The Column with Sven Andersson .se

March 5, 2010

The Game of Deception
Horse power [Hp] or Donkey power [Dp] that's the question!

Sven Andersson is a sports car enthusiast and writes in the RRI Column on an irregular basis on controversial subjects relating to cars in general and car performance in particular. Andersson has devoted half a life-time in the world of cars and has insights in everything from the car industry to the opinion of the everyday motorist.

In this the second of a total of four issues, formed as four different chapters, the RRI Column's Sven Andersson will try to give you answers for most of the common concerns about performance measurements. This particular issue deals with measurement quality.

There are a lot of questions and beliefs about engine and powertrain performance at almost any automotive web-site or forum, all over the Internet. The performance issue (speed [rpm], torque [Nm], power [Nm, Bhp] and acceleration rate [rpm/s]) is not easy to explain due to the abstract and complex physics involved.

Please consider that I will only talk about powertrain performance due to the fact that this is the only performance statement that is affordable to verify for most performance customers.

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Most important document, the same or falsified specification, misleading with performance measurements and a method of performance deception.

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Second worst case dyno concept, inadequate measurements, fantasy estimations of transmission losses, quality factors for rolling roads and importance of inlet temperature measurement.

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The Game of Deception, chapter 1, February 26, 2010

Most important document, the same or falsified specification, misleading with performance measurements and a method of performance deception.

Q0: What is the most important document for demanding performance customers?

A0: The Powertrain Performance Graph(s), PPG, supplied by professionals. The PPG document is an essential for all new or used cars, standard or modified, performance or racing cars. Without a Powertrain Performance Graph from the actual car, performance customers are vulnerable to inaccurate information.

Q1: Do all engines with the same specification perform at the same level?

A1: **NO!** Engine performance and the causes to variations in performance. Production tolerances are something all manufacturers struggle with. Some have too wide tolerances or defects in production for mechanical parts, (cylinder heads, pistons, cylinders, camshafts) sensors, fuel injectors etc. All components are slightly different (even within specification) and this will have an effect on the total performance. The goal for the manufacturer is to have a robust design that is not sensitive to tolerances. However, the difficulty and expense increases with performance and the complexity of the design. One way to reduce the effect of tolerances is to use engine adaptation, which will to some degree compensate for the variations.

Stated maximum torque and power are allowed to vary in the production within ±5% in EC / according to ISO standard. It is then up to the manufacturers to maintain as little variation as possible. Some try to maintain the he average variation as closely as possible, whereas others try to stay within the specific interval, and whilst others struggle to keep it above the lower limit.

It is important to remember that the specifications are certified in an engine dynamometer with more or less unlimited cooling. This also incorporates long stabilization times before the actual performance measurement. This opens possibilities, for instance, to use over-boost functions for shorter periods. Additional power consumers, i.e. air conditioning, servo pumps, cooling fans, etc may reduce the available performance from the engine.

The installation in the vehicle can affect the output. A very cramped engine installation may give local heating problems. Routing of inlet air can easily raise the temperature and reduce performance. There are also installation effects (defects) from exhaust systems- and engine cooling capacity problems, too high exhaust back pressure and too high water cooling temperature due to high demands for head wind cooling. The engine cooling system (radiator) may be designed for a maximum "surrounding temperature" of for example +30°C and above that temperature, the engine control system has to reduce the performance output. The engine design may be sensitive to fuel quality and even to test conditions. An engine running close to the border of knocking *may reach the knocking limit* if the atmospheric pressure is high.

Q2: Is it possible that the stated engine power of my new and/or used car has been falsified?

A2: YES! To prove that a manufacturer is misleading is very difficult and that is because of the official test itself. It has to be made on an engine dyno and to remove the engine from a modern vehicle to get it running on the engine dynamometer is practically impossible. The whole car will be needed because the ECU (Engine Control Unit) checks for all the other onboard computers, sensors, etc in the car and if it cannot find them it will not start!

The manufacturer can be close to the lower limit of the allowed tolerance. Whether they choose it deliberately or not makes no difference to the performance customer.

NOTE! Automotive customers pay for what is claimed in the engine but they get what is available to the wheel hubs!

Performance may have also been adjusted at normal service work. It is usual that the service station updates the software and in the worst case this may include reductions of performance. The engine performance may be reduced when the engine is used in the car, due to the following; engine over- heating or engine mechanical problems, exhaust emission problems, transmission over load, general reliability problems, all resulting in high warranty costs.

Some sports car / race engines may be specified at a low inlet temperature of +15°C instead of the common +25°C. This will boost the specification of maximum power with approx. 2% only based on the temperature, added to that you may have knocking problems at a higher inlet temperature.

Official tests are done Steady State, but in reality the performance at full throttle (WOT) accelerations are of greater interest. The only Steady State in real life will be at the top speed.

NOTE! Performance during accelerations may differ significantly from the Steady State results. Maximum stated power and torque may be outside the usable areas, i.e. automatic gearboxes may shift before maximum power is reached and maximum torque may be specified below the stall speed of the transmission converter.

Maximum power and torque only specifies two points. It might be two narrow peaks and not a good description of the engine performance as a whole. Always demand a Powertrain Performance Graph, PPG over the whole "engine" working area (idle to maximum engine speed).

The market situation may from time to time force some automotive manufacturers to state the "same" performance numbers as tough competitors. In the best case this will be reached during ideal conditions with unlimited cooling.

Q3: Is it possible to mislead when dealing with performance measurements?

A3: **YES!** Inaccurate measurement systems are common and this is the main reason for the spreading the Donkey power [Dp] statements (please see **A16**) instead of accurate measured [Bhp] or [kW] according to Best Known Practice, BKP.

Some of the dyno concepts, such as the rolling road, are simply not suitable for quality and scientific measurements and they clearly shows that there is a lack of underlying physical understanding and sense of professionalism.

A well-informed performance consumer could easily distinguish this type of garage grade dynos from a true measurement system tool and should always demand true powertrain performance according to Best Known Practice, BKP.

The Game of Deception, chapter 2, March 5, 2010

Calibration a critical quality issue, measurements during changing acceleration rates good enough, worst case dyno concept.

Q4: Is use of inaccurate measurement tools a method of performance deception?

A4: YES! A dynamometer has to be a professional measurement device not only named as such. For example the ROTOTEST VPA-RX chassis dynamometers are designed to meet industrial demands on measurement accuracy, according to Best Known Practice, BKP. A performance customer has always the right to demand high quality and safety for both the car and tyres when purchasing performance measurements.

WARNING! Most chassis dynamometers (garage grade rolling roads and/or garage grade hub dynos) have as a best practice a total measurement tolerance of ±7% on the absolute measured value (for the most uncomplicated method, the Steady State measurement). This means 93 to 107 hp for a 100 hp engine, or 279 to 321 hp for a 300 hp engine. In most cases this implies less than accurate measurements. For a race car Powertrain Performance measurements with such low level of accuracy chances are small to perform a winning engine calibration and it is not possible to carry out a professional investigation on why the car is not fast enough.

Another method used to claim false measurement accuracy is to show relative measurements during a short period. Often is a test car used as an example, head lights on and off for example. This type of demonstrations only shows that the test equipment has a good sensitivity for small power outputs. It tells nothing about calibrated absolute measurement accuracy. For calibration please see **Q5** below.

NOTE! A clock that stand still, show you the absolute right time twice, every 24 hours!

Q5: Is dynamometer calibration a critical quality issue?

A5: YES! Always ask for the calibration procedure for the used dynamometer and with what accuracy the total measurement change is performed. Any calibration of only the torque- or "pressure" sensor will not tell the whole story, *it must be a calibration of the total measurement chain*, with tyres and parasitic losses (rolling roads). Second hand measurements (hydraulic pressure instead of torque measurements for hydraulic garage grade

dynamometers) are not good enough for professional usage. If your questions are not answered properly, do not waste your money, use another test supplier.

Q6: Is use of inertia engine and inertia chassis dynos with measurements during changing acceleration rates good enough?

A6: NO! Uncontrolled acceleration engine or/and chassis dynos will always give measurement that are not possible to compare - so called Donkey power [Dp] (see **A16**) due to non-constant acceleration rates [rpm/sec]. Measurement results will change with the acceleration rate, when using a known inertia [kgm^2] (a drum, flywheel etc.) as a braking device. The acceleration rate will change with the engine power output:
More power = more braking, less power = less braking!?

The inertia influences: The larger inertia (flywheel), the larger "mechanical filtration" of the test results (The power variations will be hidden due to the physics of a flywheel).

NOTE! Flywheels are used in combustion engines to smooth out torque variations.

WARNING! *Inertia engine and chassis dynamometers are a low cost unprofessional dynamometer solution!* Performance graphs from these types of garage grade dynos do not in any way give correct test result for comparing of performance.

NOTE! Test results are not comparable in any way (due to acceleration rate fluctuations), even between test runs at the same "acceleration garage grade dyno".

Q7: What is the worst case dyno concept?

A7: The "Road Dyno" is a computer box, measuring the engine speed. This concept uses the same physical background as the inertia rolling roads or engine dynos. The base concept is useless due to performance measurements during non constant acceleration rates [rpm/sec]. A "Road Dyno" has all of the worst drawbacks of the rolling road. Non constant acceleration rates instead of Steady Rate™ [rpm/sec], its dependence on powertrain inertia, the tyre - road traction, used gear, plus a couple of other variation factors as wind speed, road slope angle, weight of the vehicle, aero dynamics of the vehicle and dragging brakes.

The many uncertainties with this type of attempt to measure performance are why racing engineers (with advanced data acquisition systems) cannot claim missing engine performance, despite well grounded suspicions.

NOTE! "Road Dynos" could be used as a toy, just for fun, but absolutely not in professional performance measurements.

Sven Andersson