

- Road Vehicles –  
- Steady State Test Mode -  
- Powertrain Performance Comparison Test Code –  
- Performance Assessment  
of Aftermarket Performance Modification -

## Status of Document

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## 0. Definitions

- 0.1. *'Net powertrain performance' means the power and torque obtained on the test bed at the end of the driveshaft at the corresponding engine speed. The efficiency of the transmission, gearbox etc. shall not be taken into account.*
- 0.2. *'Powertrain dynamometer' means the test-bed used to obtain the measurements. The dynamometer measures the speed and torque available at the drive shafts, i.e. the speed and torque available to the wheel.*
- 0.3. *'STD' or 'Standard vehicle' means a commercially available series produced vehicle in its original form without any modifications as it was produced by the vehicle manufacturer.*
- 0.4. *'APM' or 'Aftermarket Performance Modifications [APM]' means changes or alterations of the standard vehicle in terms of performance.*

## 1. Scope

1.1. *This standard has been issued by Rototest Research Institute to specify:*

1.1.1. A procedure for performance assessment of Aftermarket Performance Modifications [APM]. The procedure is made up by:

1.1.1.1. **Steady state comparison**

Assessment of two comparable steady state tests. Testing of powertrain performance at constant speeds for two different test vehicle set-ups, standard and with Aftermarket Performance Modifications [APM]. Reported as Graph and maximum points for the standard vehicle and Graph and maximum points for the [APM] vehicle

1.1.2. Reference vehicle set-up and test conditions.

1.1.3. A method for correcting observed powertrain performance to reference conditions.

1.1.4. A method for determining net powertrain performance with a powertrain dynamometer.

## 2. Field of Application

2.1. *This test code document is applicable to vehicles with four-stroke spark ignition (SI), compression ignition (CI) engines and rotary piston engines, naturally aspirated and pressure charged either using a mechanical supercharger or turbocharger, with and without charge air cooling. This document:*

2.1.1. Applies to motor vehicles intended for use on the road, with or without bodywork, having at least four wheels and a maximum curb weight of 3 500 kg.

2.1.2. Applies for one wheel drive, two wheel drive and four wheel drive vehicles with automatic and manual transmissions.

### 3. Test cell requirements and Vehicle set-up

#### 3.1. Test cell cooling system

- 3.1.1. The airflow speed towards the vehicle must be 60 km/h or higher at an area of minimum 0.5 m<sup>2</sup>.
- 3.1.2. Spot cooling (with additional fans) for engine air inlet and intercooler(s) are allowed.
- 3.1.3. Ambient temperature and cooling airflow must have the same temperature within +/- 5 °C

#### 3.2. Test cell air supply system

- 3.2.1. Enough air flow towards the vehicle must be provided to maintain the temperature conditions of 25° +/- 10°C at the vehicle engine air inlet system.
- 3.2.2. The air provided to the engine must be clean. That is it must be free of engine exhaust gases, fuel vapor and other significant contaminants (paint fumes, dust, etc.).
- 3.2.3. The air must be "dry", that is no water is allowed to be added (no spraying or leaking water nearby).

#### 3.3. Test cell exhaust extraction system

- 3.3.1. The exhaust extraction system must not influence the vehicle's exhaust flow.
- 3.3.2. The exhaust gas must be vented to barometric pressure.

#### 3.4. Test cell instrumentation accuracy

- 3.4.1. The torque measurement tolerance must be  $\leq \pm 1.2\%$  of measured value and the speed with  $\leq \pm 0.2\%$  of measured value.
- 3.4.2. The measurement device must have calibration features for torque and speed.
- 3.4.3. Temperature measurements should have a tolerance equal of better than  $\pm 2^\circ\text{C}$ .
- 3.4.4. Barometric pressure should be measured with a tolerance of at least  $\pm 0.1$  kPa.
- 3.4.5. Engine air inlet and exhaust pressures must have a tolerance of at least  $\pm 1$  kPa.
- 3.4.6. Other pressure shall have a tolerance of at least  $\pm 10$  kPa.

#### 3.5. Powertrain Performance measurements

- 3.5.1. The powertrain dynamometer must be direct-coupled/flange mounted to the drive shafts so as to not include any slippage. The torque and speed measured must be measured in terms of direct measurements. Indirect measurements are not allowed. Examples of this kind of dynamometers are the hub dynamometer system so called "ROTOTEST VPA-R" chassis dynamometer, or a wheel dynamometer so called "Kistler RoaDyn", or measurement devices installed on the drive shafts.
- 3.5.2. All measurements must be performed with a measurement speed of  $\geq 20$  Hz, excluding temperatures which must be measured with  $\geq 2$  Hz.
- 3.5.3. All measured data must be related to engine speed.
- 3.5.4. Power must be reported in the SI unit [kW] and for torque [Nm]. Other units may be reported as complement to these two.

### 3.6. *Temperature and pressure*

- 3.6.1. Pressure and temperature of the engine air inlet supply, used for the purpose of corrections, shall be measured in a manner to obtain the actual conditions at the vehicle engine air inlet system.
- 3.6.2. The temperature of the inlet air to the engine (ambient air) shall be measured within 0.15 m downstream of the air inlet ductwork.
- 3.6.3. The inlet air pressure is the barometric pressure.
- 3.6.4. Inlet manifold pressure shall be measured as static pressure in a section common to several cylinders and always downstream any throttle valve. If inlet manifold temperature is also measured it shall be measured in such a manner that the temperature correlate with the measured pressure.
- 3.6.5. Coolant temperatures in liquid-cooled engines shall be measured at the inlet and outlet of the engine, in air-cooled engines at points specified by the manufacturer.
- 3.6.6. Engine coolant temperature is allowed to be measured by the On Board Diagnostic system OBD.
- 3.6.7. Engine oil pressure and temperature are allowed to be measured by the On Board Diagnostic system OBD. Oil temperature is allowed to be measured at the oil-dipstick.
- 3.6.8. Fuel inlet temperature for diesel fuel injection shall be measured in engine fuel feedline before any high pressure pump.

### 3.7. *Vehicle fuel supply system*

- 3.7.1. From the vehicle's normal fuel supply or from a separate fuel supply.
- 3.7.2. Fuel temperature for CI engines is recommended to be temperature controlled.

### 3.8. *Vehicle charge air cooler*

- 3.8.1. Enough air flow at the vehicle must be provided to simulate a vehicle ambient temperature of 25° +/- 10°C at the engine air cooler system.
- 3.8.2. The engine inlet air temperature downstream the air cooler must always be reported.

### 3.9. *Engine equipment*

- 3.9.1. All engine systems in the vehicle must be running, such as servo pump, generator/alternator, fuel pumps.
- 3.9.2. All electric power consuming equipment (not necessary for running the engine) is allowed to be switched off, such as electrical heaters, air condition, lights, radio etc.

### 3.10. *Vehicle Run-in*

- 3.10.1. The powertrain is recommended to be run-in according to the manufacturer's recommendation.

## 4. Presentation of Results

4.1. This section contains a list of test data to be recorded and procedures for presenting the results.

### 4.2. Reporting Requirements

4.2.1. All reported results shall carry the notation: "Powertrain Performance obtained and corrected in accordance with RRI-200808". Any deviation from this document, its procedures, or limits shall be noted. All reported or advertised test data bearing the notation RRI-200808 shall include a minimum of the following information at each test point:

4.2.1.1. Engine speed

4.2.1.2. Corrected net Powertrain Performance

4.2.1.3. Total reduction for used gear

### 4.2.2. Powertrain Performance graphs

4.2.2.1. Steady state power graphs must have each measuring point showed at the graph line. Both graphs must be present, the standard reference graph and the Aftermarket Performance Modification [APM] graph.

### 4.3. Recorded Vehicle Conditions

4.3.1. Each test conducted according to the test procedure defined in this document must be accompanied with a record of the following test conditions:

#### 4.3.1.1. INLET AIR SUPPLY CONDITIONS

4.3.1.1.1. Air supply pressure

4.3.1.1.2. Air supply vapor pressure

4.3.1.1.3. Air supply temperature and location for measurement probe.

4.3.1.1.4. If present boost pressure and location for measurement probe.

4.3.1.1.5. If present temperature downstream charge air-cooler (inter-cooler)

#### 4.3.1.2. POWERTRAIN CONDITIONS

4.3.1.2.1. Used gear and powertrain total reduction

4.3.1.2.2. FWD, RWD, 4WD, manual or automatic transmission with/without converter

4.3.1.2.3. If measured; gearbox oil temperature

4.3.1.2.4. If measured; rear axle (differential) oil temperature

#### 4.3.1.3. SPARK IGNITION ENGINE FUEL-LIQUID

4.3.1.3.1. Fuel type and/or blend

4.3.1.3.2. Research and motor octane numbers

4.3.1.3.3. Lower heating value

#### 4.3.1.4. SPARK IGNITION ENGINE FUEL-GASEOUS

- 4.3.1.4.1. Fuel type or grade
- 4.3.1.4.2. Composition
- 4.3.1.4.3. Density at 15 °C and 101 kPa
- 4.3.1.4.4. Lower heating value

#### 4.3.1.5. DIESEL FUELS

- 4.3.1.5.1. ASTM or other fuel grade
- 4.3.1.5.2. Density at 15 °C
- 4.3.1.5.3. Viscosity at 40 °C
- 4.3.1.5.4. Lower heating value (optional)

#### 4.3.1.6. LUBRICATING OILS : ENGINE

- 4.3.1.6.1. API engine service classification
- 4.3.1.6.2. SAE-viscosity grade
- 4.3.1.6.3. Manufacturer and brand name

#### 4.3.1.7. LUBRICATING OILS : TRANSMISSION

- 4.3.1.7.1. Gearbox oil, Manufacturer and brand name
- 4.3.1.7.2. Rear axle oil, Manufacturer and brand name

### 4.4. Recorded Test Data

4.4.1. For each test point measured according to the test procedure defined in this document the following minimum information must be recorded:

- 4.4.1.1. Torque (measured at the end of the drive shaft)
- 4.4.1.2. Engine speed
- 4.4.1.3. Fuel supply pressure and temperature
- 4.4.1.4. Oil temperature
- 4.4.1.5. Coolant temperature
- 4.4.1.6. If recorded, oil pressure
- 4.4.1.7. If recorded, ignition and/or injection timing
- 4.4.1.8. If recorded, inlet manifold air temperature and
- 4.4.1.9. If recorded, total pressure drop across the inlet air system
- 4.4.1.10. If recorded, total pressure drop across the exhaust system

### 4.5. Recorded Vehicle Data

4.5.1.1. The following information must accompany all test records:

- 4.5.1.1.1. Engine manufacturer
- 4.5.1.1.2. Displacement
- 4.5.1.1.3. Bore and stroke
- 4.5.1.1.4. Number and configuration of cylinders
- 4.5.1.1.5. Carburetion or injection system type
- 4.5.1.1.6. Pressure-charging system type, if applicable.



4.5.1.2. The following background vehicle data must accompany all test records:

- 4.5.1.2.1. Make and vehicle model
- 4.5.1.2.2. Manufacturing year
- 4.5.1.2.3. Type of engine
- 4.5.1.2.4. Type of transmission, manual, automatic etc. Front Wheel Drive , RWD, 4WD

4.5.1.3. Additional Recorded Information. Record of any other pertinent test data as determined by the manufacturer. This may include, but is not limited to: test date, engine serial number, test number, test location, etc

#### 4.6. Recorded Vehicle Modifications

4.6.1.1. Any system listed below that has been modified from standard vehicle must be described and accompany test records.

- 4.6.1.1.1. Inlet Air System
- 4.6.1.1.2. Pressure Charging System
- 4.6.1.1.3. Change Air Cooling System
- 4.6.1.1.4. Electrical System
- 4.6.1.1.5. Ignition System
- 4.6.1.1.6. Ignition and Timing Control
- 4.6.1.1.7. Emissions Control System
- 4.6.1.1.8. RFI/EMI Controls (radio frequency or electromagnetic interference)
- 4.6.1.1.9. Fuel Supply System
- 4.6.1.1.10. Fuel Supply Pump
- 4.6.1.1.11. Engine Cooling System (liquid)
- 4.6.1.1.12. Lubrication System
- 4.6.1.1.13. Exhaust System
- 4.6.1.1.14. Auxiliary Drives such as Power Steering Pump, AC Compressor, Vacuum Pumps, Air Compressors, etc.
- 4.6.1.1.15. Brakes

## 5. Test procedure

### 5.1. Test Operating Conditions

- 5.1.1. The engine and drive-line must be started and warmed up in accordance to manufacturer's specifications. Engine coolant temperature at normal conditions and engine oil-temperature at  $\geq +80$  °C.
- 5.1.2. Engine speed shall not deviate from the nominal speed at steady state measurements by more than  $\pm 75$  min<sup>-1</sup>.
- 5.1.3. Fuel inlet temperature for diesel fuel injection systems without internal correction it is recommended to be controlled to  $40$  °C  $\pm 4$  °C for unit injector systems, and  $40$  °C  $\pm 4$  °C for dump/line/nozzle systems. Test fuel temperature control is not required on SI engines.
- 5.1.4. All accessories switched off.
- 5.1.5. Brakes must be controlled and disengaged so that no energy consuming slip is present.

## 5.2. Test Points at Steady State

- 5.2.1. Measurements shall be taken at sufficient number of engine speeds to define correctly the power curve completely between the lowest and the highest engine speeds recommended by the manufacturer. The speed interval shall be no greater than 500 min<sup>-1</sup>. One of the operating speeds shall be the rated peak power speed, one shall be the rated peak torque speed. The operating speeds shall also include two additional speeds spaced +/- 200 min<sup>-1</sup> from the rated peak power and peak torque speeds.

## 5.3. Test sequence - Powertrain performance at steady state

### 5.3.1. 0) Calibration

Calibration of test equipment or at manufacturers of test equipment standard procedures.

### 5.3.2. 1) Pre conditioning

Conditioning speed 80 km/h at 10 kW power output during 10 minutes.

Tolerances: +/- 4 km/h, +/- 0.8 kW

The following average temperatures from the last 30 seconds shall be reported:

- 5.3.2.1. Engine cooling fluid temperature
- 5.3.2.2. Engine oil temperature
- 5.3.2.3. Engine inlet temperature

### 5.3.3. 2) Test point conditioning

Conditioning speed 80 km/h at 10 kW power output during maximum 3 minutes.

Tolerance: +/- 4 km/h, +/- 0.8 kW

Min time until coolant fluid-, inlet- and oil-temperature is within +/- 5 °C from 'Pre Conditioning'.

### 5.3.4. 3) Load increase

Transport from test point conditioning to measurement speed shall include change to full load within 5 sec and start of measurement within 8 sec.

### 5.3.5. 4) Measurement

Test time for each test point is 30 + 10 sec. Engine speed during a reading shall not deviate from the selected speed by more than +/- 75 min<sup>-1</sup>. Average performance for the last 10 seconds shall be reported.

### 5.3.6. 5) Load decrease

Transport from test point speed to test point conditioning.

Max time is 15 sec.

### 5.3.7. 6) Repeated from 2) until all test points are measured.

### 5.3.8. 7) Control of test equipment calibration.

## 5.4. Failures to comply with stated rules during a test run.

*The test is allowed to be restarted at any point with a new Pre Condition run. Test point after a restart is allowed to be combined with test points before the restart and with a maximum deviation of atmospheric pressure of +/- 5 hPa. Total test procedure must be completed within 8 hours.*

## 6. Comparison requirements

- 6.1. *This section defines the requirements to be met in order to produce a comparison between standard vehicle and APM vehicle according to this document.*
- 6.1.1. General requirements  
The test conducted on the standard vehicle represents the reference test. The test conducted on the APM vehicle must be conducted under equal test conditions. Test conditions are allowed to differ +/- 10 hPa and +/- 5°C from reference test conditions.
- 6.1.2. Vehicle identity  
The vehicle's identity (chassis number) must be equal for the reference test and the APM vehicle test.
- 6.1.3. Test sequence  
Must be equal (as in 5) and all test points are run in the same gear as in the reference test or in a manner that the closest represents the gear used in the reference test.
- 6.1.4. Transmission modification  
If present the modification must be documented as a part of the total modification.
- 6.1.5. Test vehicle mileage  
Max 200 km from the end of reference test according to 5.
- 6.1.6. Test cell cooling  
Must be the same as in the reference test.
- 6.1.7. Test session limit  
Elapsed time from the start of the reference test to the end of the APM vehicle test must not exceed 7 days (168 hours).
- 6.1.8. Documentation  
All hardware modifications must be documented as status before and after modification.

## 7. Powertrain Performance correction

- 7.1. *Measurements shall be corrected according to ISO 1585, if not stated otherwise. Only the part in ISO 1585 defining the correction method is applicable to this document.*
- 7.2. *Correction references conditions*
- 7.2.1. Engine air inlet temperature of 25°C
- 7.2.2. Engine air inlet pressure of 990 hPa (dry barometric pressure).
- 7.3. *Limits*
- 7.3.1. Vehicles with internal correction methods shall not be corrected.
- 7.3.2. No corrections are allowed for engine air inlet temperatures < +15°C and > +35°C.

## **8. Document references**

8.1. *ISO 1585 – Road vehicles – Engine test code – net power*

8.2. *Surface Vehicle standard*

*Engine power test code – spark ignition an compression ignition – net power rating*

*SAE J1349*