

**APPLICATION OF UN/ECE REGULATIONS TO HYBRID VEHICLES**  
**Discussion paper**

Transmitted by the expert from France

**A. INTRODUCTION**

1. ECE REGULATIONS CONCERNED:

Regulation No. 83 – Emissions of M1 and N1 categories of vehicles

Regulation No. 101 – Emissions of CO<sub>2</sub> and fuel consumption measurement

Regulation No. 85 – Measurement of the net power

and possibly

Regulation No. 10 – Electromagnetic compatibility

Regulation No. 51 – Noise of M and N categories of vehicles

Regulation No. 68 – Measurement of maximum speed

Regulation No. 100 – Safety of battery electric vehicles

2. SCOPE: vehicles of categories M1 and N1.

3. AIM:

3.1. Ensure continuity and coherence between Regulations from a pure thermal vehicle to a pure electric vehicle.

3.2. Hybrid vehicle regulations should take into account their specific characteristics:

(i) very low exhaust emissions,

(ii) very low CO<sub>2</sub> emissions.

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**B. PROPOSAL**

1. DEFINITIONS AND CATEGORIES OF HYBRID VEHICLES

A hybrid vehicle is a vehicle fitted with at least a thermal engine and at least an electric engine.

The hybrid vehicle classification should, in particular, take into account the following criterias :

(a) off electric charge capability ,

(b) range during pure electric mode.

(c) ...

	Off Vehicle Charge Capability			Not Off Vehicle Charge Capability		
CLASS	Pure Electric Vehicle	Electric vehicle with a range extender	OVC Hybrid Electric Vehicle	Not OVC Hybrid Thermal Electric Vehicle	Thermal Vehicle with Electric Assistance	Pure Thermal Vehicle
RANGE IN PURE ELECTRIC MODE	Minimum range in pure electric mode on complete urban and extra urban cycles	Minimum range in pure electric mode on complete urban and extra urban cycles	Minimum range in pure electric mode on complete urban cycles	Minimum range in pure electric mode on elementary urban cycles	No range in electric mode	-
TANK CAPACITY	-	very limited	as a pure thermal	as a pure thermal	as a pure thermal	as a pure thermal

1.1. Definition of a pure electric vehicle

Vehicle in which on-board electric energy is used for traction purpose and which is dependent of external electric infrastructure.

1.2. Definition of a electric vehicle with a range extender

Pure electric vehicle principle, for which the range is extended by an on-board thermal source, occasionally used, and which is characterised by the following:

- (a) Possibility of charging directly to electric network,
- (b) A normal functioning in pure electric mode,
- (c) A "sufficient" range in pure electric mode, on ECE + EUDC cycle,
- (d) A limited fuel tank capacity,
- (e) Possibly, a thermal power limitation.

1.3. Definition of an O.V.C. hybrid electric vehicle

- (a) Possibility of charging directly to electric network,
- (b) Can run on a pure electric mode,
- (c) Has a « sufficient » urban range in electric mode.

1.4. Definition of a Not O.V.C. hybrid thermal electric vehicle

- (a) No possibility of charging directly to electric network,
- (b) Can run on a pure electric mode,
- (c) Has a limited urban range in electric mode

1.5. Definition of a thermal vehicle with electric assistance

- (a) hybrid vehicle without external charging possibility
- (b) with no range in pure electric mode

## 2. AMENDMENTS TO EXISTING ECE REGULATIONS

### 2.1. Regulation No. 83 – Emissions of M1 and N1 categories of vehicles

All the requirements of this Regulation could be adapted and apply to hybrid vehicles just like to thermal vehicles:

- (i) Type I, II and III tests,  
and possibly:
- (ii) Type VI test (-7 °C emissions),
- (iii) on-board diagnostics (OBD)
- (iv) Type IV (evaporative emissions), etc.

State of charge of the battery should be taken into account.

Possibly, the proper balance of the different functioning modes should be taken into account.

#### 2.1.1.1. Pure electric vehicle Not applicable

#### 2.1.1.2. Electric vehicle with a range extender

##### 2.1.1.2.1 Type 1 Test Exhaust emissions

- Preconditioning

Minimum state of charge of the battery :

The state of charge of the battery is such as the thermal auxiliary unit will start at least once during a complete cycle (ECE + EUDC).

Battery is discharging at a constant speed ([40 km/h]) of the vehicle until :

- an indicator on the dashboard shows that the maximum of range is obtained,
- or if the decrease of the speed is over [10 %],
- or if the auxiliary thermal unit begins to run.
- or by any other means that will allow the thermal auxiliary unit to start at least once during a complete cycle.

Soak between 6 h and 36 hours.

- Measurement of emissions

3 tests are carried out.

The testing procedure is the same as for pure thermal vehicles.

a) Maxi emissions (for each pollutant)

$E_i$  = Average of the 3 measurements in g/km

b) Average emissions in use (for each pollutant)

The running of the auxiliary thermal unit is exceptional and accounts for [5 %] of the annual mileage.

Annual average emissions in use in g/km :

The calculated value is K [5%] of the measured maximum emissions on the complete ECE+EUDC cycle.

$E_i \text{ avg in use} = [5\%] \times E_i \text{ in g/km}$

#### 2.1.2.2. Conformity of production

A simplified method should be defined with a normal or full state of charge of the battery.

#### 2.1.2.3. Type IV test

- Preconditioning

Minimum state of charge of the battery :

The state of charge of the battery is such as the thermal auxiliary unit will start at least once during a complete cycle (ECE + EUDC)

Battery is discharging at a constant speed ([40 km/h]) of the vehicle until :

- an indicator on the dashboard shows that the maximum of range is obtained,
- or if the decrease of the speed is over [10 %],
- or if the auxiliary thermal unit begins to run.
- or by any other means that will allow the thermal auxiliary unit to start at least once during a complete cycle

Soak between 6 h and 36 hours.

- The testing procedure is the same as for pure thermal vehicles.

#### 2.1.3. Off Vehicle Charge Capability Hybrid Electric Vehicle

##### 2.1.3.1. Type 1 test exhaust emissions

Overview

The emissions are the result of 2 types of use :

- a) Urban driving (commuter, children to school, shopping)  
These travelled distances are conducted in electric mode.
- b) Mix energy driving (on urban and extra urban cycle)  
These travelled distances are conducted in hybrid mode.

##### 2.1.3.1.1. Mix energy driving : Two tests have to be performed.

###### Test number 1

- Preconditioning :  
maximum state of charge of the battery

Soak between 6 h and 36 hours

- The testing procedure is the same as for pure thermal vehicles.

## Test number 2

- Preconditioning

Minimum state of charge of the battery :

The state of charge of the battery is such as the thermal unit will start at least once during a complete cycle (ECE + EUDC).

Battery is discharging at a constant speed ([40 km/h]) of the vehicle until :

- an indicator on the dashboard shows that the maximum of range is obtained,
- or if the decrease of the speed is over [10 %],
- or if the auxiliary thermal unit begins to run.
- or by any other means that will allow the thermal auxiliary unit to start at least once during a complete cycle.

Soak between 6 h and 36 hours.

- The testing procedure is the same as for pure thermal vehicles.

### 2.1.3.1.2. Average measurement tests number 1 and 2 (for each pollutant)

a) Maxi emissions (for each pollutant)

$E_i$  = Average of the 2 measurements in g/km

b) Average emissions in use (for each pollutant)

The running of the thermal unit accounts for [60 %] of the annual mileage.

Annual average emissions in use in g/km :

The calculated value is K [60%] of the measured maximum average emissions on the complete ECE+EUDC cycle (2 state of SOC maxi, mini).

$$E_i \text{ avg in use} = [60\%] \times E_i \text{ in g/km}$$

### 2.1.3.2. Conformity of production

A simplified method should be defined with a normal or full state of charge of the battery.

### 2.1.3.3. Type IV test

- Preconditioning

Minimum state of charge of the battery :

The state of charge of the battery is such as the thermal auxiliary unit will start at least once during a complete cycle (ECE + EUDC).

Battery is discharging at a constant speed ([40 km/h]) of the vehicle until :

- an indicator on the dashboard shows that the maximum of range is obtained,
- or if the decrease of the speed is over [10 %],
- or if the auxiliary thermal unit begins to run.
- or by any other means that will allow the thermal auxiliary unit to start at least once during a complete cycle.

Soak between 6 h and 36 hours.

- The testing procedure is the same as for pure thermal vehicles.

#### 2.1.4. Not O.V.C. hybrid thermal electric vehicle

##### 2.1.4.1. Emissions measurement (testing overview)

a) Preconditioning procedure in order to obtain a state of charge of the battery not depending on the initial state of charge.

b) Measure of an average value of emissions and fuel consumption that could depend on the functional strategies used.

##### 2.1.4.1.1. Preconditioning

Without sampling, a number (n) of complete cycles (urban + extra urban) is carried out without prolonged stoppage.

Value of n is determined as follows :

$$n \geq 2 + \frac{\text{discharge capacity of battery in Wh}}{[1000]}$$

soak : 6 h to 36 hours

##### 2.1.4.1.2. Testing

3 tests are carried out on the complete cycle (urban and extra urban) with a soak between 6 h and 36 hours after each test.

##### 2.1.4.1.3. Emissions calculation CO, HC, NOx, if necessary PM

$E_i$  = average of the 3 measurements g/km

##### 2.1.4.2. Conformity of production

A simplified method should be defined.

##### 2.1.4.3. Type IV test

- Preconditioning

Minimum state of charge of the battery :

The state of charge of the battery is such as the thermal auxiliary unit will start at least once during a complete cycle (ECE + EUDC).

Battery is discharging at a constant speed ([40 km/h]) of the vehicle until :

- an indicator on the dashboard shows that the maximum of range is obtained,
- or if the decrease of the speed is over [10 %],
- or if the auxiliary thermal unit begins to run.
- or by any other means that will allow the thermal auxiliary unit to start at least once during a complete cycle.

Soak between 6 h and 36 hours.

- The testing procedure is the same as for pure thermal vehicles.

##### 2.1.5. Thermal vehicle with electric assistance

Same as the not O.V.C. hybrid thermal electric vehicle (see paragraph 2.1.4) .

2.2. Regulation No. 101 – Emission of CO2 and fuel consumption measurement

2.2.1. Minimum range in pure electric mode

The minimum range for each category is to be defined (cycle and distance).

2.2.1.1. Electric vehicle with range extender

The test of electric range is made in pure electric mode.

The testing procedure is the same as for pure electric vehicles.  
The minimum range covers at least (4) ECE + EUDC cycles.

2.2.1.2. O.V.C. Hybrid electric vehicle

The test of minimum electric range is done in pure electric mode, same as the pure electric vehicle but on urban driving cycles, and covers at least (5) ECE urban driving cycles.

2.2.1.3. Not O.V.C. Hybrid thermal electric vehicle

The test of minimum electric range is done in pure electric mode, same as the electric vehicle, but on urban driving cycles, and covers at least (X) ECE elementary urban cycles.

2.2.2. Fuel consumption

Adaptation of the electric and thermal methods of fuel consumption measurements in this Regulation.

Fuel consumption measurement :

- (i) Electric : expressed in Wh/km,
- (ii) Thermal : expressed in l/100 km.

2.2.2.1. Consumption of the pure electric vehicle

In accordance with Annex 6 of Regulation 101  
Electric energy consumption

2.2.2.2. Two consumptions of the electric vehicle with a range extender

2.2.2.2.1. Pure electric mode as § 2.2.2.1.

2.2.2.2.2. Mode with use of the thermal auxiliary unit

Same procedure as in paragraph 2.1.2.

- Preconditioning

Minimum state of charge of the battery :

The state of charge of the battery is such as the thermal auxiliary unit will start at least once during a complete cycle (ECE + EUDC).

Battery is discharging at a constant speed ([40 km/h]) of the vehicle until :

- an indicator on the dashboard shows that the maximum of range is obtained,
- or if the decrease of the speed is over [10 %],

- or if the auxiliary thermal unit begins to run.
- or by any other means that will allow the thermal auxiliary unit to start at least once during a complete cycle

Soak between 6 h and 36 hours.

- Measurement of the fuel consumption.

3 tests are carried out

The testing procedure is the same as for pure thermal vehicles.

The running of the auxiliary thermal unit is exceptional and accounts for [5 %] of the annual mileage.

Annual average consumption in use

The calculated value is K [5%] of the measured maximum consumption on the complete ECE+EUDC cycle

C (with range extender) = Average of the 3 measurements      in l/100km

Annual average consumption in use

C average = [5%] x C      in l/100 km

#### 2.2.2.3. Two consumptions of the O.V.C. hybrid electric vehicle

2.2.2.3.1. Pure electric mode consumption of electricity in electric mode is expressed in watt-hours/km and measured as a pure electric vehicle but on urban cycles.

2.2.2.3.2. Fuel consumption in mix energy mode.

Mix energy driving : Two tests are conducted

##### Test number 1

- Preconditioning :  
maximum state of charge of the battery

Soak between 6 h and 36 hours.

- Measurement of the fuel consumption.

The testing procedure is the same as for pure thermal vehicles

##### Test number 2

- Preconditioning :

Minimum state of charge of the battery :

The state of charge of the battery is such as the thermal auxiliary unit will start at least once during a complete cycle (ECE + EUDC)

Battery is discharging at a constant speed ([40 km/h]) of the vehicle until :

- an indicator on the dashboard shows that the maximum of range is obtained,
- or if the decrease of the speed is over [10 %],
- or if the auxiliary thermal unit begins to run.
- or by any other means that will allow the thermal auxiliary unit to start at least once during a complete cycle



Soak between 6h and 36 hours.

- Measurement of the fuel consumption :

The testing procedure is the same as for pure thermal vehicles.

Test results :

C = Average of the 2 measurements in l / 100 km

#### 2.2.2.4. Consumption of the not O.V.C. hybrid thermal electric vehicle

The test procedure is the same as for emissions (paragraph 2.1.4)

C = Average of the 3 measurements in l / 100 km

#### 2.2.2.5. Consumption of thermal vehicle with electric assistance

Same as the not O.V.C. hybrid thermal electric vehicle (paragraph 2.2.2.4)

#### 2.2.3. CO<sub>2</sub> emissions

Adaptation of the electric and thermal methods of CO<sub>2</sub> measurements in this Regulation.

State of charge of the battery should be taken into account.

Possibly, the proper balance of the different functioning modes should be taken into account.

#### 2.2.3.1. CO<sub>2</sub> of the pure electric vehicle

Not measured by regulation R.101.

#### 2.2.3.2 CO<sub>2</sub> emissions of the electric vehicle with a range extender

##### 2.2.3.2.1. The CO<sub>2</sub> emissions in electric mode are taken equal to zero.

##### 2.2.3.2.2. Mode with use of the thermal auxiliary unit

Same procedure as in paragraph 2.1.2.

- Preconditioning :

The state of charge of the battery is such as the thermal auxiliary unit will start at least once during a complete cycle (ECE+EUDC).

Minimum state of charge of the battery :

Battery is discharging at a constant speed ([40 km/h]) of the vehicle until :

- an indicator on the dashboard shows that the maximum of range is obtained,
- or if the decrease of the speed is over [10 %],
- or if the auxiliary thermal unit begins to run.
- or by any other means that will allow the thermal auxiliary unit to start at least once during a complete cycle.

Soak between 6 h and 36 hours.

- Measurement of CO<sub>2</sub> emissions.

3 tests are carried out

The testing procedure is the same as for pure thermal vehicles.

The running of the auxiliary thermal unit is exceptional and accounts for [5 %] of the annual mileage.

Annual average consumption in use

The calculated value is K [5%] of the measured CO<sub>2</sub> emissions on the complete ECE+EUDC cycle

CO<sub>2</sub> (with range extender) = Average of the 3 measurements in l/100km

Annual average CO<sub>2</sub> emissions in use

CO<sub>2</sub> average = [5%] x CO<sub>2</sub> (minimum battery charge mode) in l/100 km

#### 2.2.3.3. CO<sub>2</sub> emissions of O.V.C. hybrid electric vehicles

##### 2.2.3.3.1. The urban driving mode is the electric one.

This use would be considered as an equivalent of 40% of the annual mileage.

The CO<sub>2</sub> emissions in electric mode are taken equal to zero.

##### 2.2.3.3.2. CO<sub>2</sub> in mix energy mode.

Mix energy driving : Two tests are conducted

###### Test number 1

- Preconditioning :  
maximum state of charge of the battery

Soak between 6 h and 36 hours.

- Measurement of CO<sub>2</sub> emissions.

The testing procedure is the same as for pure thermal vehicles

###### Test number 2

- Preconditioning :

Minimum state of charge of the battery :

The state of charge of the battery is such as the thermal auxiliary unit will start at least once during a complete cycle (ECE + EUDC)

Battery is discharging at a constant speed ([40 km/h]) of the vehicle until :

- an indicator on the dashboard shows that the maximum of range is obtained,
- or if the decrease of the speed is over [10 %],
- or if the auxiliary thermal unit begins to run.
- or by any other means that will allow the thermal auxiliary unit to start at least once during a complete cycle.

Soak between 6 h and 36 hours.

- Measurement of CO<sub>2</sub> emissions :

The testing procedure is the same as for pure thermal vehicles.

Test results :

CO<sub>2</sub> = Average of the 2 measurements

This mixed use would be considered as an equivalent of 60% of the annual mileage.

Annual average CO<sub>2</sub> emission value = 0.60 x CO<sub>2</sub> hybrid mode

2.2.3.4. CO<sub>2</sub> emissions of not O.V.C. hybrid thermal electric vehicle

The test procedure is the same as for emissions (paragraph 2.1.4)

CO<sub>2</sub> = Average of the 3 measurements

2.2.3.5. CO<sub>2</sub> emissions of thermal vehicle with electric assistance

Same as the not O.V.C. hybrid thermal electric vehicle (paragraph 2.2.3.4)

2.3. Regulation No. 85 – Measurement of the net power

Electric and thermal engine power measurements are already taken into account in this Regulation.

A combination of the electric power and the thermal power is to be considered in order to reach real functioning conditions.

Measurement of the maximum absorbed power on a chassis dynamometer could be considered, if it would be easier to perform.

2.3.1. Electric vehicle with a range extender

Measurement of the power delivered to the wheels at the highest speed over a 30 minutes period on a chassis dynamometer.

2.3.2. O.V.C. hybrid electric vehicle

2.3.2.1. First method

2.3.2.1.1. Thermal unit  
As a pure thermal vehicle.

2.3.2.1.2. Electric power unit  
As pure electric vehicle

2.3.2.1.3. Combined resultant power  
Sum of the two powers which could be linked with the wheels.

2.3.2.2. Alternative method

Measurement of the power delivered to the wheels at the highest speed over a [10] minutes period on a chassis dynamometer.

Measurement in pure electric mode of the maximum absorbed power on a chassis dynamometer.

For this test, the period could be shortened, either if an indicator on the dashboard shows that the maximum of range is near obtained, or if the decrease of the maximum speed is over [5 %].

2.3.3. Not O.V.C. hybrid thermal electric vehicle

As a pure thermal vehicle.

Electric power measurement

A measurement in pure electric mode of the maximum absorbed power on a chassis dynamometer could be made by manufacturer.

For this test, the period could be shortened, either if an indicator on the dashboard shows that the maximum of range is near obtained, or the decrease of the maximum speed is over [5 %].

2.3.4. Thermal vehicle with electric assistance

As a pure thermal vehicle.

2.4. Other UN/ECE Regulations

Regulation Nos. 10 (Electromagnetic compatibility),

51 (Noise),

68 (Measurement of maximum speed),

and 100 (Safety of battery electric vehicles)

should be taken into account and adapted to hybrid vehicles, if necessary.

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