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Questions to Emissions Analytics

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Q1. You have been stating in the press that you have been testing a wide range of vehicles present on the UK market. What and how many vehicles have you tested? What were the results and what is in your view the explanation for those exceedances? Did you alert the UK authorities of the exceedance of NOx emission from diesel vehicles, and when? If yes, what was their response?

A1. We have tested over 800 European vehicles since 2011, evenly split between diesel and gasoline and across a wide range of makes and models. All vehicles tested are either Euro 5 or Euro 6. On average CO_2 emissions are 30% above the combined results from the New European Driving Cycle-based official test, and this excess is similar for gasoline and diesel. For NO_x emissions, on average gasoline vehicles are 42% below the regulated level, while diesels are 4.8 times the limit on average.

The explanation of the differences falls broadly into three areas. First, the NEDC test is a cycle of low speeds and acceleration, which is inherently more gentle than typical real-world driving, which has higher emissions and fuel consumption. Second, the wider protocol of the official test has other elements which in our view flatter the results compared to reality, e.g. the benefit of stop-start engine technology is bigger on NEDC than in real-world. Third, the protocol is drafted in such a way that leaves some discretion and undefined areas that create loopholes which can be exploited to achieve better official results than would be achieved in normal driving.

It is important to qualify this by pointing out that our background is not in laboratory type approval testing or vehicle engineering for car manufacturers, and so we have not been party to this "optimisation" activity and therefore we rely upon research and reports from third party organisations which have studied the various initiatives in more detail. However, we can be certain from our data that the first point, the gentle nature of the NEDC, is a significant contributor to the emissions gap.

We have been publishing this data into the public domain since 2012. Initially, we published real-world fuel economy data via consumer media in the UK, thereby putting it into public hands for free. Since 2014 we have published NO_x data, culminating in the launch of the EQUA Air Quality Index in April 2016, which publishes ratings of over 500 vehicles, again free into the public domain. The primary aim of these services is to allow consumers to choose on an informed basis.

In parallel with this, we have developed discussions with UK government departments and manufacturers, including explaining our methodology and findings in order to show the problems with the existing type approval and compliance process. We have never reported a vehicle for apparent non-compliance to the certification agency.

Q2. Did you ever simulate a NEDC test on the road using PEMS? If so, what were the results? Did you ever notice NOx emissions exceeding the norms by a factor 3 of more? Who exactly has access to the data?

A2. No, we have never simulated a NEDC test on the road. We have focused on creating real-world driving cycles to show the more realistic performance of vehicles.

Q3. Research by EA (the EQUA Air Quality Index) on more than 250 Euro 5 and Euro 6 vehicles, found that just one of 201 Euro 5 diesels did not exceed the limit, while only seven of 62 Euro 6 diesels did so. Do these results show that it is technically possible for car manufacturers to meet EU legal limits for NOx but that most are refusing to do so? What, in your opinion, would be the reasons for cars

not meeting the legal limit and are any of these reasons justifiable from a technical or engineering perspective?

A3. It is technically possible for diesel vehicles to meet the EU legal limits in real-world driving. As the technical solutions involve some combination of added capital cost and increased operating cost of the vehicle, in a highly competitive market it would not be surprising if manufacturers seek to abate NO_x as little as possible consistent with achieving legal compliance. Similar diesel vehicles achieve compliance on an even lower official NO_x limit in the USA – but at a cost, and on a different cycle.

So, it is an optimisation problem in the dimension of purchase price, operating cost and emissions level. There are of course limits to how much NO_x and CO_2 can be reduced on diesel cars without making their cost completely uncompetitive in the market, but the current EU regulations do not push this limit.

Q4. Your research (the EQUA Air Quality Index) claims that no other car manufacturers had fitted their cars with a similar defeat device as used by VW, which recognises when the car is being driven on a test cycle. Can you be sure that none of the cars you tested used a different variety of defeat device? Such as a thermo-window device which senses when the ambient temperature is beyond the conditions specified in the test procedure? Or a hot-restart defeat device based either upon a timer or on the temperature of the engine when it is restarted? Could these devices have been used but not yet detected? Is it possible to detect such devices?

A4. We haven't claimed that no other manufacturer has installed a VW-type defeat device. Our test method has been designed to show what real-world performance is rather than specifically finding such defeat activity.

Our testing does happen to be suitable for identifying some strategies, such as the thermal windows. We test at a range of ambient temperatures, typically in the 5 to 25 degrees Celsius range, and so can look at the average NO_x emissions above and below certain temperature thresholds. While the majority of manufacturers show no material difference in emissions between high and low ambient temperatures, a small number have higher emissions at lower temperatures. This is circumstantial rather than categorical evidence of reducing exhaust-gas recirculation or after-treatment system activity at lower temperatures.

Q5. Some car manufacturers justify switching off the EGR system at certain temperatures in order to protect the engine. Is this justified? If so, what might happen to the engine if the EGR is not switched off and under what conditions/temperatures is this relevant?

A5. Unfortunately, this is not our area of expertise.

Q6. The NOx emission control techniques available at the time of adoption of the Euro5/6 legislation (in 2006) were EGR, LNT and SCR. Is it technically possible to meet the NOx limit value that was set to apply for all new vehicles sold in 2015, i.e. 80 mg/km "in normal use" with one or a combination of those technologies? Is it possible to meet the Euro6 NOx limit value "in normal use" with LNT technology alone? Is it technically possible to meet the US Federal or Californian NOx limit values with a combination of those technologies?

A6. See answer A3 above. The Euro 6 limit can be met in real-world driving generally by combinations of EGT and LNT, or EGR and SCR. It is possible to meet Euro 6 in normal use with EGR and LNT, which has been demonstrated by the Volkswagen Group vehicles that have achieved A ratings on our EQUA Air Quality Index. An A rating means that the 80 mg/km is met on our real-world test. Of the eight diesel vehicles that have received A ratings so far, four of those used LNT systems.

Although we have only recently started NO_x measurements in the USA, we believe it is possible to meet the Federal and Californian standards for diesels vehicles by using SCR but not LNT. However, the use of SCR alone has risks, for example it does not function well when the exhaust is cold. As a result, there is a move towards installing LNT and SCR together, which is a lower risk but higher cost option.

Q7. Your organization is specialized in RDE testing using PEMS. According to several experts, the use of PEMS might lead to different results that need to be taken into account by applying a conformity factor, in addition to the legal limits set in the regulation 715/2007. According to your experience, what is the uncertainty margin linked to the use of portable measurement devices? How can these uncertainties be reduced and by when?

A7. For NO_x measurement, the test-to-test variability for on-road measurement using PEMS under the Emissions Analytics' method is up to +/- 25%. If the test is conducted on a track, thereby eliminating the effect of unpredictable traffic flow, that variability falls to approximately 10%. Therefore, for Real Driving Emissions, if the principle is that a margin of error should be given to reflect measurement variability, a Conformity Factor of 1.25 might be justifiable. However, the RDE protocol differs in certain ways from the Emissions Analytics' method, which will lead to higher variability.

For CO_2 and fuel economy measurement, the test-to-test variability for on-road measurement is up to 5% in our experience. With the test conducted on the track that variability falls to +/- 3%. Therefore, PEMS has proven to be a robust tool for real-world fuel economy measurement.

Q8. When did you start to use PEMS? How does PEMS differ from other systems used by Emissions Analytics?

A8. We started PEMS testing in 2011, and we have only ever used PEMS. The reason for this is that our belief is that PEMS has the best combination of accuracy, authenticity and cost. The accuracy is not far short of the laboratory. It is ultimately authentic as you can test actual customer cars on the real highway with normal drivers. While still requiring significant investment, PEMS does require the same order of magnitude as for setting up a laboratory with dynamometers.

Q9. Is PEMS the same kind of equipment that will be used by the testing authorities? According to your tests, have the PEMS proved to be reliable and the results accurate? In your opinion, is it necessary to set conformity factors in the new RDE test procedure at all? If so, are the conformity factors of 2.1 (from 2017 to 2020) and 1.5 (from 2021) justifiable?

A9. The PEMS we use is the same as will be used by testing authorities. Our main equipment is the SEMTECH-LDV from Sensors, Inc of Michigan. Although we typically are not conducting type approval activity, the equipment we use conforms to those standards in both EU and the USA.

The reliability of PEMS equipment has been quite impressive. We use our analysers intensively: typically, each analyser is used every working day of the year and still the durability has been good. As a guide, about one in five tests ends in failure. However, only about one in ten fails due to equipment problems, and the majority of those problems are relatively minor and can be fixed by us. The remainder require some intervention from the PEMS manufacturer. Of the non-equipment reasons for failure, the main causes are bad weather and malfunction of the test vehicle itself.

For information on the accuracy of the PEMS systems, please see the answer A7 above.

There is clearly a test-to-test variability using PEMS – as there is with a laboratory, although the levels are slightly higher with PEMS. Whether that variability should be borne by the vehicle manufacturer or a margin of error given in the regulation is a political choice, not a technical one.

If the choice is to give a margin of error, then a Conformity Factor as low as 1.25 could be justified as mentioned in the answer A7. The initial Conformity Factor of 2.1 has been chosen – as far as we understand – such that it can be achieved with only software changes by the manufacturers. The later Conformity Factor of 1.5 is at the very cautious end of estimates of the variability of PEMS measurement. However, even that will come at some cost to manufacturers in order to comply, which will be passed on in part to consumers via some combination of higher diesel car prices and higher operating costs.

As a comparison, the US regulation has had an effective Conformity Factor of 0.4 for many years, although the test cycle of which this is based is fundamentally different from RDE.

Q10. The UK government testing has found no evidence of other car manufacturers using defeat device software, as found in the VW case. However, it is clear that real driving emissions are far above the level of those conducted under the type approval testing mechanisms. Hopefully the new type approval proposal currently going through the co-decision process will improve testing and thus lowering emissions. Member States (via TCMV) have repeatedly said there is a limit to reducing CFs below a certain level, that there is an inherent uncertainty that means there must be a margin of error built in (as seen with the October vote). As we move away from a pass/fail system of Type Approval and head towards better testing and closing the gap to a CF of 1, can you explain/elaborate the wide variation in vehicle performance in this regard?

A10. It is true there is a wide variation in the real-world NO_x performance of Euro 6 diesel vehicles currently. Of the around 70 such vehicles tested so far by Emissions Analytics, eight have met the 80 mg/km limit in real-world driving (equivalent to a Conformity Factor on RDE of 1). The worst performing vehicle has a Conformity Factor of 14.4. These vehicles would have all been certified to the same standard.

The mechanisms for creating the exceedances are set out in the answer A1 above. The size of the exceedances for any individual model then depends on the manufacturers' use of these mechanisms. In other words, how far is the manufacturer willing to use the loopholes and grey areas to achieve NO_x compliance at the smallest cost in terms of the price of the vehicle and the operating cost?

It is perhaps worth noting that – notwithstanding the clearly illegal defeat device in the USA – of the major manufacturers, Volkswagen appears to have acted most closely to the spirit of the regulation in

Europe, as it accounts for seven out of the eight vehicles with A ratings on the EQUA Air Quality Index, suggesting a Conformity Factor of 1 on its existing models.

Q11. Under what conditions do you conduct emission tests? Are they in line with what the European Commission had in mind when setting emission targets?

A11. Emissions Analytics established its test protocol in 2011, long before RDE was fully defined. Our philosophy was to embody the range of typical, rather than extreme, driving in a real on-road test using PEMS. This is similar to the basis of RDE. While I have no knowledge of what was in the European Commission's mind when it set the targets, it would seem reasonable to conclude that our test broadly reflects RDE and that the emissions targets should be achievable on our test.

Areas of agreement between the two methods are many, including the use of PEMS on the public highway, a mix of urban, rural and motorway driving, use of market fuel, real-world payload and so on. The main area of difference between the two methods is in the standardisation of the route and the use of normalisation tools. Emissions Analytics uses a fixed route each time, for all cars, in order to minimise the role of statistical normalisation, and the normalisation itself relies neither on CO_2 windows nor power bins as a proxy for work done by the engine, but rather on real driving characteristics.

Q12. How and by whom is Emissions Analytics financed? What are your links to the car manufacturers?

A12. Emissions Analytics is a private, commercial UK company owned by three private shareholders including me. It has been financed by these individuals. The company operates across Europe and has a wholly-owned subsidiary in the USA.

Revenues are generated by subscription access to our database of over 1200 vehicle tests and from custom testing activity. The tests that form the database are conducted by Emissions Analytics as the principal, financed from its resources, and therefore are completely independent of regulators and manufacturers.

Emissions Analytics' revenue base is highly diversified, and so does not come disproportionately from one source. Over half of European car manufacturers by sales are subscribers to our database or employ Emissions Analytics for custom testing.

None of the shareholders or directors of the company have been personally employed by regulators or manufacturers in the past.