

PROPOSAL FOR AN EMISSIONS TEST PROCEDURE FOR
HEAVY DUTY HYBRID VEHICLES (HD-HV'S)

Note: This document contains a proposal to develop a new annex to global technical regulation No. 4 (WHDC) concerning the emissions of pollutants and CO₂ from heavy duty hybrid vehicles under the 1998 Agreement. It is based on the text of informal document No. GRPE-59-02 distributed during the fifty-ninth session of GRPE (ECE/TRANS/WP.29/GRPE/59, paras. 12 and 13), and on Working Papers No. HDH-01-03 and HDH-02-03, as discussed at the 1st and 2nd HDH meetings.

A. OBJECTIVE OF THIS PROPOSAL

The objective of this proposal is to establish an amendment to global technical regulation (gtr) No. 4 (WHDC) with respect to pollutant emissions and CO₂ emission from heavy duty hybrid vehicles under the 1998 Global Agreement. If the scope of gtr No. 4 is considered not to be appropriate it will be considered to develop a new gtr making reference to the relevant parts of gtr No. 4.

Greater fuel efficiency and the reduction of CO₂ emissions are becoming an increasingly urgent issue in view of global warming and surging petroleum prices. Hybrid vehicles (HV's) are recognized as one solution for achieving lower emissions and increased fuel efficiency. Consequently, a widespread introduction of HV's 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 ECE Regulation No. 83, no provisions exist today within the ECE framework for heavy duty hybrids.

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 HV's disregarding the vehicle application is not the optimal technical solution. Since engine speed and load cycles of HV's are indeed different from those of conventional powertrains, it is necessary to incorporate vehicle and operation related elements into the certification procedure.

B. DESCRIPTION OF THE PROPOSED REGULATION

The proposal aims to provide an engine based test procedure and harmonized technical requirements for pollutant emissions and CO₂ for certification of HV's. The test procedure will focus on the HILS (Hardware-in-the-Loop) 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.

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

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 Hardware In the Loop Simulation (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 CO₂ 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.

HILS includes the following elements:

- 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.;
- The MG (motor-generator) model represents the electric motor, the generator or other regenerative braking system whose input data are generated from component testing;
- The transmission model represents clutch and gearbox, the gear ratios and efficiencies;
- 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.
- Driver model
- Energy storage state of health (SOH)
- Component testing

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 n° 4 (WHDC).

For the final methodology, the following will be considered:

- A system that results in outputs that are quantifiable, verifiable, and reproducible;
- A system that results in outputs that provide a method for assessing real world compliance broadly and on a case by case basis;
- A system that is capable of incorporating updated information and new data to produce the most accurate outputs;
- 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.

The following ambitious timetable is proposed:

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

C. 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"
