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**Economic Commission for Europe****Inland Transport Committee****World Forum for Harmonization of Vehicle Regulations****One-hundred-and-fifty-second session**

Geneva, 9–12 November 2010

Item 17.4 of the provisional agenda

**Progress on the development of new global technical regulations  
or on the amendments to established global technical  
regulations – Gtr No. 4 (World-heavy-duty certification  
procedure (WHDC))****Proposal for the development of either amendments to gtr  
No. 4 adding a new emission test procedure for heavy-duty  
hybrid vehicles (HD-HV'S) or a new gtr****Submitted by the representative of the European Union\***

This document contains a proposal to develop a new annex to global technical regulation No. 4 (WHDC) concerning the emissions of pollutants and CO<sub>2</sub> from heavy duty hybrid vehicles. It is based on the text of informal document No. GRPE-60-12 distributed during the sixtieth session of the Working Party on Pollution and Energy (GRPE) (ECE/TRANS/WP.29/GRPE/60, para. 8). It is distributed to the World Forum for Harmonization of Vehicle Regulations (WP.29) and to the Executive Committee (AC.3) of the 1998 Agreement for consideration.

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\* In accordance with the programme of work of the Inland Transport Committee for 2006–2010 (ECE/TRANS/166/Add.1, 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. Objective of this proposal**

1. The objective of this proposal is to establish an amendment to global technical regulation (gtr) No. 4 (WHDC) with respect to pollutant emissions and CO<sub>2</sub> emissions from heavy duty hybrid vehicles in the framework of the 1998 Global Agreement. If the scope of gtr No. 4 is not considered to be appropriate it will be proposed to develop a new gtr making reference to the relevant parts of gtr No. 4.

2. Greater fuel efficiency and the reduction of CO<sub>2</sub> emissions are becoming an increasingly urgent issue in view of global warming and surging petroleum prices. Hybrid vehicles (HVs) are recognized as one solution for achieving lower emissions and increased fuel efficiency. Consequently, a widespread introduction of HVs has taken place during the last years, primarily for passenger cars. But also commercial vehicle manufacturers have introduced, or announced the introduction, of several hybrid concepts for urban, delivery and extra-urban operation. While testing of passenger car hybrids is covered by UNECE Regulation No. 83, no provisions exist today within the UNECE framework for heavy duty hybrids.

3. With gtr No. 4, a globally harmonized emissions testing procedure for conventional commercial vehicles have been established. Traditionally, emissions testing of conventional heavy duty vehicles involve engine testing, and the certified engine can then be installed in any vehicle independent of its application. Contrary to conventional vehicles, emissions testing and certification of HVs disregarding the vehicle application is not the optimal technical solution. Since engine speed and load cycles of HVs are indeed different from those of conventional powertrains, it is necessary to incorporate vehicle and operation related elements into the certification procedure.

## **II. Description of the proposed regulation**

4. The proposal aims to provide an engine based test procedure and harmonized technical requirements for pollutant emissions and CO<sub>2</sub> for certification of HV's. The test procedure will focus on the Hardware-in-the-Loop Simulation (HILS) approach, which starts from a vehicle cycle and simulates powertrain and vehicle components to result in a HV specific engine cycle for emissions testing and measurement. This allows using the test cell environment, data evaluation procedures and emissions calculations already specified in gtr No. 4. The proposal is intended to cover a wide range of HV technologies including but not limited to serial hybrids, parallel hybrids, electric hybrids, hydraulic hybrids, plug-in hybrids, range extenders and start/stop solutions. Non-tractive or Power Take-Off (PTO) operation should be considered, since much of the benefit associated with the use of hybrid technology is associated with the use of recovered energy for extended PTO operation.

5. During the course of this work, the feasibility of a chassis dynamometer based emission test procedure will be assessed as an alternative to HILS. The result of this activity will be reported to GRPE.

6. It is proposed to use the vehicle speed pattern of the World Harmonized Vehicle Cycle (WHVC) developed under the WHDC mandate as the starting point for the HILS method. Similar to the original WHDC approach, where a standard gearbox model was used for converting the WHVC into the standard engine cycle WHTC, HILS uses individual powertrain components (e.g. engine, transmission, electric motor, battery, accumulator), vehicle parameters (e.g. mass, inertia) and a driver model for creating the individual HV engine cycle. This HV engine cycle is then used for pollutant emissions and CO<sub>2</sub> testing. The engine cycle (speed/load pattern) created by HILS will be verified against

the engine cycle resulting from a chassis dyno test. A certain HV vehicle standardization will be incorporated to accommodate a powertrain system in a range of similar vehicles.

7. HILS includes the following elements:
  - (a) The vehicle model covers running and acceleration resistance, taking into account rolling and air resistance coefficients, vehicle mass, rotating equivalent mass, speed and acceleration, etc.;
  - (b) The MG (motor-generator) model represents the electric motor, the generator or other regenerative braking system whose input data are generated from component testing;
  - (c) The transmission model represents clutch and gearbox, the gear ratios and efficiencies;
  - (d) The battery, capacitor and accumulator models express the conditions of the battery/capacitor/accumulator, state of charge (SOC), capacity, resistance, charge and discharge power, etc.;
  - (e) Driver model;
  - (f) Energy storage state of health (SOH);
  - (g) Component testing.
8. In order to take specific vehicle operation into account, modifications to the WHVC with respect to using subsets of the cycle (urban, rural, motorway) in combination with appropriate weighting or scaling factors will be investigated. General emissions testing and measurement provisions will be based on gtr No. 4 (WHDC).
9. For the final methodology, the following will be considered:
  - (a) A system that results in outputs that are quantifiable, verifiable, and reproducible;
  - (b) A system that results in outputs that provide a method for assessing real world compliance broadly and on a case by case basis;
  - (c) A system that is capable of incorporating updated information and new data to produce the most accurate outputs;
  - (d) A system that is appropriately transparent as to allow governmental entities the latitude to easily assess its performance and ensure accuracy and a level playing field.
10. The following ambitious timetable is proposed:

<b>Item</b>	<b>Time</b>
IG meeting (timing and budget)	10/2010
Report to GRPE	01/2011
2 years work programme	
IG final report to GRPE	01/2013
GRPE adoption	01/2014
WP.29 adoption	06/2014

### **III. Existing regulations and international standards**

Japanese Regulation:

Kokujikan No. 60 of 30 June 2004, "Measurement Procedure for Exhaust Emission from Electric Hybrid Heavy-Duty Motor Vehicles";

Kokujikan No. 281 of 16 March 2007, "Measurement Procedure for Fuel Consumption Rate and Exhaust Emissions of Heavy-Duty Hybrid Electric Vehicles using Hardware-In-the-Loop Simulator System"

Kokujikan No. 282 of 16 March 2007, " Test Procedure for HILS System Provisional Verification for Heavy-Duty Hybrid Electric Vehicles"

SAE Standards:

SAE J 2711 "Recommended Practice for Measuring Fuel Economy and Emissions of Hybrid-Electric and Conventional Heavy-Duty Vehicles"

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