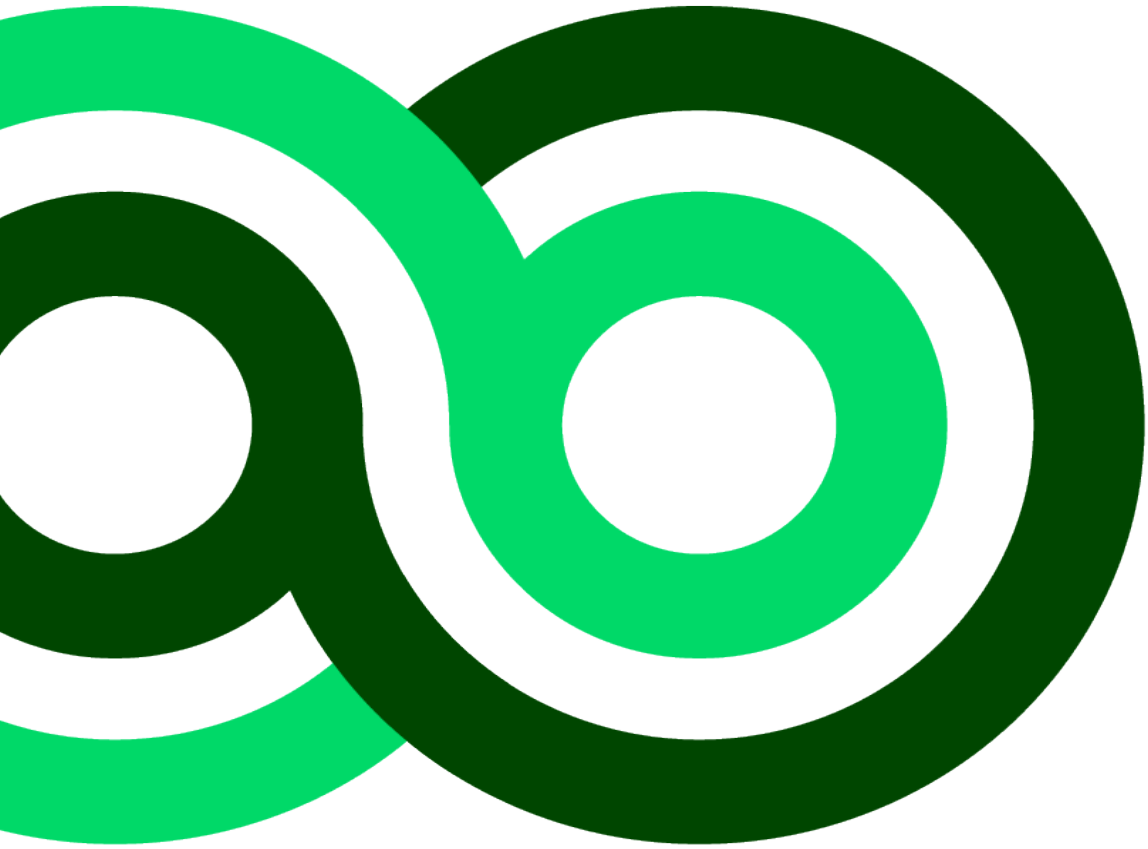
TEST PROCEDURE

Special Requirements for Hybrid Electric Vehicles (HEV)

Version 1.0.0 February 2021



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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. We assume that this has in first place no important influence on the task we have to fulfill here. The definitions used here: ‘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 power trains we focus on the same measurement values as we have 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 are the the latest version of the GNCAP Overall test procedure (see GNT_Overall_GNCAP_Test_Procedure_WG_*).

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_GNCAP_Test_Procedure_WG_*) 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 10km/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. 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_GNCAP_Test_Procedure_WG_* and GNT_WLTC+_WG_* 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 14°C ± 3 °C while performing all the tests shown in GNT_Overall_GNCAP_Test_Procedure_WG_*.

3.3 Free Urban Trip

Before starting the dyno chassis testing (CS-mode) it has to be ensured that the High Voltage Battery of the Hybrid Vehicle is in a low SoC. To reach this state a free trip on an urban route shall be performed until ICE starts, then drive for another 20km 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 14 ±3°C – for at least 9h; 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. That means it is not possible in some cases (vehicles) to reach the reference SoC and a coolant temperature > 80°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

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+_warm_* 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 REECi as calculated using the equation is less than 0.04.

$$REEC_i = \frac{|\Delta E_{REESS,i}|}{E_{cycle} \times \frac{1}{3\,600}}$$

3.8 Testing

It is recommended to follow the order shown for NOVC and OVC-HEV in the table in GNT_Overall_GNCAP_Test_Procedure_WG_*. 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 CD mode, which is excluded.

The last WLTC preconditioning cycle before WLTC_warm_CS can be taken as WLTC warm. Here the brake-off criterion should be met and the coolant temperature has reached 80°C at the beginning. (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_GNCAP_Test_Procedure_WG_* and GNT_PEMS+_WG* 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+_WG_*). 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+_WG_*). No HV battery and 12V battery charging shall be done during and after soaking.

4.3 SoC Adjustment

The adjustment of the SoC is needed before the PEMS+_eco_warm and PEMS+_heavy_warm tests. Adjust SoC to same SoC as at the end of WLTC Preconditioning during warm-up phase.

5. Summary of electrical measurements and correction

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 (kCO2 = 1)	No	Yes	20 Hz	REESS (kCO2 = 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. Full Load Curve

The full load curve shall be determined in accordance to the latest version of GNT_propulsion_unit_performance_max_engine_load_WG * document. But it could happen that it is not possible to conduct this procedure because of the internal strategy of the motor management system. In this case the best reachable curve should be established. The test is not counted for a valid Green NCAP test and is regarded for the time being as research.

Full load curve for OVC-HEV shall be done in CS mode.

7. 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 CO_2-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 CS-mode is for the determination of the clean air and greenhouse gas index and the CD-mode for the determination of the energy efficiency index.

The input from the testing into the rating documents will be in accordance to gasoline vehicles; that means a table for CS testing and a table for CD testing is provided.

The multiple WLTC cycles in the CD sequence - (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 transition or translation cycle. This cycle is counted as (n+1). The calculation for the rating is done with n-cycles. Here the average of the different elements is used for the (single) output table.

7.1 Driving range in charge depleting mode for OHV-HEV

7.1.1 EAER (Equivalent All Electrical Range)

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

7.1.2 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.

7.2 Driving Range in charge sustaining mode for OHV-HEV

The driving range test defined in GNT_Driving_Range_Test* 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* for ICE vehicles.

8. Further Specifications

The utility factor reported in the regulation is too complex for taking it into account here.

After the free urban trip of 20 km and before going to the chassis dyno for the WLTC warm-up a soaking is required. The condition to be fulfilled is coolant and oil temperature > 23 +/- 5 ºC.

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 and the 15 minutes idling should be skipped as well since it is designed to cool-down the after-treatment system and it has no sense in this case.

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

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

* = latest version