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## Economic Commission for Europe

### Inland Transport Committee

### World Forum for Harmonization of Vehicle Regulations

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#### 1998 Agreement:

Consideration and vote by AC.3 of draft UN GTRs

and/or draft amendments to established UN GTRs, if any

Proposal for a new UN GTR, if any

Proposal for a new UN GTR on In-vehicle Battery

Durability for Electrified Vehicles

## Proposal for a final status report on the development of a new Amendment to UN Global Technical Regulation on In-Vehicle Battery Durability for Electrified Light-Duty Vehicles

Submitted by the Working Party on Pollution and Energy\*

[To be revised]

\* In accordance with the programme of work of the Inland Transport Committee for 2022 as outlined in proposed programme budget for 2022 (A/76/6 (part V sect. 20) para 20.76), the World Forum will develop, harmonize and update UN Regulations in order to enhance the performance of vehicles. The present document is submitted in conformity with that mandate.



# Final status report on the development of a new Amendment to UN Global Technical Regulation on In-Vehicle Battery Durability for Light-Duty Electrified Vehicles

## I. Introduction

1. Owing to the pressing need to reduce emissions of greenhouse gases (GHG) and other air pollutants, the market share of electrified vehicles is expected to grow in the future. A key component of these vehicles is the traction battery that is used to store and deliver energy to power the movement of the vehicle and the systems within it. Improvements in the performance of batteries to deliver increased driving range, reduced charging times and greater affordability are a significant focus for manufacturers and technological developments in this area are expected to accelerate the uptake of electrified vehicles by consumers.

2. Despite the expected improvements in the performance of new electrified vehicles, the continued in-use performance of the battery over time is not currently regulated. The primary motivation for the development of a GTR on in-vehicle battery durability therefore stems from the recognition that the environmental performance of electrified vehicles may be affected by excess degradation of the battery system over time.

3. Loss of electric range and loss of vehicle energy efficiency are both primary concerns. Loss of electric range could lead to a loss of utility, meaning electric vehicles are driven less and therefore displace less distance travelled that might otherwise be driven in conventional vehicles. A loss in utility could also dampen consumer sentiment and curb the market growth necessary for electric vehicle sales to deliver on fleet emissions reductions. Loss of vehicle efficiency could impact the upstream emissions by increasing the amount of electricity needed per vehicle distance travelled. Both can affect not only the utility of the vehicle to the consumer, but also the environmental performance of the vehicle. Loss of environmental performance is important, in particular because governmental regulatory compliance programs often credit electrified vehicles with a certain level of expected environmental benefit, which might not be realized over the life of the vehicle if excess battery degradation occurs.

4. In addition to changes in range and energy consumption, hybrid electric vehicles are often equipped with both a conventional and electric powertrain, and for these vehicles the criteria pollutant emissions from the conventional powertrain could be impacted by the degradation of the battery over time.

5. The development of a GTR on in-vehicle battery durability therefore aims to provide a harmonized methodology to address these concerns by introducing a method by which the health of the battery can be monitored over time and by setting minimum performance requirements for the durability of the battery.

## II. Procedural background

6. The Informal Working Group (IWG) on Electric Vehicle and the Environment (EVE) was set up in June 2012 following the approval by WP.29/AC.3 of ECE/TRANS/WP.29/AC.3/32. This document established two distinct IWGs to examine environmental and safety issues related to Electric Vehicles (EVs): the IWG on EVE, reporting to the Working Party on Pollution and Energy (GRPE), and the IWG on Electric Vehicle Safety (EVS), reporting to the Working Party on Passive Safety (GRSP). The proposal was supported by the European Commission, the United States of America, China, and Japan.

7. A second mandate for the IWG on EVE, divided into Parts A and B was approved in November 2014 by AC.3 to conduct additional research to address several recommendations that grew out of the first mandate, and develop UN GTR(s), if appropriate. The second mandate was separate from the IWG on EVS.

8. Part A of the second mandate of the IWG on EVE (ECE/TRANS/WP.29/AC.3/40) included “battery performance and durability” as one of the topics authorized for study and potential GTR development. Specifically, Part A authorized activity “to further develop the recommendations for future work outlined in the Electric Vehicle Regulatory Reference Guide by:

(a) Conducting additional research to support the recommendations;

(b) Identifying which recommendations are suitable for the development of Global Technical Regulation(s) (GTR(s)) by the World Forum for Harmonization of Vehicle Regulations (WP.29);

(c) Developing a work plan.

9. The work of the IWG on EVE on battery performance and durability under Part A of the EVE mandate was reported to WP.29 in a status report as informal document WP.29-170-31 at the 170th meeting of WP.29, 15-18 November 2016.

10. At the close of Part A the IWG on EVE recommended that GRPE and WP.29 endorse the option of extending the mandate of the IWG on EVE to continue active research into the topic of battery performance and durability without committing to the development of a GTR at that time. This was endorsed and work continued on this topic within Part B of the mandate.

11. The IWG on EVE presented a draft status report to GRPE in May 2019 on the research on in-vehicle battery durability and performance. The status report indicated that there was sufficient information to allow a UN GTR for in-vehicle battery durability to be started. The IWG on EVE recommended at the 79th GRPE session in May 2019 that the UN GTR on in-vehicle battery durability be developed under a new mandate.

12. AC.3 subsequently approved document ECE/TRANS/WP.29/AC.3/57 authorizing the IWG on EVE to develop a new UN GTR on in-vehicle battery durability which will be developed in 2 phases:

(a) Phase 1: deliver a first version of a UN GTR on in-vehicle battery durability to AC.3 by November 2021 with:

(i) Definition of and requirements for electrified vehicle battery performance criteria;

(ii) Requirements for reading and/or displaying battery health information and usage data from the vehicle;

(iii) A provisional in-service conformity test which will include generic usage criteria and a statistical method.

(b) Phase 2: develop a second version of the UN GTR on in-vehicle battery durability with the following:

(i) The development of a methodology to define Normal Usage Indices (NUI) based on data read from vehicles;

(ii) Refined performance criteria requirements for in-vehicle battery durability through assessment of further modelling and data collected from real vehicles and the use of NUIs.

13. This report covers the development of the both the first version of the UN GTR under phase 1 and its amendment under phase 2 of the mandate.

### **III. Development of the UN GTR**

14. Following several years of information gathering and deliberation among the IWG members on the feasibility of drafting a UN GTR, the UN GTR was developed over the course of around 20 IWG meetings over approximately two years, with 50 to 60 attendees participating in the meetings. The meetings and development process are transparent. Documents and reports generated for all of the IWG meetings are posted on the UN website:

<https://wiki.unece.org/pages/viewpage.action?pageId=2523151>

15. The governing committee of the IWG comprises of a Chairperson, two Vice-Chairs, and a Technical Secretary. A drafting coordinator is typically appointed for the drafting of specific UN GTRs. Chairperson is taken by the representatives of the United States and the Vice-Chairs are taken by the representatives of Japan and China. The Technical Secretary is taken by the representative(s) of Canada. For this UN GTR, the drafting coordinator was a representative of the European Commission.

16. Other members of the group who have contributed to the development of the UN GTR include representatives from many other Contracting Parties, automotive industry trade association groups, vehicle manufacturers, and technical experts.

17. The main discussions on the development of the UN GTR commenced at the 34th session of the IWG on EVE and focussed on the format and content of the UN GTR. A framework for the UN GTR was soon developed that centred around the concepts of a minimum performance requirement (MPR) for the in-vehicle battery, a readable on-board battery health monitor, an in-use verification procedure for assessment of the health monitor and a data collection process for assessment of durability against the MPR.

18. The framework established also provided the means by which to collect data for ongoing development of the UN GTR in a phase 2, together with negating the need to conduct validation testing in the course of preparing the UN GTR.

19. Early agreement was reached that the UN GTR should not seek to dictate the algorithm used by the manufacturer in determination of on-board battery health metrics, but instead provide a means to ensure the accuracy of any values through in-use verification. Two metrics were created, named the state of certified energy (SOCE) and the state of certified range (SOCR), which would form the basis for assessment within the UN GTR.

20. Early agreement was also reached that the UN GTR would not seek to create new test methods for assessment of vehicle range and battery energy, but instead rely upon the test procedures already employed within a Contracting Party for those purposes.

21. Initial drafting of the UN GTR started in the 37th session of IWG on EVE and an increased frequency of meetings was commenced in recognition of the significant work required on drafting and the novel basis of this UN GTR.

22. The IWG spent a significant amount of time considering appropriate MPR values that would prevent underperforming products entering the market whilst still being technically feasible for manufacturers. A number of data sources were considered in order to try and understand the performance of electric vehicles within the current fleet. A consensus amongst Contracting Parties was eventually reached at the beginning of 2021, which resulted in the establishment of MPRs based upon SOCE that are included within this UN GTR. A view was taken that SOCR would be monitored but not subject to an MPR requirement in phase 1 and phase 2 of the UN GTR for potential inclusion of range-based MPRs for Part B and accuracy requirements for Part A in a future amendment of this GTR.

23. Other key areas that the IWG focussed on included: the creation of family definitions for both the verification of on-board monitors and the assessment of battery durability, the statistical procedure for assessment of accuracy requirements for the on-board monitors, the handling of vehicles that have been used atypically or for vehicle-to-grid, and the definition of usable battery energy for the purposes of this UN GTR.

24. IWG on EVE has kept GRPE up to date on the development of the UN GTR. This included sharing a first draft of the proposed UN GTR as an informal document at the 82nd session of GRPE in January 2021 (see informal document GRPE-82-27). A second draft was also submitted as a working document (ECE/TRANS/WP.29/GRPE/2021/18) at the 83rd session of GRPE in June 2021, but it was necessary to defer consideration of the proposal pending agreement on the final provisions of the UN GTR within the IWG on EVE. A special November session of GRPE was therefore requested, in which a final draft would be presented.

25. Key outstanding issues that needed to be resolved in order to finalize the UN GTR included:

- (a) Agreement on handling of vehicles that had not been subject to normal use;
- (b) Allowances for vehicles that have been used for vehicle-to-grid;
- (c) Agreement on a statistical procedure for verification of on-board monitors; and
- (d) Finalization of usable battery energy definitions.

26. A breakout group was established to explore options for the statistical method used in Part A (Verification of Monitors). Representatives from the European Commission's Joint Research Centre used datasets from the 'Transport tEchnology and Mobility Assessment Platform' (TEMA) to evaluate various methods, comparing against simulations by industry experts, before presenting their findings to the IWG.

27. The subject of vehicle-to-grid was discussed, and how it could be considered in the UN GTR. An equation was devised to calculate a 'virtual distance' value for vehicles designed for vehicle-to-grid usage, which could be summed with the distance driven to establish a total distance. A part C was added in phase 2 of the GTR development in order to address the accuracy of the reported virtual distance. Different proposals for the verification of the reported virtual distance have been discussed: with a single test with one to three vehicles, with maximum three vehicles for a fail decision and with a statistic increasing number of vehicle up to 4 for a pass decision. The EVE IWG reached consensus on last as described here after. An agreed verification procedure use case with an adequate number of vehicles (at least 1 and not more than 4) used in V2X or not-traction purposes shall be performed. The verification of the reported virtual distance shall lead to a fail in the verification procedure if the reported virtual distance is more than 5% higher than the measured virtual distance. This may lead to the requirement that the manufacturer repairs or replaces the faulty virtual distance calculator in all affected and future vehicles in the battery durability family, to correct already reported virtual distances for this family and to repeat the procedure for verification of Part B in order to confirm the pass or fail.<sup>28</sup> Significant discussion was also held regarding the handling of vehicles that had been subject to abnormal use. Initial proposals included the use of monitor flags to identify abnormal use, however, consensus was eventually reached to simplify and improve robustness of the process by eliminating the flags and adjusting the processes accordingly.

29. A breakout group was also created to establish definitions for certified and measured values of usable battery energy. Representatives from the European Commission, Japan and industry experts worked together closely to determine a solution that also addressed regional regulations, ensuring the UN GTR is applicable to regions that do not apply UN GTR No. 15 or the WLTP procedure.

30. Electrified vehicles of category 2 are at an earlier stage of adoption within the fleets of many Contracting Parties and subsequently in-use data relating to battery durability are not so readily available for these vehicles. For this reason, it was difficult to determine a suitable and achievable MPR for category 2 vehicles during the first phase of the mandate. During the second phase of development of the GTR, further TEMA modelling was presented confirming that a difference of only 5% is adequate to address the difference in use between category 1 and category 2 vehicles. It has been raised by manufacturers that in future the batteries of these vehicles may also be used for supplementary purposes, in addition to propulsion, which could have further impacts on battery durability. It was therefore agreed during the second phase of the mandate to also take into account the extra use of batteries installed in Category 2 vehicles for non-traction purposes. This was added in the calculation of Virtual Mileage.<sup>31</sup> A list of values to be read from the vehicle has been introduced during phase 1 in the Annex 2 of the GTR containing information designed to survey the vehicle usage together with the SOCE and SOCR. This list of values has been updated in the specific metrics and requirements during the phase 2.

32. A finalized version of the amended UN GTR is to be presented by the IWG on EVE at the 90th session of GRPE.

33. More detailed discussion of the technical approaches considered by the IWG on EVE can be found in the Technical Background section of this UN GTR.

