

**Informal Working Group Report to GRSP on Electric Vehicles Safety GTR and related activities
(May 2017)**

The EVS GTR is a result of numerous meetings and excellent cooperation between the governments of Canada, China, the European Union, Japan, Korea and the United States including standards organizations, testing authorities and industry experts.

In 2012, the United Nations World Forum for Harmonization of Vehicle Regulations (WP.29) adopted a joint proposal by the United States of America, Japan 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.

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.

The Terms of Reference (ToR) for the electric vehicle safety (EVS) working group was adopted with the goal of establishing a global technical regulation (GTR) for electric vehicles (EVs) covering high voltage electrical protection, safety of electrical components, and rechargeable electric energy storage system (REESS).

An Informal Working Group (IWG) was formed to develop in-use and post-crash safety requirements using science-based, data driven and performance-based approach.

Over the last five years, the IWG which comprised of over 50 members have conducted 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>.

Given the complexity of issues discussed, the informal working group requested an extension of the mandate three times: 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 GTR by WP.29 in November 2017 session.

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.

Under such circumstances, IWG agreed that the most appropriate way to establish the 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 GTR for Phase 2, which is expected to start as soon as possible.

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.

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.

Specific in-use requirements aiming 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 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.

With respect to protection from water effects, manufacturers have a choice 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.

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.

Management of gases is a particularly important aspect of this GTR. To avoid human harm that may occur due to 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.

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 visual 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.

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.

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.

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.

Two additional sets of requirements relate to warnings to the driver in case of the thermal event in REESS and low energy content in REESS.

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 the REESS SOC may significantly influence REESS reaction to specified test requirements.

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 GTR post-crash performance requirements.

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.

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.

Importantly, 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.

Finally, while the objective of the IWG was to develop EVS 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.
