle Safety Standard, Article 91-4 – Electrolyte Spillage and Electric Shock Protection

### **International Industry standards:**

- ISO 23273-3 -- Fuel cell road vehicles –Safety specifications – Part 3: Protection of persons against electric shock
- ISO6469 -- Electrically propelled road vehicles
- ISO 6469-1 (2009) -- Electrically propelled road vehicles – Safety specifications – Part 1: On-board rechargeable energy storage system
- ISO 6469-2 (2009) -- Electrically propelled road vehicles – Safety specifications - Part 2: Vehicle operational safety means and protection against failures

- ISO 6469-3:2001 -- Electric road vehicles – Safety specifications – Part 3: Protection of persons against electric hazards
- SAE J1766 -- Electric and Hybrid Electric Vehicle Battery Systems Crash Integrity Testing
- SAE J2578 -- General Fuel Cell Vehicle Safety
- SAEJ2929 -- Electric and Hybrid Vehicle Propulsion Battery System Safety Standard- Lithium -based Rechargeable Cells
- SAEJ2464 -- Electric and Hybrid Vehicle Rechargeable Energy Storage System Safety and Abuse Testing

## Environment

USA: U.S. Code of Federal Regulations (CFR) Title 40: Protection of the Environment; Parts 85, 86, 600 (Light-duty); Parts 85, 86, 600, 1033, 1036, 1037, 1039, 1065, 1066, and 1068 (Medium-, heavy-duty)

EU: Regulation (EC) No. 715/2007 on type approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance

Regulation (EC) No. 595/2009 on type-approval of motor vehicles and engines with respect to emissions from heavy duty vehicles (Euro VI) and on access to vehicle repair and maintenance information

Regulation (EU) No 510/2011 setting emission performance standards for new light commercial vehicles as part of the Union's integrated approach to reduce CO<sub>2</sub> emissions from light-duty vehicles

Regulation (EC) No. 443/2009 setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO<sub>2</sub> emissions from light-duty vehicles

## IV. Timeline

- **14-18 November 2011:** World Forum for Harmonization of Vehicle Regulations (WP.29) (155th session) – agreement on establishment of two informal Working Groups on electric vehicles submitted to the AC.3.
- **January 2012:** End of the work of the REESS informal working group, its final outcome to be considered in the informal working group on EVs safety requirements.
- **January 2012:** feedback of other parties interested to join the group on the proposal.
- **13-16 March 2012:** official adoption of the decision to launch the two informal working groups by WP.29 in Geneva, Chairs and secretaries are elected.
- **March 2012:** first meetings of the two informal working groups.
- **Spring 2012,** adoption of Terms of Reference for each informal working group by the GRPE and GRSP, respectively.

22. The respective Chairs will manage the various aspects of the work ensuring that the agreed action plan is implemented properly and that milestones and timelines are set and met.

- **2012-2013:** meetings of the working group, regular reporting to the Administrative Committee.
- **2014:** possible adoption of global technical regulation(s).



## **Final report on the development of Global Technical Regulation No. 20 on Electric Vehicle Safety (EVS)**

1. The electric vehicle safety (EVS) UN GTR is a result of numerous meetings and excellent cooperation between the governments of Canada, China, Japan, the Republic of Korea, the United States of America and the European Union including standards organizations, testing authorities and industry experts.
2. In 2012, the United Nations World Forum for Harmonization of Vehicle Regulations (WP.29) adopted a joint proposal by Japan, the United States of America and the European Union to establish two working groups to address the safety and environmental issues associated with electric vehicles. Later in 2012, China joined the three original co-sponsors.
3. The objective of the two working groups was to seek regulatory convergence on the global scale via the work in the framework of the 1998 Agreement.
4. The Terms of Reference (ToR) for the EVS informal working group (IWG) was adopted with the goal of establishing a UN GTR for EVs covering high voltage electrical protection, safety of electrical components, and rechargeable electric energy storage system (REESS).
5. An IWG was formed to develop in-use and post-crash safety requirements using science-based, data driven and performance-based approach.
6. Over the last five years, the IWG which was comprised of over 50 members has held 13 meetings. The meetings and development process are transparent. Documents and reports are posted on the UN website: <https://www2.unece.org/wiki/pages/viewpage.action?pageId=3178628>.
7. Given the complexity of issues discussed, the informal working group requested three extensions of the mandate: in November 2014 (ECE/TRANS/WP.29/2014/87), November 2015 (ECE/TRANS/WP.29/2016/30) and in March 2017 (Informal document WP.29-171-33), each time by one year. The goal of IWG is the adoption of the UN GTR by WP.29 in November 2017 session.
8. To resolve particular technical issues in an efficient manner, nine task force groups have been set up and met, in addition to numerous web conferences, nine times between October 2014 and November 2016. Task force groups successfully addressed a large number of safety related issues according to the given mandate, however, more discussion is required on some critical issues, where research and testing of methods are still in progress.
9. Under such circumstances, IWG agreed that the most appropriate way to establish the UN GTR within the given mandate was to address the agreed safety provisions in Phase 1 while leaving those safety requirements that require long-term research, verification research as well as further improvement of the UN GTR for Phase 2, which is expected to start as soon as possible.
10. This regulation applies to vehicles of Category 1 and Category 2 with a maximum design speed exceeding 25 km/h, equipped with electric power train containing high voltage bus, excluding vehicles permanently connected to the grid.
11. This regulation includes the following two sets of requirements that may be selected by Contracting Parties according to the category and gross vehicle mass (GVM) of the vehicles:

- (a) For all vehicles of Category 1-1 and vehicles of Categories 1-2 and 2 with GVM of 4,536 kg or less, the requirements of paragraphs 5. and 6. shall apply in accordance with the general requirements specified in paragraph 4;
- (b) For vehicles of Category 1-2 and Category 2 with GVM exceeding 3,500 kg, the requirements of paragraphs 7. and 8. shall apply in accordance with the general requirements specified in paragraph 4.

12. Specific in-use requirements aimed at preventing hazards to occupants of electric vehicles during normal operating conditions apply to the vehicles and REESS. With respect to vehicles, they address direct and indirect contact protection against electric shock and including markings of high voltage sources, electrical isolation, protection against water effects, functional safety after vehicle activation, when leaving the vehicle and shock protection during charging.

13. With respect to protection from water effects, manufacturers can choose to present evidence of component based assessment or conduct vehicle based water tests. Alternatively, the Contracting Party may adopt an exemption from the requirements above for vehicles equipped with an isolation resistance monitoring system.

14. Performance requirements for REESS, including Battery Management System (BMS), relate to safety during the normal operation of the vehicle under vibration conditions and thermal shock and cycling caused by low and high external temperatures that provoke mechanical stress to the components. Furthermore, requirements address REESS fire resistance ensuring that vehicle occupants have adequate evacuation time, and define protection conditions for REESS in the case overcharge, over-discharge, over-temperature, over-current and external short circuit. These tests may be performed equally at the vehicle level. With respect to a fire resistance test, the IWG developed an alternative test procedure using Liquefied Petroleum Gas (LPG) burner.

15. Management of gases is a particularly important aspect of this UN GTR. To avoid human harm that may occur from potential toxic or corrosive emissions, for REESS other than open-type traction batteries, venting is proposed as a pass/fail criterion for the following in-use tests: vibration, thermal shock and cycling, external short circuit protection, overcharge protection, over-discharge protection, over-temperature protection and over-current protection. This regulation includes a no-fire criterion which addresses the issue of vented gas flammability.

16. The informal working group examined the feasibility to establish a robust and repeatable method to verify the occurrence of venting and the potential exposure of vehicle occupant to the gases caused by venting condition associated with combustion and/or decomposition of electrolyte, in the in-use test. No method other than visualization technique was found at this stage for verifying the occurrence of venting as a basis for assessing the influence of venting gases to vehicle occupants. Based on the outcome of research, modifications to the requirements and methods with respect to leakage and evaporation of non-aqueous electrolyte may be necessary in the future.

17. The thermal propagation test procedure that would address the scenario of internal short circuit is currently not adopted as a requirement. Vehicle manufacturers shall make available documentation demonstrating the vehicle's ability to minimize the risk associated with single cell thermal runaway caused by an internal short circuit. Moreover, the vehicle shall provide an advance warning indication to allow occupant egress or five minutes prior to hazardous conditions inside the passenger compartment.

18. UN GTR introduces warnings for REESS operations and specifies requirements to evaluate the proper functioning of vehicle controls that manage REESS safe operation in overcharge, over-discharge, over temperature and overcurrent conditions.

19. Due to the complexity and varied designs of vehicle controls that manage REESS safe operation, no single test procedure could be developed that would fully evaluate whether a warning tell-tale turns on in the event of operational failure of the BMS. Therefore, manufacturers are required to provide documentation demonstrating that a warning to the driver will be provided in the event of operational failure of one or more aspects of vehicle controls that manage REESS safe operation.
20. Two additional sets of requirements warn the driver in case of the thermal event in REESS and low the energy content in REESS.
21. The IWG placed important emphasis on agreeing on specifications for adjustment of State Of Charge (SOC) prior to running test procedures; in particular those involving thermal events, given that the REESS SOC may significantly influence REESS reaction to specified test requirements.
22. Each Contracting Party under the UN 1998 Agreement may maintain its existing national crash tests (e.g. frontal, side, rear, or rollover) and shall comply with UN GTR post-crash performance requirements.
23. Vehicle post-crash requirements focus at preventing hazard to occupants and ensuring safe state of the REESS after a crash. The provisions include protection from electric shock that can be accomplished by meeting one of the following options: low electrical energy, low voltage, physical protection or isolation resistance.
24. Post-crash requirements regarding the safety of REESS at the vehicle level address the issues of electrolyte leakage, fire hazard and REESS retention requiring REESS to remain attached to the vehicle by at least one component and REESS outside passenger compartment shall not enter passenger compartment. At the moment, venting is not proposed as a requirement for tests addressing safety of REESS post-crash. Mechanical shock and mechanical integrity are the two tests assessing post-crash performance of REESS at the component level.
25. Importantly, UN GTR introduces safety requirements for heavy duty vehicles that cover general electrical safety for vehicle, vehicle specific functional safety, REESS safety in-use and inertial load on REESS. For most part, the tests and requirements for heavy vehicles are the same as for passenger vehicles.
26. Finally, while the objective of the IWG was to develop EVS UN GTR as robust as possible, work on thermal propagation and initiation methods remains in progress and should be completed in Phase 2. Other technical items that may be addressed in Phase 2 include REESS water immersion test, longer duration fire resistance test, REESS rotation test and vibration profile, detecting flammability, toxicity and corrosiveness of vented gas, post-crash REESS safety assessment and stabilization procedures, safety requirements for low mass and low speed electric vehicles and protection during AC and DC charging.
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