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Working Party on Pollution and Energy (GRPE)
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agenda item 6.)

GRPE AD-HOC WORKING GROUP ON HYBRID VEHICLES

STATUS REPORT

(Application of ECE Regulations to hybrid vehicles)

Transmitted by the Expert from France

Note: The text reproduced below was prepared by the expert from the France and distributed without a symbol (informal document No. 14) during the forty-third session of GRPE (TRANS/WP.29/GRPE/43, para. 53).

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At its forty-second session GRPE approved the setting-up of a working group on hybrid vehicles and adopted its mandate.

This group including experts from Germany, Netherlands, Japan, Sweden, Italy, United-Kingdom, OICA and France met twice to work on:

1. Definitions
2. Categories of hybrid electric vehicles (HEV)
3. Regulations to be amended in priority
4. Principles of test methods for emissions and fuel consumption measurements

The group's approach is to be pragmatic in order to propose quickly amendments to existing regulations for homologation of hybrid vehicles coming into the market very soon (mandate from GRPE).

In addition the Dutch delegation proposes a parallel activity to produce a document that describes and analyses fundamental problems that cannot be dealt with adequately within the context presented by the mandate of the GRPE-HEV working group.

It was decided by the group that this new activity should be decided by GRPE, because not in the initial mandate.

This report gives progress on the work undergoing in the GRPE ad-hoc group. The future regulation amendments for introduction of hybrid vehicles will be based on the definitions and the test principles mentioned hereafter and agreed by the group, bearing in mind that some items are still under consideration and that parts of the text are in square brackets because still under discussion.

1. DEFINITIONS

1.1. General definition of hybrid vehicles (HV):

A hybrid vehicle (HV) means a vehicle with at least two different energy converters and two different energy storage systems (on vehicle) for the purpose of vehicle propulsion.

1.2. Definition of hybrid electric vehicles (HEV):

A hybrid electric vehicle (HEV) means a vehicle that can draw mechanical propulsion energy from both of the following on-vehicle sources of stored energy/power:

1.2.1. a consumable fuel

1.2.2. an electrical energy/power storage device (e.g.: battery, capacitor, flywheel ...)

2. CATEGORIES OF HEV (including driver's selectable modes)

Vehicle charging	Off-Vehicle Charging (a) (OVC)		Not Off-Vehicle Charging (b) (NOVC)	
	With	Without	With	Without
Operating mode switch				

(a) also known as "externally chargeable"

(b) also known as "not externally chargeable"

3. PRIORITY SEQUENCE IN ECE REGULATIONS REVISIONS

It was decided to give high priority in the revisions of Regulation No. 83, Regulation No. 101 and Regulation No. 85.

4. TEST METHODS FOR EMISSIONS AND FUEL CONSUMPTION MEASUREMENTS

As a general principle, for the following test procedures, the HEV will be tested under the most favourable conditions and the worst-case conditions.

For emissions, the test results must comply with the limits under the two test conditions.

For CO₂/energy consumption, the average of the two test results will be considered.

4.1. Externally chargeable (OVC HEV) without an operating mode switch

4.1.1. Emission tests

Two tests are performed under the following conditions:

Test 1: Type I test has to be carried out with a fully charged 1/ electrical energy/power storage device.

Test 2: Type I test has to be carried out with an electrical energy/power storage 2/ device in minimum state of charge (maximum discharge of capacity).

In test 1 and test 2, mass emissions of each pollutant (HC, CO, NO_x and PM, if required) in g/km have to meet the emission limits.

Final test result (for communication): mean value of Test 1 and Test 2

4.1.2. CO₂ / energy consumption

Test 1: - same as for emissions
- charge of the battery according Regulation No. 101 with measurement of energy: E1
- discharge of the battery down to minimum state of charge 2/

Test 2: - same as for emissions
- charge of the battery according Regulation No. 101 with measurement of energy: E2
- discharge of the battery down to minimum state of charge 2/
- charge of the battery according Regulation No. 101 with measurement of energy: E3

1/ If the manufacturer delivers no recommendations about charging of the battery for HEV which are externally chargeable, the procedures described in Regulation No. 101, Annex 6 paragraph 2.4.1.2. are applied.

2/ Definition of minimum state of charge of the electrical energy/power storage device:
During preconditioning the consumable fuel power unit of the HEV must start up at least once when discharging at constant speed of [40 km/h] or with manufacturer's recommendation.

Final test results (for communication):

CO₂ (g/km): mean value of Test 1 and Test 2 on complete cycle (urban + extra-urban).

Energy consumption: fuel consumption (l/100 km): average value of Test 1 and Test 2

electric consumption (Wh/km):
$$\frac{E1 + (E2-E3)}{\text{total distance during Test 1 and Test 2}}$$

As an option, manufacturer may request an extra test on urban cycle only following the complete procedure above-mentioned

4.2. Externally chargeable (OVC HEV) with an operating mode switch

4.2.1. Emission tests

Two tests are performed under the same conditions as in 4.1.1.

The emission limits must be achieved both in Test 1 and Test 2, according to the following table:

OVC HEV with an operating mode switch: measurement of emissions

Hybrid-modes Battery state of charge	- Pure electric - Hybrid	- Pure fuel consuming - Hybrid	- Pure electric - Pure fuel consuming - Hybrid	- Hybrid mode n <u>*/</u> - Hybrid mode m <u>*/</u>
	Switch in position	Switch in position	Switch in position	Switch in position
Test No. 1 Fully charged	Hybrid	Hybrid	Hybrid	Most electric hybrid mode
Test No. 2 Min. state of charge	Hybrid	Fuel consuming	Fuel consuming	Most fuel consuming mode

*/ for e.g.: sport, economic, urban, extra-urban position, ...

Tests results are calculated as in 4.1.1.

4.2.2. CO₂/energy consumption

Two tests are performed under same conditions as in 4.1.1.

Both electric energy and fuel consumption and CO₂ emissions must be reported for each test.

Depending on the different operating modes this procedure has to be carried out for each switch position, according to the following table:

OVC HEV with an operating mode switch: measurement of CO₂/energy consumption

Hybrid-modes Battery state of charge	- Pure electric - Hybrid (c) Switch in position	- Pure fuel consuming - Hybrid Switch in position	- Pure electric - Pure fuel consuming - Hybrid Switch in position	- Hybrid mode n - Hybrid mode m Switch in position
Test n° 1: Fully charged	Electric (a) Wh/km	Hybrid l/100 km and Wh/km	Electric (a) Wh/km	Most electric hybrid mode l/100 km and Wh/km
Test n° 2: Min. state of charge	Hybrid (b) Wh/km and l/100 km	Fuel consuming l/100 km	Fuel consuming l/100 km	Most fuel consuming mode l/100 km and Wh/km

- (a) If the vehicle range on electric mode is lower than one complete cycle, the test is carried out on hybrid mode only.
 (b) Same test procedure as in 4.1.2.
 (c) Case of an electric vehicle with a range extender: considered as an OVC vehicle with an operating mode switch, having an extended range of [a maximum of 25 per cent or/and a limited fuel tank capacity of 15 l]. For these vehicles (almost electric vehicles), the tests are carried out according to the first column of the table above but for CO₂ emissions and energy consumption calculation purposes, an annual average coefficient in service of [X %] may be used.

Test results reporting to be specified later on.

4.3. Not externally chargeable (not OVC HEV) without an operating mode switch.

4.3.1. Emission tests

For NOVC vehicles two types need to be distinguished:
 vehicles with a negligible Δ SOC over a type I test
 vehicles with a non-negligible Δ SOC over a type I test

Δ SOC: net change in electrical energy over duration of test cycle.

If it can be demonstrated for a vehicle that the condition:

$$\Delta E_{\text{batt}} / E_{\text{consumed fuel}} \cong \Delta Ah * V_{\text{batt}} / E_{\text{consumed fuel}} \leq n \%, \text{ with e.g. } n = 2 - 4$$

is always fulfilled over a type I test, then the vehicle's Δ SOC can be considered to have a negligible influence on the measured pollutant emissions (as well as on fuel consumption and CO₂-emission). For such a vehicle only one type I test (including preconditioning, soak and measurement) is performed to measure emissions.

For vehicles that do not fulfil the above-mentioned condition some form of Δ SOC-correction method is required to perform a meaningful measurement of pollutant emissions, fuel consumption and CO₂-emission.

A possibility proposed for these type of vehicles is to perform type I tests until the previous condition is fulfilled (up to 3 tests) and then take the mean emissions of the number of tests performed that must meet the emissions standards.

For the next meeting the Dutch delegation will prepare a document with a description and analysis of the different available options for Δ SOC-correction, taking into account the Japanese, German and French views on this issue as expressed in previous documents submitted to the working group. This document will use information obtained from international literature, the MATADOR-project and other previous projects.

4.3.2. CO₂ / energy consumption

If it can be demonstrated for a vehicle that the condition:

$$\Delta E_{\text{batt}} / E_{\text{consumed fuel}} \cong \Delta Ah * V_{\text{batt}} / E_{\text{consumed fuel}} \leq n \%, \text{ with e.g. } n = 2 - 4$$

is always fulfilled over a type I test, then the vehicle's Δ SOC can be considered to have a negligible influence on the measured fuel consumption and CO₂-emission. For such a vehicle only one type I test (including preconditioning, soak and measurement) is performed to measure fuel consumption and CO₂-emission.

For vehicles that do not fulfil the above-mentioned condition some form of Δ SOC-correction method is required to perform a meaningful measurement of pollutant emissions, fuel consumption and CO₂-emission.

A possibility proposed for this type of vehicles is to perform type I tests until the previous condition is fulfilled (up to 3 tests) and then use the mean value of the number of tests performed.

4.4. Not externally chargeable (Not OVC HEV) with an operating mode switch

Still under discussion.

5. NEXT MEETING: 12 March 2002 in Paris.
