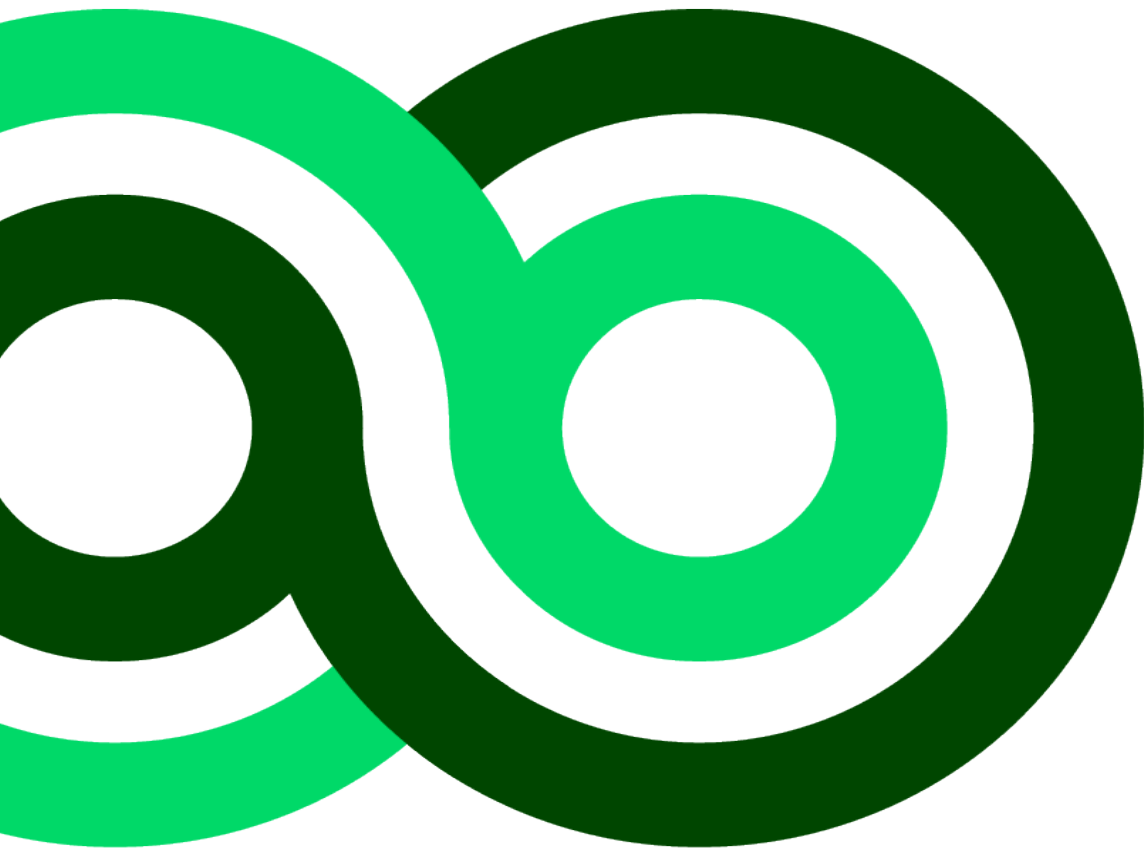


TEST PROCEDURE

Special Requirements for Hybrid Electric Vehicles





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Version 2.0.0 April 2022

Special Requirements for Hybrid Electric Vehicles

1. Preface

There are different construction designs of hybrid vehicles on the market, e.g. mild hybrid, micro hybrid, range extender and plug-in hybrid vehicles.

Here we regard only vehicles which have both an on board electrical and a combustion engine for acceleration. There are different systems of hybrid vehicles according to the positioning of the electric motor, parallel and serial types or the number of included motors. It is assumed that this has in first place no important influence on the task to be fulfilled. The definitions used are: 'hybrid electric vehicle' (HEV) is a hybrid vehicle where one of the propulsion energy converters is an electric machine and within these category: 'not off-vehicle charging hybrid electric vehicle' (NOVC-HEV) is a hybrid electric vehicle that cannot be charged from an external source; 'off-vehicle charging hybrid electric vehicle' (OVC-HEV) is a hybrid electric vehicle that can be charged from an external source.

In future it can be possible to take into account also other construction designs.

As hybrid vehicles are a combination of combustion and electrical powertrains, the focus is on the same measurement values as for ICE and PEV vehicles. That means electrical power, pure electrical range, all relevant pollutants, fuel consumption and energy efficiency and green house gas emission.

Recuperation is taken into account as the design of the vehicle includes it intrinsically.

The basis for the testing of NOVC and OVC-HEV is the latest version of the Overall test procedure (see GNT_Overall_Test_Procedure).

In this document the special provisions for hybrid electric vehicles are defined. If a requirement is made here it is obligatory for the test procedure. Conflicting requirements in other documents are not valid. The hybrid procedures for NOVC and OVC-HEV (see GNT_Overall_Test_Procedure) is to be applied when a vehicle is equipped with a high voltage battery of at least 60 V and is able to drive with a minimum velocity of 10 km/h in pure electrical mode.

2. Driving Modes

Tests are carried out in only one driving mode, usually the default mode when starting the car. If an "Auto" mode is available, it should be regarded as the default mode and be prioritised. The experiences from testing have shown that the default mode is not working on the chassis dyno in all cases or the vehicle switches automatically in a certain mode depending on SoC (Charge depleting tests shall be started with completely charged HV battery). If this is the case a suitable and reasonable mode is to be chosen by the Lab. This should be noted in the test report.

Only road traffic modes (e.g. Sport, Sport+, Eco, Eco+ etc.) will be considered.

Defined Race Modes (e.g. Race, Drift etc.) shall not be applied.

If there is no default mode or manufacturer's declaration, the mode will be chosen by the lab. The mode selection has to be recorded in the test. It is assumed that Hybrid Vehicles will always have an automatic gearbox and shift automatically.

3. Requirements for Chassis Dyno Testing

All provisions made in GNT_Overall_Test_Procedure and GNT_WLTC +_Test_Procedure are also valid for hybrid vehicles. Additionally in this chapter some special provisions are defined for hybrid vehicles.

3.2 Test cell temperature

The test cell temperature shall be $23^{\circ}\text{C} \pm 3^{\circ}\text{C}$ while performing all the tests shown in GNT_Overall_Test_Procedure.

3.3 Free Urban Trip

Before starting the dyno chassis testing in charge sustaining mode (CS-mode) it has to be ensured that the High Voltage Battery of the Hybrid Vehicle is in a SoC, corresponding to CS-mode. To reach this state a free trip on an urban route shall be performed until ICE starts, then drive for another 20 km with a moderate velocity so that the battery is not being recharged. The time and/or distance of the drive should be sufficient to achieve a quasi constant SoC.

3.4 Soaking

The soaking shall be done at $23 \pm 3^{\circ}\text{C}$ for at least 9 h; No HV battery neither 12V battery charging shall be done during this period. For NOVC-HEV, especially with small HV-batteries, it is possible that the SoC varies during soaking. This is acceptable in a small range.

3.5 SoC

The value of the SoC can be taken from the OBD; if this is not possible a service tool can be used and as a last opportunity it can be read from the dashboard. The nominal value itself need not be absolutely precise. Most important is the adjustment to the reference value.

There can be a trade off between the SoC and the coolant temperature in Hybrid vehicles on warm tests, since in some cases (vehicles) it is not possible to reach the reference SoC and a coolant temperature $> 80^{\circ}\text{C}$ at the same time. The

achievement of the reference SoC before warm tests must prevail over the coolant temperature requirement.

If this is the case in WLTC+ and PEMS+ testing, the driver should try to reach the desired coolant temperature within 10 minutes. If it is not successful within this time a lower coolant temperature is acceptable.

3.6 Road load adaptation

The vehicle shall be put in neutral gear position in order to avoid any regeneration of the electrical system.

3.7 Preconditioning

A WLTC Cycle according to GNT_WLTC+_Test_Procedure shall be performed as a preconditioning tool. Note the SoC hereafter as the reference SoC when the break-off criterion is reached. This is the case when the relative electric energy change REEC_i ,as calculated using the equation below, is less than 0.04.

$$REEC_i = \frac{|\Delta E_{REESS,i}|}{E_{cycle} \times \frac{1}{3600}}$$

3.8 Testing

It is recommended to follow the order shown for NOVC and OVC-HEV in the table in GNT_Overall_Test_Procedure. It is also possible to switch the order of some of the blocks as long as PEMS+ testing comes after Laboratory emissions testing. It is in the responsibility of the Lab.

In general the same pollutants for hybrid vehicles are measured as for ICE vehicles, with the exception of PM for OVC-HEV in charge depleting mode (CD mode), which is excluded.

The last WLTC+ cycle (confirmation cycle) of the charge depleting sequence WLTC_cold_def_CD can be considered a valid WLTC_warm_def_CS. The coolant temperature should be 80°C at test start. (Necessary condition: FTIR calibration shall be checked valid so 2 tests can be conducted).

4. Requirements for On-Road Testing

All provisions made in GNT_Overall_Test_Procedure and GNT_PEMS+_Test_Procedure are also valid for NOVC and OVC-HEV. Additionally in this chapter some special provisions are defined for NOVC and OVC-HEV.

4.1 Preconditioning

The preconditioning shall be done in accordance to PEMS+ procedure (GNT_PEMS+_Test_Procedure). The SoC shall be adjusted to same SoC as at the end of WLTC preconditioning.

4.2 Soaking

Soaking shall be performed as it is defined in the PEMS+ procedure (GNT_PEMS+_Test_Procedure). No HV battery and 12V battery charging shall be done during and after soaking.

4.3 SoC Adjustment

An adjustment of the SoC is needed before the PEMS+_eco_warm and PEMS+_heavy_warm tests in CS mode. The SoC is to be adjusted to the SoC corresponding to the fulfillment of the break-off criterion at the end of the charge depleting sequence WLTC_cold_def_CD (see chapter 3.7).

5. Summary of electrical measurements and correction requirements

The following table is a summary of the measurements and correction to be done for the different vehicle/motor types:

		Low Voltage Battery				High Voltage Battery			
		Voltage	Current	Frequency	Correction	Voltage	Current	Frequency	Correction
ICE	Laboratory	No	Yes	20 Hz	RCB	N/A	N/A	N/A	N/A
	PEMS	No	No	No	None	N/A	N/A	N/A	N/A
HEV / PHEV CS	Laboratory	No	Yes	20 Hz	REESS (kCO ₂ = 1)	No	Yes	20 Hz	REESS (kCO ₂ = 1)
	PEMS	No	Yes	10 Hz	None	No	Yes	10 Hz	None
PHEV CD	Laboratory	Yes	Yes	20 Hz	REESS*	Yes	Yes	20 Hz	REESS*
	PEMS	Yes	Yes	10 Hz	REESS*	Yes	Yes	10 Hz	REESS*

* REESS is measured but not used for correction since it will be used directly in rating results

6. Test Analysis and Rating

The output data from testing NOVC-HE-vehicles are to be treated in the same way as for ICE vehicles. For the CO₂ RCB-calculation the nominal value of the battery is used, no measuring in the high voltage system is necessary.

The output data from testing OVC-HE-vehicles (Plug-In) are generated in two different modes, charge depleting (CD) and charge sustaining (CS).

The rating document will consider a table for CS testing and a table for CD testing.

The multiple WLTC cycles in the charge depleting sequence WLTC_cold_def_CD - (for the time being) a number of 2-6 cycles is expected until the break off criterion is reached - should be implemented into one table, which is then one part of the input data set for the rating sheet. The cycle where the break-off criterion is reached is regarded as the confirmation cycle. This cycle is counted as (n+1). The calculation for the rating is done with n-cycles. The arithmetic average of the n cycles is the rated result of the charge depleting sequence WLTC_cold_def_CD.

6.1 Driving range in charge depleting mode for OHV-HEV

6.1.1 EAER (Equivalent All Electrical Range)

For the rating the EAER is used. It is a calculation according to the formula in GNT_WLTC+_Test_Procedure (Sub annex 8, chapter 4.4.4.1).

6.1.2 AER (All Electrical Range)

The all electrical range for OVC-HEV is taken from the CD testing and is calculated at the moment when the combustion engine starts for the first time. It is not used for the rating. It can differ from the value claimed by the OEM.

6.2 Driving Range in charge sustaining mode for OVC-HEV

The driving range test defined in GNT_Driving_Range_Test_Procedure for PEV is not applicable for OVC-HEV. The driving range for NOVC- and OVC-HEV (in CS mode) can be obtained as it is defined in GNT_Driving_Range_Test_Procedure for ICE vehicles.

7. Further Specifications

The utility factor reported in the regulation is not taken into account.

The energy need not be split in high voltage and low voltage, since we are applying REESS. It can be split in the test report but at the end it should be processed as a sum of both.

For the PEMS+_heavy_cold in CD (100% SoC) the warm-up should be skipped in order to start the test with actual 100% of SoC. The 15 minutes idling before a PEMS+ heavy test should be skipped as well.

For the PEMS+_eco_cold in CD (100% SoC) the warm-up should be skipped as well for the same reason, but the 15 minutes idling after 8-12 km shall be kept since for some OVC-HEV vehicles the battery could be discharged and exhaust aftertreatment cooled down.

The GNT_WLTC+_CAT_Test_Procedure test for OVC-HEV shall be done in CS mode.

* = latest version