Boost Pressure vs. Blow-by

Diesel Performance Parts ring sets with Total Seal Gapless 2nd Ring Technology

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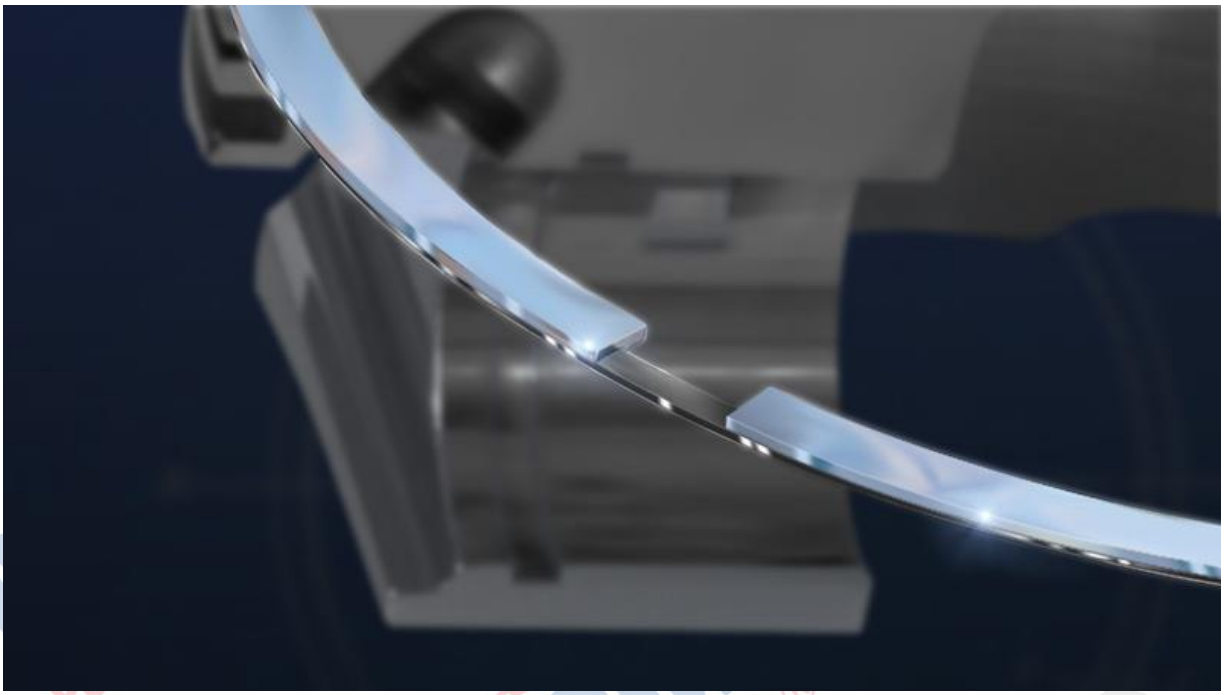


The Background

There are continuing discussions on-line about engine blow-by in diesel turbocharged engines. How much is normal and what is abnormal? Is there anything that can be done to reduce engine blow-by?

Engine blow-by is cylinder combustion pressure that leaks past the rings, into the crankcase, and out the engine breather. This does not include a pressurised crankcase from a leaking air compressor seal (on trucks) or a leaking turbocharger seal. It also does not include leaking valve seats.

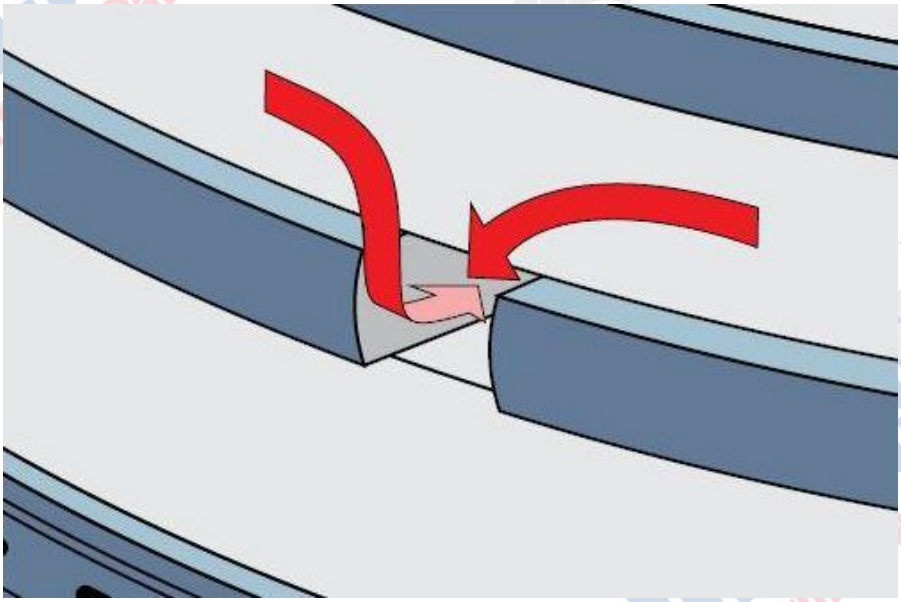
Blow-by occurs on all internal combustion engines with reciprocating pistons and rings. The top and second rings must seal in the piston ring grooves and on the bore walls to stop oil entering the combustion chamber above the top ring, while keeping enough oil on the bores to stop metal-to-metal contact of the rings and bores, and keeping the cylinder sealed. The top ring is a 100% compression ring and 0% oil control ring, the 2nd ring is a 20% compression ring and 80% oil control ring (approximately) and the oil ring is a 0% compression ring and 100% oil control.

Any cylinder pressure that escapes from the cylinder, other than as designed by the opening of the exhaust valves, is lost power and torque and thus an inefficiency. Piston rings will seal best under the following conditions:

- The rings were installed the right way up and using the correct installation tool, ensuring the rings are still flat (not distorted while twisting the rings on by hand) and round (not over-stretched using an incorrect ring installation tool).

- The bores are round and parallel. This is best achieved with the main caps fitted and tensioned and the block bored and honed using a torque plate.
- The block has the correct bore size and finish – plateau hone crosshatch. A good engine machining shop with a diamond hone will be able to do that and provide you the Rk, Rpk and Rvk measurements of your finished bore and the finished bore size for your pistons.
- The rings are not damaged when the piston is being installed into the engine block. Tapered slide-in sleeves specific to your engine are much better than wind-in ring compression style tools.

If all these factors are catered for and the engine is run-in correctly, you will have the best chance of minimal blow-by, which is measured in LM (Litres per Minute) or CFM (Cubic Feet per Minute). Even with all these factors under control, combustion gases will leak through the ring gaps. Top and 2nd rings have very low ring tensions and rely on combustion gases entering behind the rings and forcing them out onto the bore walls. The oil ring on the other hand has very high tension and relies on that to seal with the bore and control the amount of oil that gets to the 2nd and top rings.



Combustion gas leakage through the top ring gap is essential to the correct operation of the second ring. Once the gas escapes past the 2nd ring it no longer serves any purpose and becomes a loss.

The Test Equipment

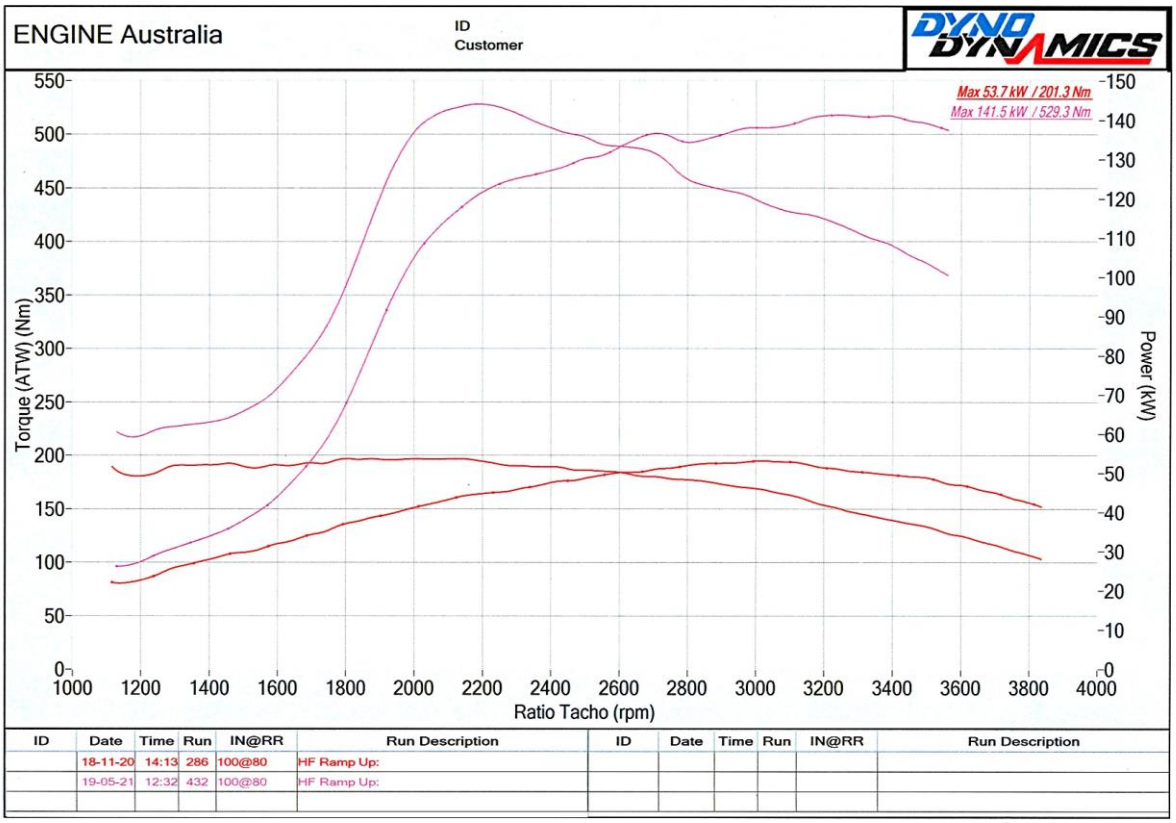
The Engine Australia R&D Workshop uses a Performance Trends Blowby Sensor to measure CFM flow from the crankcase during chassis dyno testing. The Sensor has been wired and coded to the DynoDynamics control software that enables us to pair the results with any other variable being monitored e.g. power, torque, inlet manifold boost, RPM, etc. The sensor is fitted to a hose attached to the crankcase breather. While not ideal, it can be attached to the catch can breather outlet if the engine has a serious oil problem from the crankcase breather.

Performance Trends Blowby Sensor

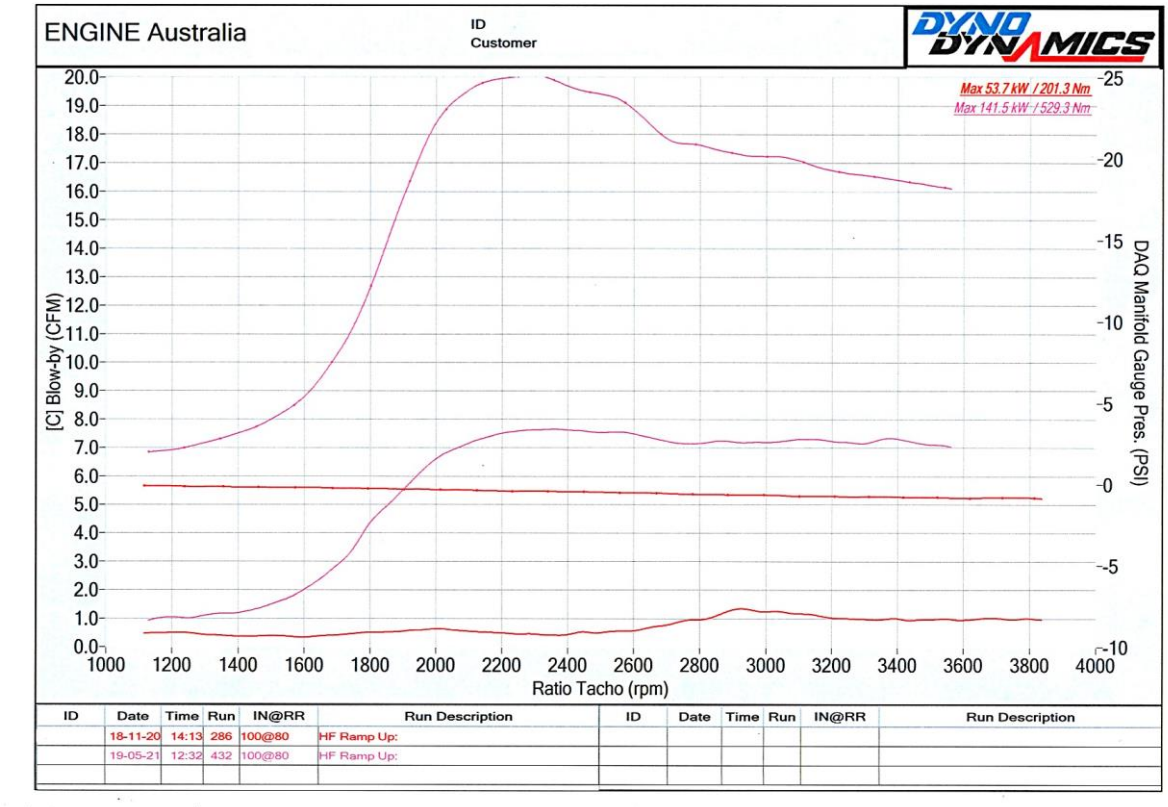
The Test

Two Engine Australia staff vehicles with 1HZ engines have been used for development and testing purposes. The bottom ends of both engines are the same – cryogenic treated blocks, cranks, heads and camshafts, Diesel Performance Parts oil gallery cooled 1HZ-T pistons (ceramic coated crowns and Moly/Teflon skirt coatings), Diesel Power Parts engine rebuild kit with ACL Race bearings, Diesel Performance Parts billet conrods, in-house fully balanced engines, new harmonic balancers and cylinder heads worked, machined and assembled in-house. One engine was naturally aspirated and fitted in a Troopy the other already turbocharged and intercooled in a 80 series wagon. Both vehicles run 84 cm (33”) diameter tyres.

The Troopy engine was rebuilt and left naturally aspirated for 10,000 kms. The engine was then given a stage 1 turbo upgrade to 135 kW. This is a 1600 – 3600 RPM engine. Graphic 1 below shows the rear wheel power and torque curves on the chassis dyno. The naturally aspirated engine runs a small vacuum and little blow-by. The turbocharged build is running 172 kPa (25 psi) inlet manifold boost and 198 – 227 LM (7 to 8 CFM) blow-by. As you would expect, the blow-by line shadows the boost line.



Graphic 1. Power and torque curves on chassis dyno for 1HZ-T stage 1 performance build.

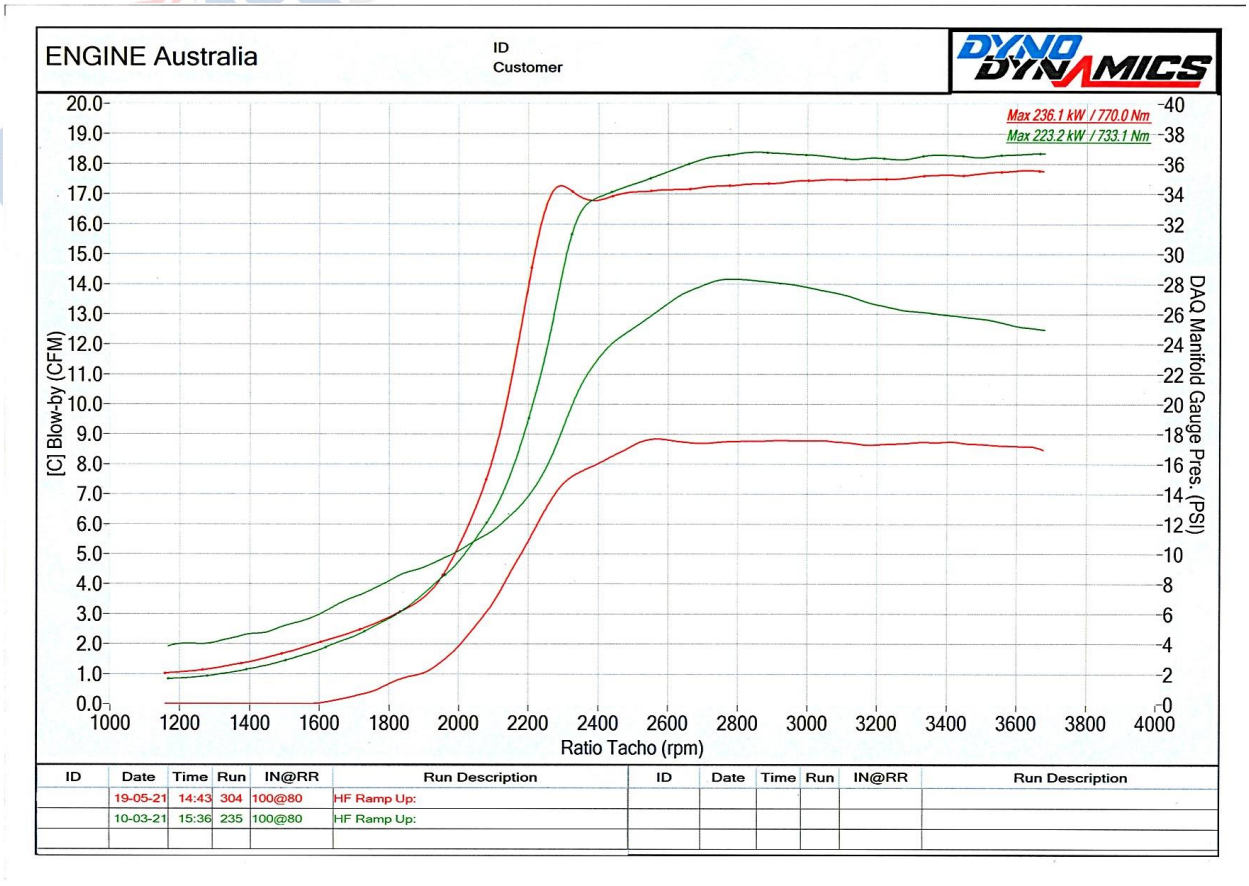


Graphic 2 shows the blow-by in CFM and the inlet manifold pressure for this engine in both build formats.

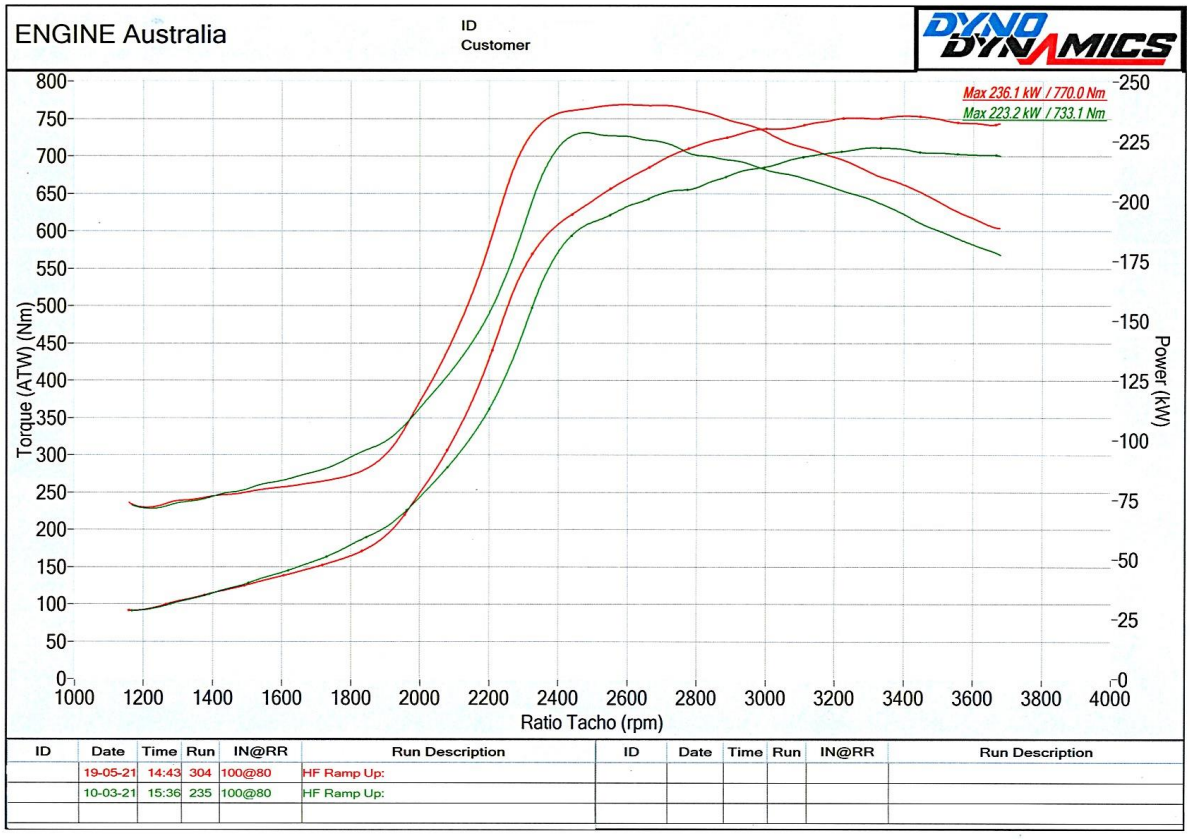
Diesel Performance Parts Rings with Total Seal Gapless Second Ring Technology.

The second engine was running a stage 3 turbo upgrade to 225 kW for 40,000 kms. The engine was stripped down, bores honed and a set of Diesel Performance Parts rings with Total Seal Gapless Second Ring Technology fitted. This refreshed engine ran 252 kW and 858 N.m of torque. The boost was wound back down to be close to the pre-Gapless rings reading. Graphic 3 shows the pre-Gapless rings blow-by vs inlet manifold pressure and the same for the Gapless rings but with boost adjusted down. The blow-by for around 248 kPa (36 psi) inlet manifold pressure was running up to 396 LM (14 CFM). With the Gapless Second rings installed, a similar inlet manifold pressure saw a blow-by of 255 LM (9 CFM).

The Gapless Second Ring Technology has not been fitted to the Stage 1 build engine at this stage. With 36% decrease in blow-by in the Stage 3 engine build, it is possible the Stage 1 build may see a drop in blow-by to 142 – 156 LM (5 - 5.5 CFM).



Graphic 3. The Diesel Performance Parts rings with Gapless Second Ring Technology resulted in a significant (36%) reduction in blow-by. This appears to continue to improve as the engine gets more operational hours.



Graphic 4. Toyota 1HZ-T stage 3 performance build engine detuned to 248 kPa (36 psi) inlet manifold pressure.

Results.

The blow-by tests on the chassis dyno clearly shows that with standard design ring packs, the blow-by increases as the turbocharger boost increases. Blow-by has many negative effects, but in summary, blow-by results in decreased engine efficiency and performance. Engine Australia has been working with Total Seal to bring Gapless Second Ring Technology to Japanese diesel engines in performance applications. Gapless Top Ring Technology is used in naturally aspirated V8 and in-line engines, while Gapless Second Ring Technology is used in turbocharged or supercharged engines, particularly diesel engines, for better oil control and reduced blow-by. This technology is being introduced by Engine Australia to their range of Diesel Performance Parts Rings with Total Seal Gapless Second Ring Technology for a limited range of Japanese diesel engines. We hope to increase the range as marketplace acceptance increases.

Available from:

Engine Australia

Phone: 1300 364 463