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JRC Contribution to EVE IWG:
Hybrid System Power Determination

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Working Group on Electric Vehicles
and the Environment (EVE)

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Activity Summary

Hybrid System Power Determination Validation Program at JRC

- Phase 1 – VeLA 8 dyno tests only
  - Two OICA vehicles have been tested
  - N1 was tested on 11th-13th June 2018 in VeLA 8 JRC Lab
  - N2 was tested on 2nd-6th July 2018 in VeLA 8 JRC Lab
  - Updates/suggestions for the GTR drafting from the outcomes of the validation test program

- Phase 2
  - N2 vehicle by JRC
    - VeLA8 dyno tests carried out on 4th-8th November 2019
    - Hub dyno tests foreseen in January 2020
    - Wheel torque transducer foreseen in January 2020
  - N3 vehicle by another OEM that would like to participate; probably hub dyno tests on February

JRC VeLA 8 – in Ispra (VA), Italy

- Electric and hybrid vehicles testing facility
- Energy efficiency and exhaust emissions measurements
- From Light- to Medium-Duty Vehicles
- Climatic chamber (-30/+50 ºC)
- Chassis Dynamometer
  - Roller surface: metal sprayed
  - Full power 4WD 300 kW
  - Max. tractive force 7,000N up to 108km/h
  - Roller type single
  - 4WD
- Cooling Fan
  - Type: Vertical inlet
  - Outlet area: 0.4 (800mm x 500mm) m²
  - Axial windspeed fan with 90° bow and air inlet from the top
  - Bulk flow: 60000 m³/h
  - Distance from front of vehicle: moveable

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Vehicle N1

- Pre-testing exercise with “Golden engineering”
- Vehicle N1 is a petrol plug-in hybrid 4WD parallel TTR vehicle
- Rated engine power:235 kW @95rps
- Electric motor: 65 kW
- 8-speed gear automatic transmission
- 10.4 kWh Li-ion polymer battery

Vehicle N2

- Vehicle N2 is a petrol parallel 2WD hybrid vehicle
- Rated engine power:77kW@5700 rpm
- Electric motor: 32 kW
- DCT double-clutch gearbox 6-speed automatic transmission
- 1.56kWh Li-ion polymer battery

Vehicle N2 – JRC

- Vehicle N2 is a petrol parallel 2WD hybrid vehicle
- Rated engine power:77kW@5700 rpm
- Electric motor: 32 kW
- DCT double-clutch gearbox 6-speed automatic transmission
- 1.56kWh Li-ion polymer battery

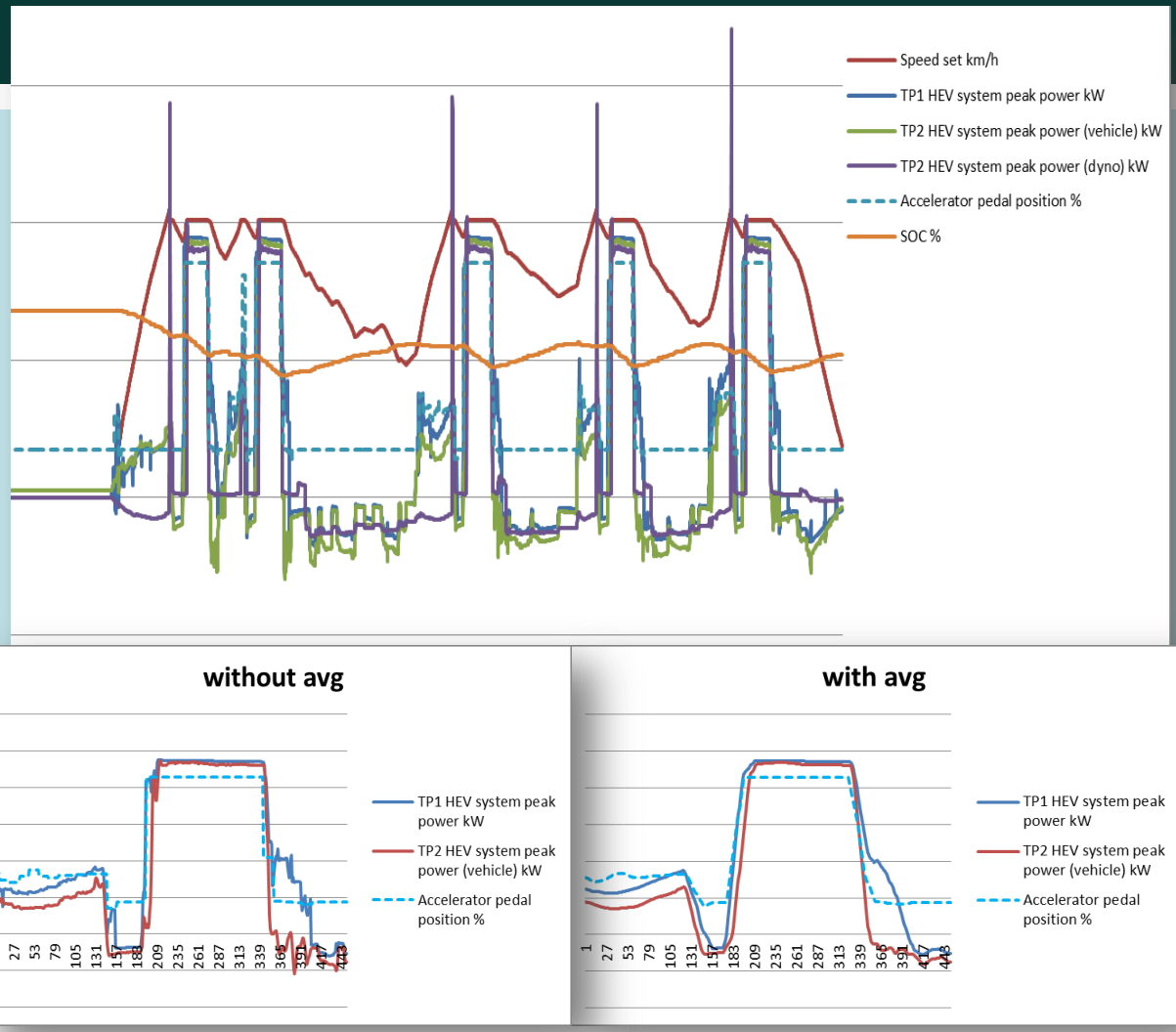
Data acquisition systems

	N1	N2	N2 JRC	Acquisition Frequency
Power Analyser • HV REESS current • HV REESS voltage • 12V current and voltage • Three current phases inverter	☑ ☑ ☑ - -	☑ ☑ ☑ ☑ -	☑ ☑ ☑ - ☑	20Hz as prescribed
CANbus data Vehicle speed, engine speed, HV REESS current, HV REESS voltage, HV REESS SOC, Accel. pedal %, breaking pedal (optional), intake manifold pressure, engine water temperature, engine oil temperature, ATF (automatic transmission fluid) temperatures, intake air temperature HV REESS temperature	☑ ☑	☑ ☑	☑ -	10Hz
DC/DC converter current and voltage by CANbus	☑	☑	☑	10Hz
Auxiliaries load	-	-	-	
Fuel flow rate	-	☑ 2Hz	☑ 4Hz	2-4Hz depending on the system
Dynamometer data inertia (simulated), dynamometer torque, dynamometer speed, calculated power, and calculated energy dyno, via the dyno controller	☑	☑	☑	10Hz
Torque meters or drive shaft sensors	-	-	Planned	
Hub Dyno tests	-	-	Planned	

Validation testing observations: refining the dyno tests

Improving the dyno tests

- Power tests have to be carried out in dyno constant speed control mode
- Setting a maximum speed corresponding to the target power test speed will automatically change the dyno from road load control mode to constant speed control mode when the target speed is reached
- This causes a unrealistic peak of dyno forces due to the load cell reaction
- To avoid this we explore a new procedure as depicted in the plot: reaching the target speed (without full throttle), letting the dyno adjusts itself and then soon after performing the power tests at full throttle. The dyno will remain in constant speed control mode.
- Back to dyno road load control mode for the recharge of the battery



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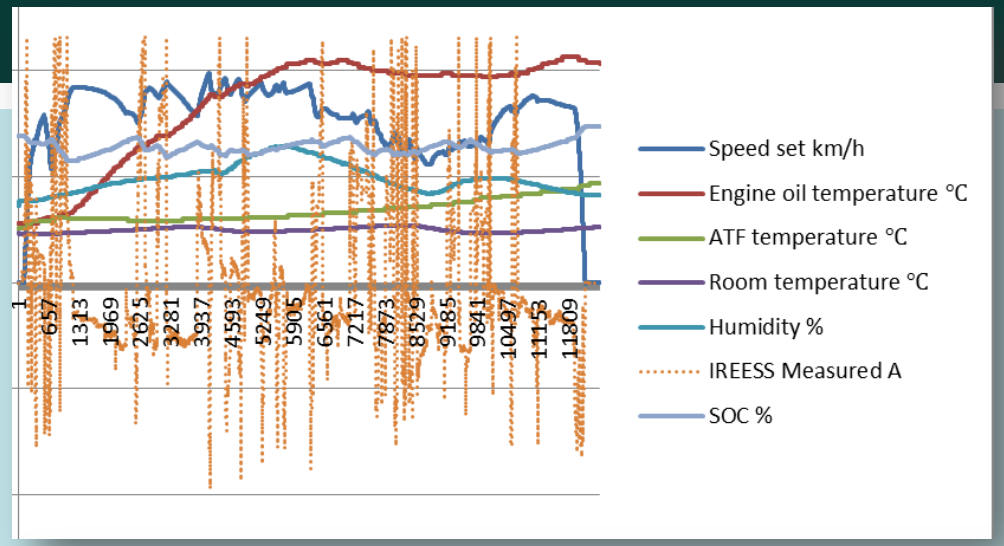
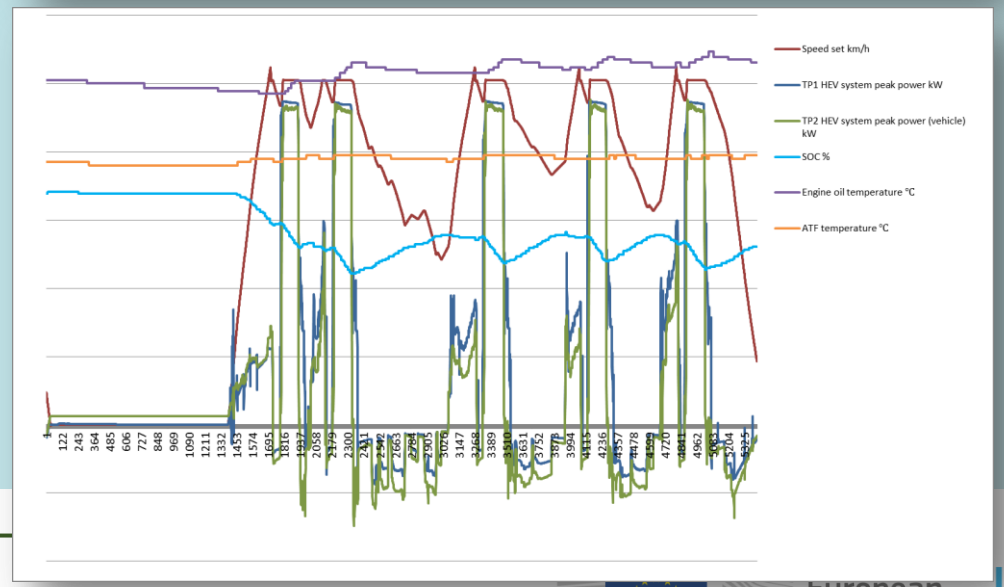
Validation testing observations: conditioning

- Conditioning prescribes 20 minutes at 60km/h.
- To assure the warming up of the engine, ATF system and HV REESS, the driving speed was increased during the tests and made more dynamic.
- Stabilisation of the temperature was observed during the power tests.
- The refined dyno procedure helped to keep the temperatures constant (ATF in particular)





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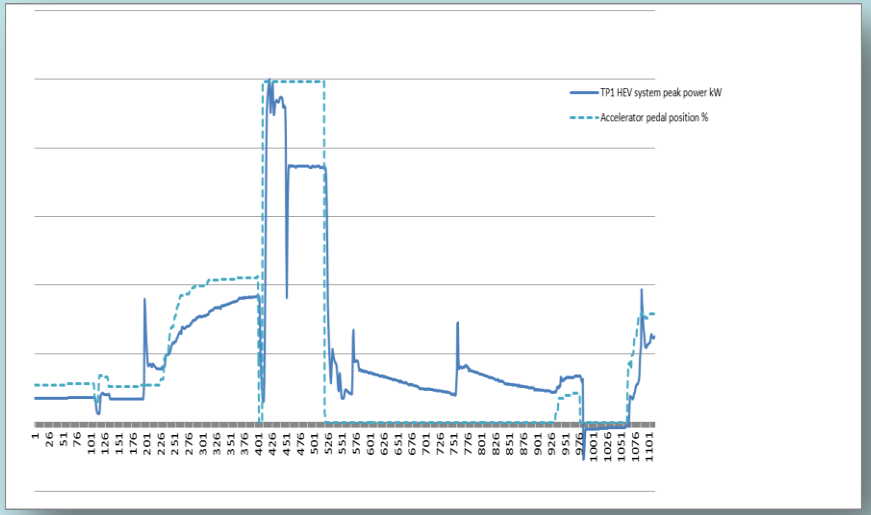
Validation testing observations: gear shifting sustained power

- Possibility to refer to the last 2 second average before the gear shifting for sustained power calculation



Validation testing observations: R85 power tolerance

For a **type-approval test** a general **2%** tolerance is allowed between measured and declared maximum power:

5.4. Interpretation of results

The net power and the maximum 30 minutes power for electric drive trains indicated by the manufacturer for the type of drive train shall be accepted if it does not differ by more than ± 2 per cent for maximum power and more than ± 4 per cent at the other measurement points on the curve with a tolerance of ± 2 per cent for engine or motor speed, or within the engine or motor speed range (X1 min –1 + 2 per cent) to (X2 min –1 – 2 per cent) (X1 < X2) from the values measured by the technical service on the drive train submitted for testing.

For **Conformity of Production** related tests a **5%** tolerance is acceptable:

R 85 - ANNEX 7 – Checks on conformity of production - 4. Measurement criteria

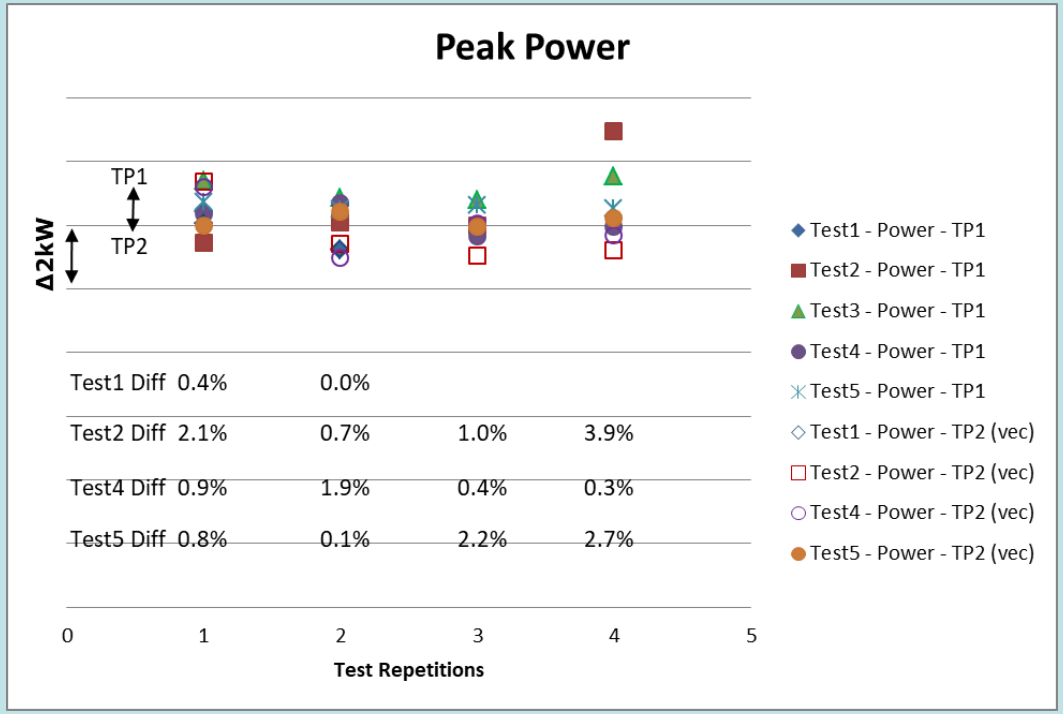
4.1. Net power of internal combustion engine

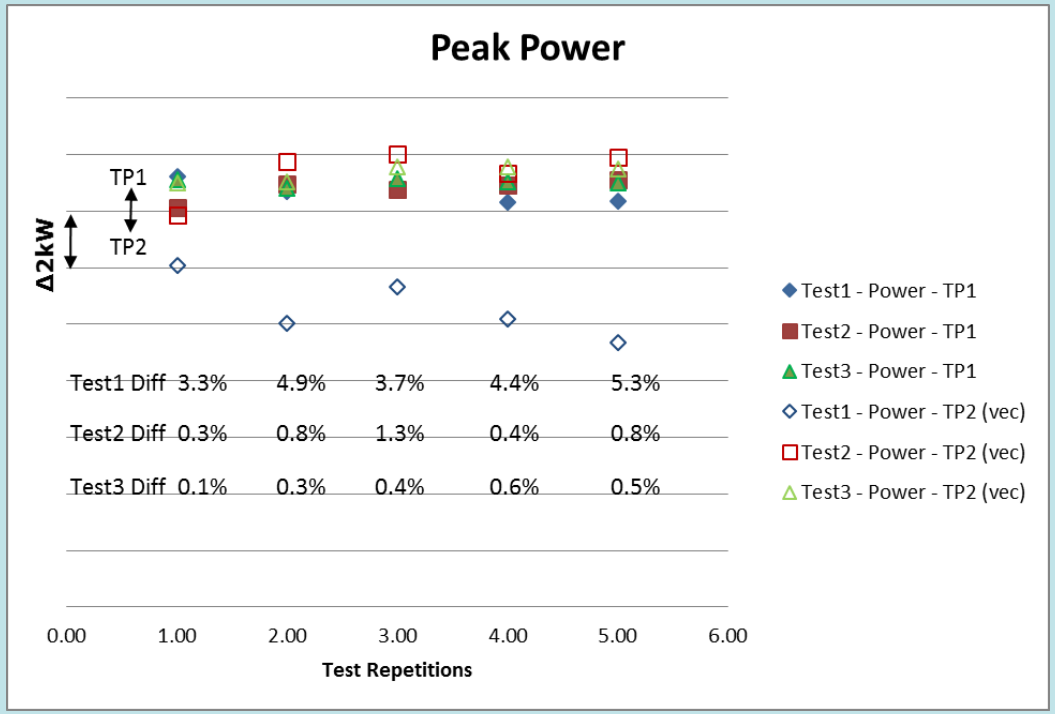
During the tests to verify conformity of production, the power shall be measured at two engine speeds S1 and S2, corresponding respectively to the measurement points of maximum power and maximum torque accepted for type approval. At these two engine speeds, which are subject to a tolerance of ± 5 per cent, the net power measured at least one point within the ranges S1 ± 5 per cent and S2 ± 5 per cent shall not differ by more than ± 5 per cent from the approval figure.

4.2. Net power and maximum 30 minutes power of electric drive trains

During the tests to verify conformity of production the power shall be measured at motor speed S1 corresponding to the measurement point of maximum power accepted for type approval. At this speed, the net power shall not differ by more than ± 5 per cent from the approval figure.

Vehicles N2 and N2 JRC results





TP1-TP2 percentage difference in peak power with tire losses correction
Values corrected to sea level.

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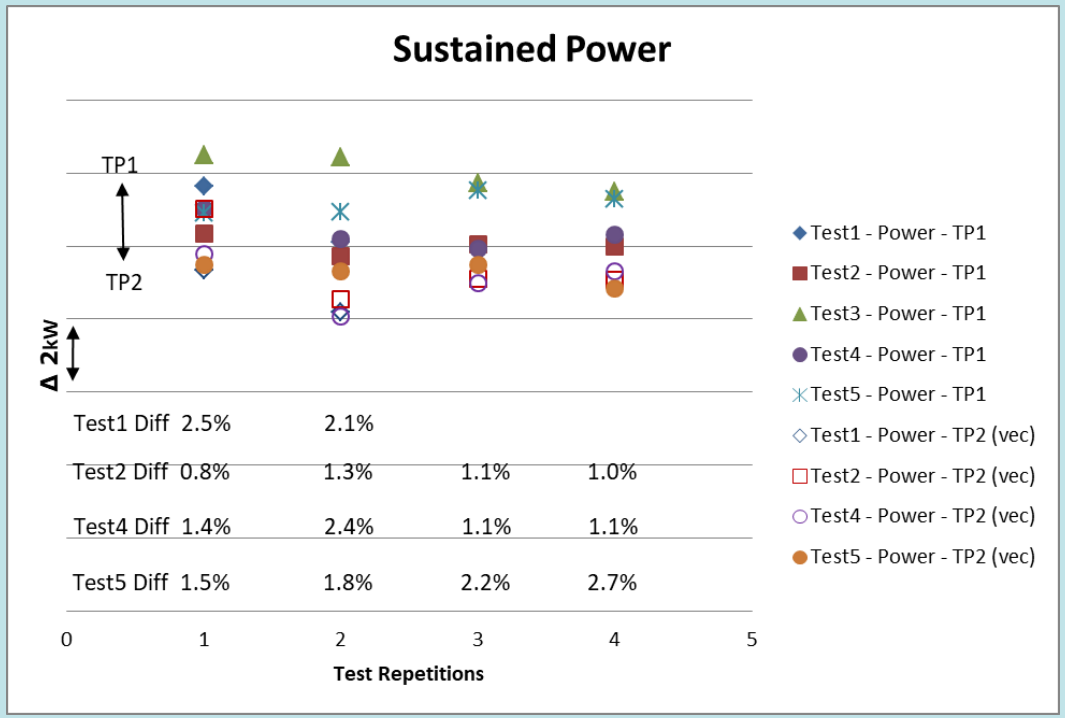
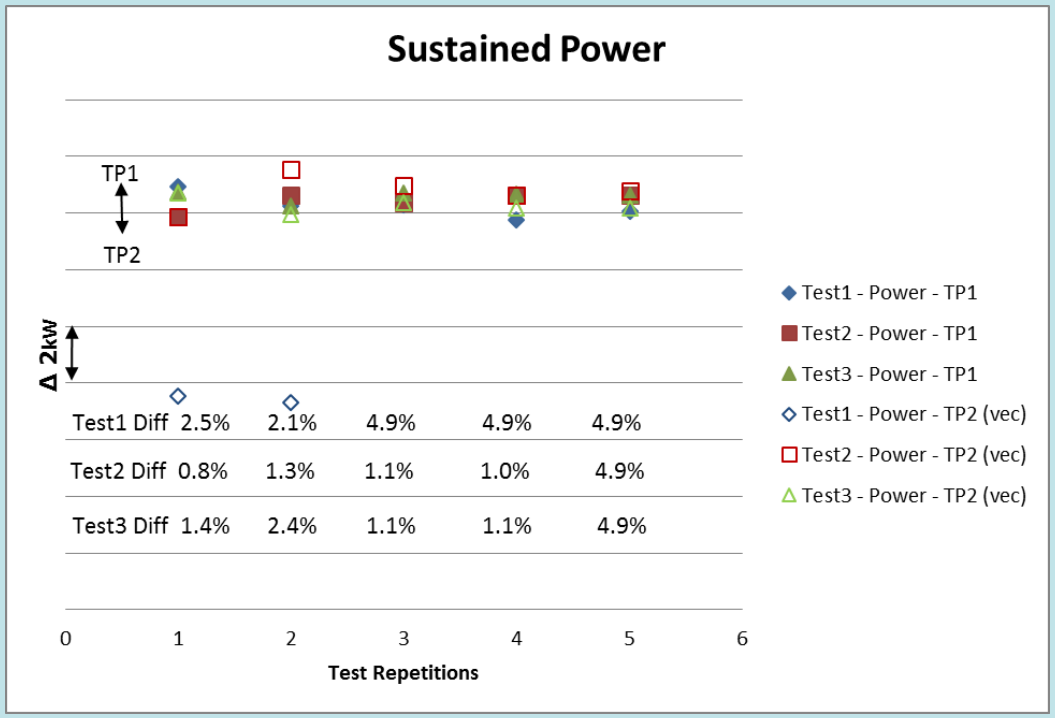
Vehicles N2 and N2 JRC results





TP1-TP2 percentage difference in sustained power with tire losses correction
Values corrected to sea level

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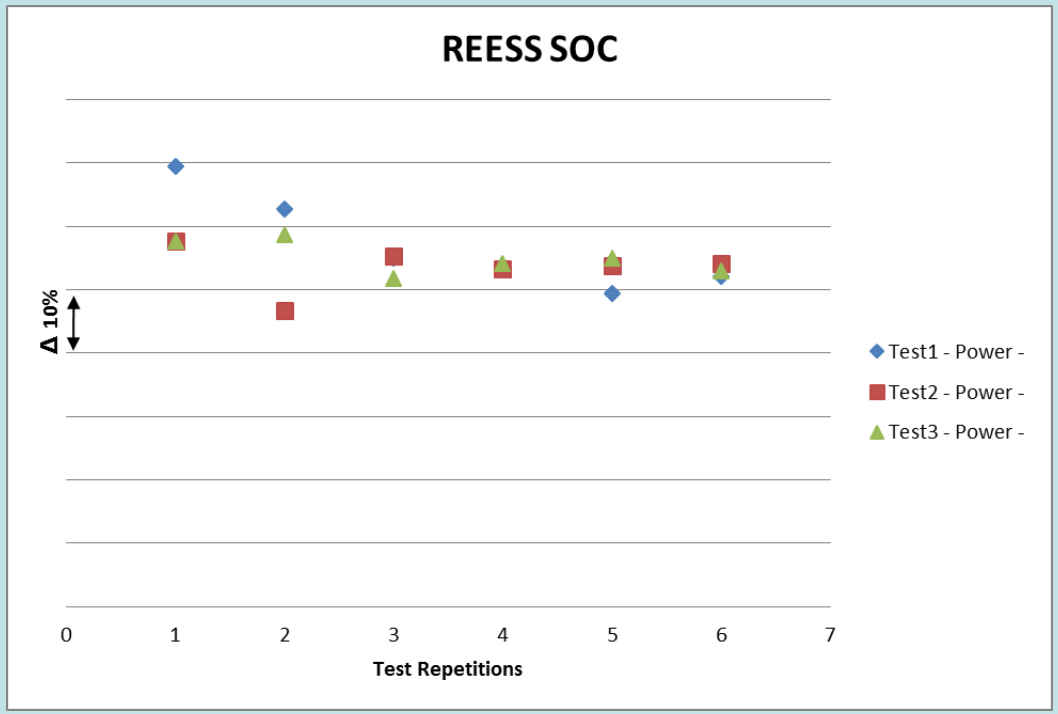
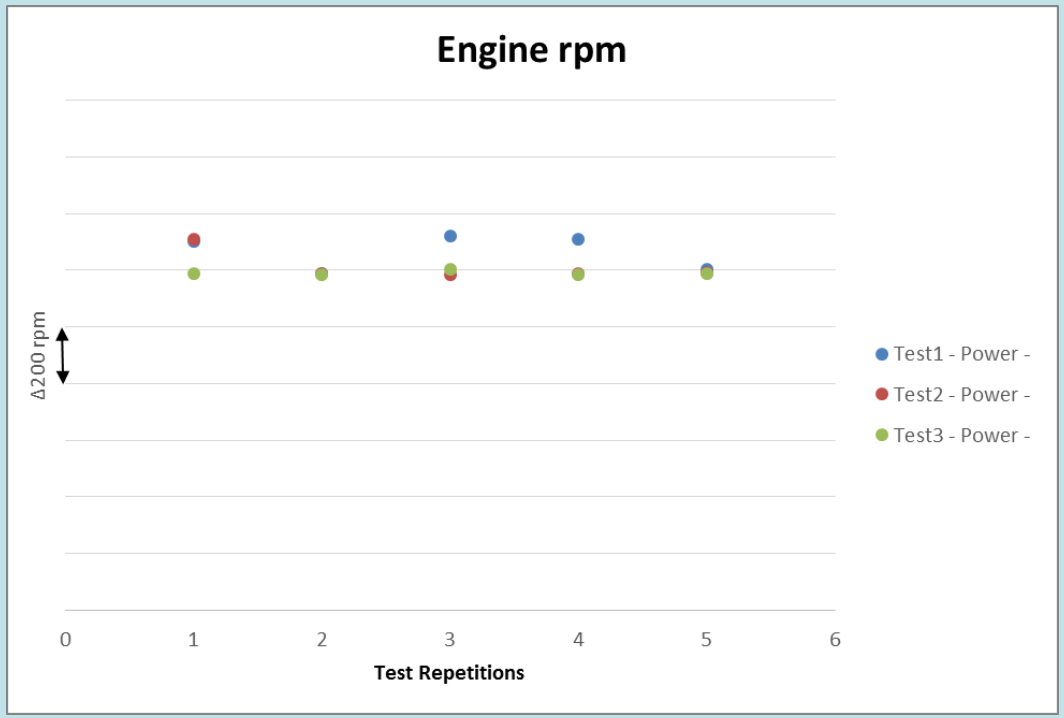
Vehicle N 2 JRC results



HV REESS SOC at the start of the test



Max engine rpm on the 10 seconds

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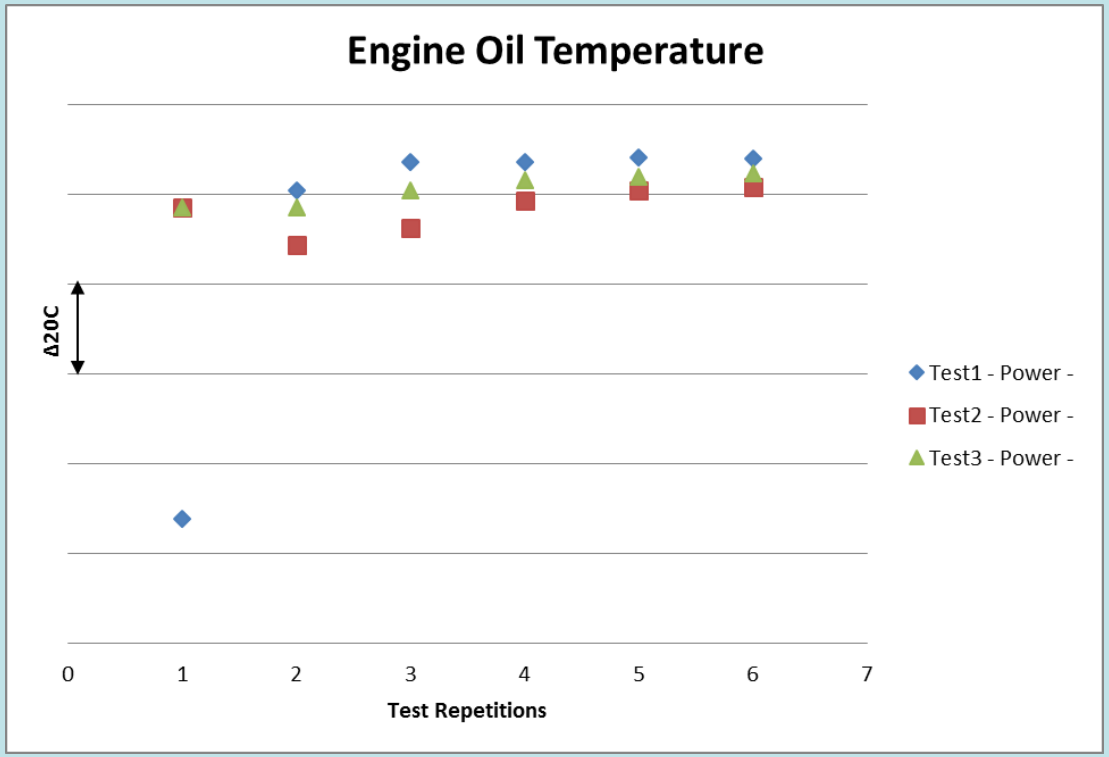
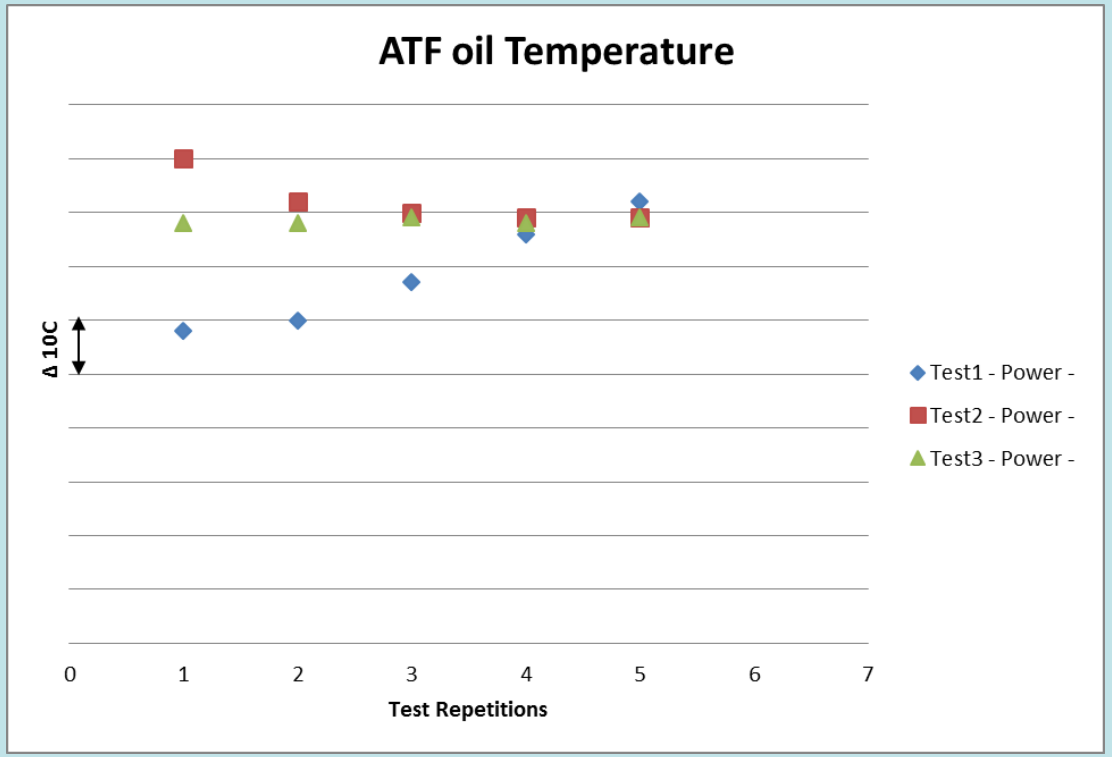
Vehicle N 2 JRC results



Engine oil temperature at the start of the test



ATF oil temperature at the start of the test

Validation testing observations

- To find the speed at which the maximum power occurs and related gear shift: acceleration from zero up to a maximum speed recording both power and gear shift by mean of the dyno controller
- Both TP1 and TP2 tests and post-processing were carried out. Difference in the two approaches with TP2 lower values possibly ascribed to the tire losses. Order of magnitude of losses (dyno-wheel) in line with other presentations.
- Fuel flow rate measured during tests of vehicle N2 and N2 JRC and compared to UN R85 corrected values. Deviation from R85 can have a big impact on TP1 results.
- REESS power from both CANbus and measurements by clamps
- ICE power corrected for altitude according to UN R85
- Low HV REESS SoC and High HV REESS SoC have an influence on the peak and sustained power calculated values
- Driving mode has an influence on the peak and sustained power calculated power

Validation testing observations: refining the calculations

- The fuel flow rate was measured during the tests and compared with the UN85 information.
- A difference during the constant speed phases of the power tests of about 6-9% (2 l/h) in average and approximately 5% in the power values were observed during first set of tests. Higher variation (up to 10%) during second set of tests with N2 JRC vehicle.
- Calculating the system power for N2 using the fuel flow rate derived engine power the TP1 sustained power becomes closer to the TP2 value while the TP1 peak power remains almost the same.
- EM power measured via HV REESS power and corrected subtracting auxiliaries and DC/DC power
- R85 engine power correction:
  - Correction of the engine power of TP1 to Ispra altitude
  - Correction of the engine power of TP2 to sea level.
  - Aside the difference in the maximum power due to the altitude (~1kW), the percentage difference between TP1 and TP2 are approximately the same.
- Corrections for the tires losses, the most important correction to be added to decrease the difference between TP1 and TP2.
- Ks calculation according to the method proposed imposing TP1=TP2:
  - Given K1, K2 is calculated imposing TP1 to be equal to TP2
  - Given K2, K1 is calculated imposing TP1 to be equal to TP2
  - Approximately the values of K1 and K2 are close to the default values from ISO (K2:[0.95,0.99] instead of 0.97;K1:[0.83,0.85] instead of 0.85);
  - Higher variation in K2 for cases with higher difference among maximum power values TP1 and TP2
- No torque meters installed on N1 and N2. Foreseen for N2 JRC vehicle this month

Thank you for the attention

Q&A

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