

# Proposal for GTR#21 revision

~ Expand the application of system bench ~

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## ■ System Power Measurement Techniques

Vehicle Type	Events	Measurement Techniques		
		CDY	Hub Dyno	System Bench
Vehicles whose maximum power exceeds that of readily available dynamometers	Homologation	NA (physically impossible)		✓
	COP* Authority verification*	NA (physically impossible)		✓**
Rest of vehicles	Homologation	✓	✓	NA → ✓
	COP* Authority verification*	✓	✓	NA → ✓**

\* : no description in current GTR but assuming that it's OK to apply different measurement techniques during homologation

\*\* : due to limited availability, few chance to apply system bench during COP and/or authority verification

**■ Proposal** To apply the system bench measurement technique to all type of vehicles. In the case of verification by authority (and COP), currently available measurement techniques (CDY or Hub Dyno) can be applied.

- Justifications**
- System bench is well-recognized measurement technique (i.e. GTR4)
  - System bench is already one of measurement techniques for system power
  - Contribute efficient homologation process

## ■ Test procedure

### 6.1 General

The following test procedures determine a vehicle system power rating for a hybrid electric vehicle, or for a pure electric vehicle with more than one propulsion energy converter.

Two test procedures are described herein.

Test procedure 1 (TP1) is based on measured electrical power, estimated ICE power, and estimated electrical conversion efficiency.

Test procedure 2 (TP2) is based on measured torque and speed at the drive shaft(s) or wheel hub(s) and estimated mechanical conversion efficiency.

TP1 and TP2 are intended to be technically equivalent methods for determining a vehicle system power rating from available measurements. TP1 and TP2 are distinguished by the specific instrumentation, measurements, other inputs, and calculations necessary to determine the vehicle system power rating.

Each powered axle that provides propulsion under the maximum power condition shall be tested by chassis dynamometer or hub dynamometer **[or system bench]**. Vehicles that are powered by two powered axles under the maximum power condition shall be tested by four-wheel-drive chassis dynamometer, or each powered axle shall be tested simultaneously by hub dynamometer **[or system bench]**.

~~In the case of vehicles whose maximum power exceeds that of readily available dynamometers, it is permissible to use a system bench in place of a dynamometer.~~

## ■ Definition

### 3.6. System bench

3.6.1. **"System bench"** means a simulated vehicle powertrain on a test bench, which is a combination of the propulsion energy storage system(s), propulsion energy converter(s) and the drivetrain(s) providing the mechanical energy at the wheels for the purpose of vehicle propulsion, plus peripheral devices.

3.6.2 Simulators may be used as part of the System bench.

3.6.3 **"Simulators"** means a virtual model built to mean a software reproduction of some of the powertrain elements.

3.6.4. **"Peripheral devices"** means energy consuming, converting, storing or supplying devices, where the energy is not primarily used for the purpose of vehicle propulsion, or other parts, systems and control units, which are essential to the operation of the powertrain. In addition, if the functions equivalent to the actual vehicle are satisfied, the equipment specifications may be substituted.

EVE63-07e proposed

## ■ Equipment Requirements

EVE63-06e proposed

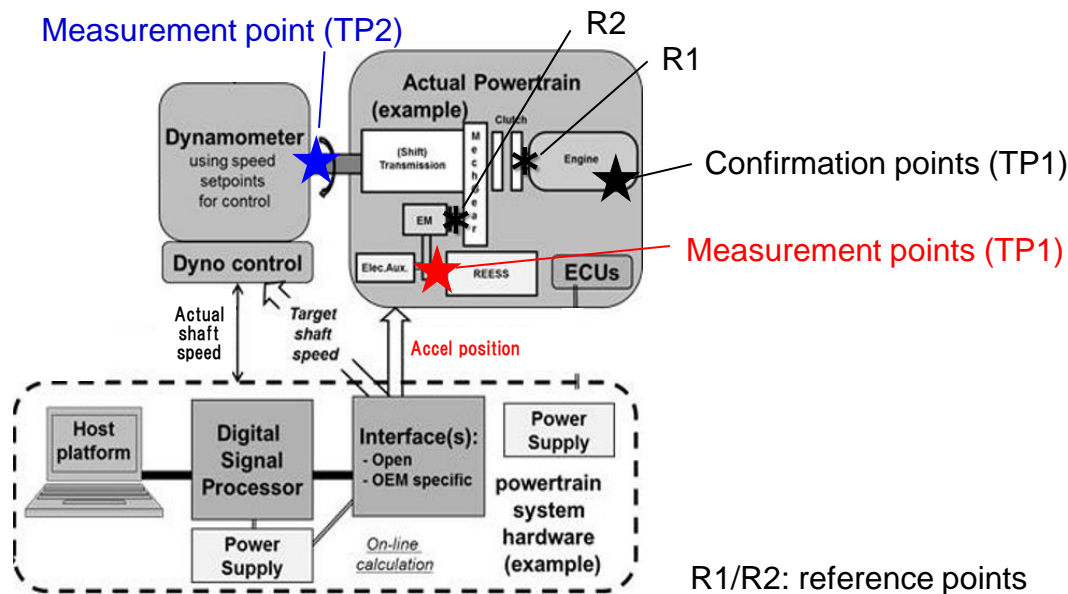
The image shows a document titled "UNECE EVE-IWG Determination of Electrified Vehicle Power" with the OICA logo. It includes "GTR 21 Test Conditions" and "GTR 21 Table 5". A central box contains "OICA comments on GTR21 EVE-IWG #63 18.-19.07.2023". The table below has columns for "Validation target", "Yes", "No", and "Remarks".

Validation target	Yes	No	Remarks
Acceleration pedal command percent	≥ 1 %		

### Under consideration (5. Test conditions)

- Cooling fan
- Dynamometer speed
- Axle/wheel rotational speed, torque

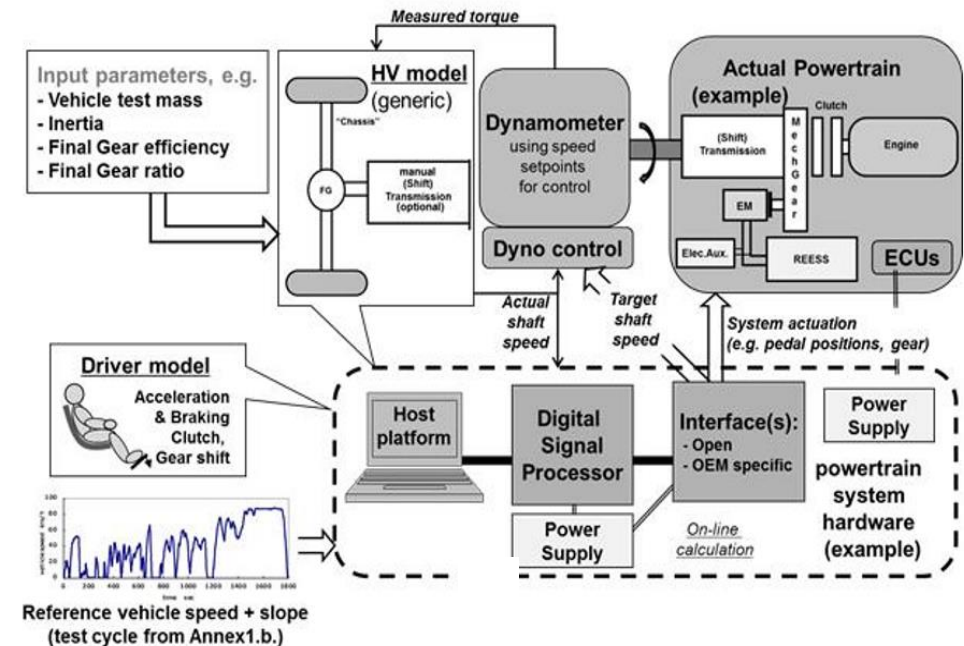
## System Configurations



[Reference]

The system bench is also used in the UN-GTR4 powertrain method.

Outline of powertrain system setup ←



### Key Points

- ✓ The system bench shall consist of the actual powertrain and ECUs of the powertrain.
- ✓ Engine/battery/motor cooling system shall be specified with sufficient cooling capacity to maintain normal operating temperatures.
- ✓ System bench shall duplicate the power loss of the auxiliary devices installed in the vehicle.  
If not the case, the power loss of the auxiliary devices shall be measured independently, then subtracted.

# Appendix

ECE/TRANS/180/Add.4/Amend.4

16 September 2021

### Global Registry

Created on 18 November 2004, pursuant to Article 6 of the Agreement concerning the establishing of global technical regulations for wheeled vehicles, equipment and parts which can be fitted and/or be used on wheeled vehicles (ECE/TRANS/132 and Corr.1) done at Geneva on 25 June 1998

### Addendum 4: United Nations Global Technical Regulation No. 4

United Nations Global Technical Regulation on Test procedure for compression ignition (C.I.) engines and positive-ignition (P.I.) engines fuelled with natural gas (NG) or liquefied petroleum gas (LPG) with regard to the emission of pollutants (WHTC)

### Amendment 4

Established in the Global Registry on 22 June 2021



UNITED NATIONS

ECE/TRANS/180/Add.4/Amend.4

## Annex 10

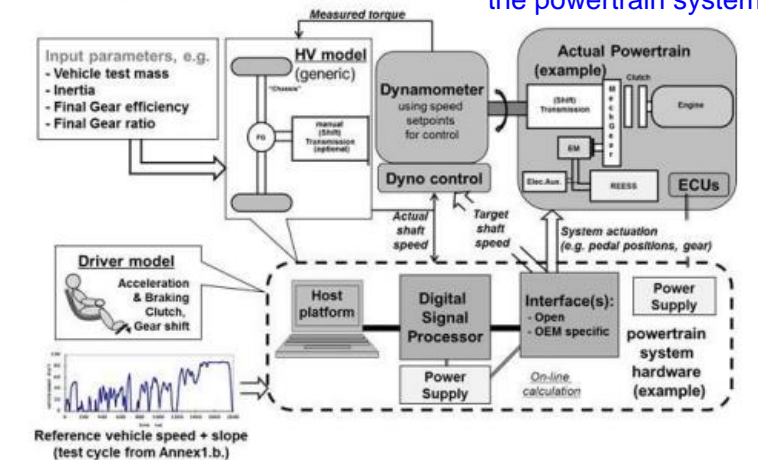
### Test procedure for engines installed in hybrid vehicles using the powertrain method

- A.10.1. This annex contains the requirements and general description for testing engines installed in hybrid vehicles using the powertrain method.
- A.10.2. Test procedure  
This annex describes the procedure for simulating a chassis test for a pre-transmission or post-transmission hybrid system in a powertrain test cell. Following steps shall be carried out:
  - A.10.2.1. Powertrain method  
The powertrain method shall follow the general guidelines for execution of the defined process steps as outlined below and shown in the flow chart of Figure 49. The details of each step are described in the relevant paragraphs. Deviations from the guidance are permitted where appropriate, but the specific requirements shall be mandatory.  
For the powertrains method, the procedure shall follow:
    - (a) Selection and confirmation of the HDH object for approval;
    - (b) Set up of powertrain system;
    - (c) Hybrid system rated power determination;
    - (d) Powertrain exhaust emission test;
    - (e) Data collection and evaluation;
    - (f) Calculation of specific emissions.

### A.10.3.1. General introduction

The powertrain system shall consist of, as shown in Figure 50, a HV model and its input parameters, the test cycle as defined in Annex 1, paragraph (b), as well as the complete physical hybrid powertrain and its ECU(s) (hereinafter referred to as the "actual powertrain") and a power supply and required interface(s). The powertrain system setup shall be defined in accordance with paragraphs A.10.3.2. through A.10.3.6. The HILS component library in accordance with paragraph A.9.7. shall be applied in this process. The system update frequency shall be at least 100 Hz to accurately control the dynamometer.

Figure 50  
Outline of powertrain system setup



Overview of the powertrain system

### A.10.3.4. Actual powertrain

The powertrain including all of its ECU(s) in accordance with the in-vehicle installation shall be used for the powertrain system setup. The provisions for setup shall be in accordance with paragraph 6. of this UN GTR and apply to the entire powertrain.

The torque measuring device shall be rigidly mounted closely to the hybrid system output shaft. For example, if a damper is needed it should be mounted on the dynamometer and its damping characteristic should not affect the torque reading.

## 6. Test conditions

The general test conditions laid down in this paragraph shall apply to testing of the internal combustion engine (WHTC, WHSC, HEC) and of the powertrain (HPC) as specified in Annex 10.

## 6.1. Laboratory test conditions

The absolute temperature ( $T_a$ ) of the engine intake air expressed in Kelvin, and the dry atmospheric pressure ( $p_s$ ), expressed in kPa shall be measured and the parameter  $f_a$  shall be determined in accordance with the following provisions. In multi-cylinder engines having distinct groups of intake manifolds, such as in a "Vee" engine configuration, the average temperature of the distinct groups shall be taken. The parameter  $f_a$  shall be reported with the test results. For better repeatability and reproducibility of the test results, it is recommended that the parameter  $f_a$  be such that:  $0.93 \leq f_a \leq 1.07$ . Contracting Parties can make the parameter  $f_a$  compulsory.

## (a) Compression-ignition engines:

Naturally aspirated and mechanically supercharged engines:

$$f_a = \left(\frac{99}{p_s}\right) \times \left(\frac{T_a}{298}\right)^{0.7} \quad (2)$$

Turbocharged engines with or without cooling of the intake air:

$$f_a = \left(\frac{99}{p_s}\right)^{0.7} \times \left(\frac{T_a}{298}\right)^{1.5} \quad (3)$$

## (b) Positive ignition engines:

$$f_a = \left(\frac{99}{p_s}\right)^{1.2} \times \left(\frac{T_a}{298}\right)^{0.6} \quad (4)$$

## 6.2. Engines with charge air-cooling

The charge air temperature shall be recorded and shall be, at the rated speed and full load, within  $\pm 5$  K of the maximum charge air temperature specified by the manufacturer. The temperature of the cooling medium shall be at least 293 K (20 °C).

## 6.3. Engine power

The basis of specific emissions measurement is engine power and cycle work as determined in accordance with paragraphs 6.3.1. to 6.3.5.

For a hybrid powertrain, the basis of specific emissions measurement is system power and cycle work as determined in accordance with paragraph A.9.2.6.2. or paragraph A.10.7., respectively.

For a hybrid powertrain, the basis of specific emissions measurement is system power and cycle work as determined in accordance with paragraph A.9.2.6.2. or paragraph A.10.7., respectively.

## 6.3.1. General engine installation

The engine shall be tested with the auxiliaries/equipment listed in Annex 7.

If auxiliaries/equipment are not installed as required, their power shall be taken into account in accordance with paragraphs 6.3.2. to 6.3.5.

## 6.3.2. Auxiliaries/equipment to be fitted for the emissions test

If it is inappropriate to install the auxiliaries/equipment required in accordance with Annex 7 on the test bench, the power absorbed by them shall be determined and subtracted from the measured engine power (reference and actual) over the whole engine speed range of the WHTC and over the test speeds of the WHSC.

## 6.3.3. Auxiliaries/equipment to be removed for the test

Where the auxiliaries/equipment not required in accordance with Annex 7 cannot be removed, the power absorbed by them may be determined and added to the measured engine power (reference and actual) over the whole engine speed range of the WHTC and over the test speeds of the WHSC. If this value is greater than 3 per cent of the maximum power at the test speed it shall be demonstrated to the type approval or certification authority.

## 6.3.4. Determination of auxiliary power

The power absorbed by the auxiliaries/equipment needs only be determined, if:

- (a) Auxiliaries/equipment required in accordance with Annex 7, are not fitted to the engine; and/or
- (b) Auxiliaries/equipment not required in accordance with Annex 7, are fitted to the engine.

The values of auxiliary power and the measurement/calculation method for determining auxiliary power shall be submitted by the engine manufacturer for the whole operating area of the test cycles, and approved by the certification or type approval authority.

## 6.4. Engine air intake system

An engine air intake system or a test laboratory system shall be used presenting an air intake restriction within  $\pm 300$  Pa of the maximum value specified by the manufacturer for a clean air cleaner at the rated speed and full load. The static

differential pressure of the restriction shall be measured at the location specified by the manufacturer.

## 6.7. Cooling system

An engine cooling system with sufficient capacity to maintain the engine at normal operating temperatures prescribed by the manufacturer shall be used.

Annex 7

**Installation of auxiliaries and equipment for emissions test**

Number	Auxiliaries	Fitted for emission test
1	Inlet system	Yes
	Inlet manifold	
	Crankcase emission control system	
	Control devices for dual induction inlet manifold system	
	Air flow meter	
	Air inlet duct work	
	Air filter	
	Inlet silencer	
2	Speed-limiting device	Yes
	Induction-heating device of inlet manifold	Yes, if possible to be set in the most favourable condition
3	Exhaust system	Yes
	Exhaust manifold	
	Connecting pipes	
	Silencer	
	Tail pipe	
	Exhaust brake	
	Pressure charging device	
4	Fuel supply pump	Yes
5	Equipment for gas engines	Yes
	Electronic control system, air flow meter, etc.	
	Pressure reducer	
	Evaporator	
	Mixer	
6	Fuel injection equipment	Yes
	Prefilter	
	Filter	
	Pump	
	High-pressure pipe	
	Injector	
	Air inlet valve	
	Electronic control system, sensors, etc.	
	Governor/control system	
	Automatic full-load stop for the control rack depending on atmospheric conditions	

Inlet system :  
Basically applies to actual vehicle specifications, but can be used for test cell equipment.

Exhaust system :  
Apply the actual vehicle specifications.

Fuel supply pump/Equipment for gas engines /Fuel injection equipment :  
Apply the actual vehicle specifications

7	Liquid-cooling equipment	No
	Radiator	
	Fan	
	Fan cowl	

Liquid-cooling equipment :  
Apply the actual vehicle specifications to water pump and thermostat  
For the rest, equipment specifications are applied

Number	Auxiliaries	Fitted for emission test
	Water pump	Yes
	Thermostat	Yes, may be fixed fully open

8	Air cooling	No
	Cowl	
	Fan or Blower	
	Temperature-regulating device	

Air cooling :  
Apply equipment specifications

9	Electrical equipment	No
	Alternator	
	Coil or coils	
	Wiring	
	Electronic control system	

Electrical equipment :  
Apply equipment specification to Alternator  
For the rest, the actual vehicle specifications are applied

10	Intake air charging equipment	Yes
	Compressor driven either directly by the engine and/or by the exhaust gases	
	Charge air cooler	
	Coolant pump or fan (engine-driven)	
	Coolant flow control device	

Intake air charging equipment :  
Apply equipment specifications to Coolant pump or fan  
For the rest, the actual vehicle specifications are applied

11	Anti-pollution device (exhaust after-treatment system)	Yes
12	Starting equipment	Yes, or test cell system
13	Lubricating oil pump	Yes

Clearly defined auxiliaries and equipment for emissions test