New diesels, new problems

Frequently Asked Questions (FAQs)

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1. **What did T&E investigate in this test programme?**

T&E has tested the emissions of two of the newest diesel cars with one of Europe’s leading laboratories. The investigation went beyond EU regulatory tests by including emissions during the periodical cleaning of Diesel Particulate Filters (‘DPF regeneration’) as well as pollutants that are currently not regulated in the European Union. (Specifically: particles smaller than 23nm, volatile and semi-volatile particles as well as ammonia.) None of the previous studies on DPF regeneration looked at real-world driving conditions, or the latest and supposedly ‘cleanest’ EU 6d-temp diesel cars with a comprehensive look at both regulated and unregulated pollutants.

1. **Why did T&E decide to conduct these tests?**

Carmakers have been claiming that new diesel cars, approved under the latest Euro 6d-temp emissions norm, are now ‘clean’. T&E wanted to put these claims to the test by measuring emissions outside of the scope of current regulations. This namely included the regeneration of Diesel Particulate Filters (DPFs). At present, emission limits don’t have to be respected on tests during which a regeneration takes place but several studies have highlighted that pollutant emissions can increase substantially during those tests[[1]](#footnote-0), which is why T&E decided to investigate this further. Moreover, currently unregulated pollutants, such as ammonia and ultrafine particles, are also of particular concern from a health perspective.[[2]](#footnote-1)

1. **What is a Diesel Particulate Filter (DPF) and how does it work?**

A diesel particulate filter (DPF) is a filter which is installed in the exhaust of all diesel cars since 2013 in order to trap soot particles, which are made in the engine, and stop them from being emitted out of the tailpipe.

1. **What is the “regeneration” of a Diesel Particulate Filter?**

Over time, as the filter becomes filled, the soot must be removed from the filter to prevent the exhaust from clogging. For this to happen the temperature of the DPF must be increased to over 550°C so the soot can be burnt off. This is called a DPF regeneration. T&E found that when the regeneration happens, there is a large increase in the emissions of most pollutants, particularly of particles. The AA (British motoring association) estimates that this occurs on average every 480 km for diesel cars.[[3]](#footnote-2)

1. **How many diesel cars on the road today have DPF filters?**

DPF filters became mandatory with the introduction of an emission limit for the number of particles (PN) from diesel cars with the Euro 5b regulation, which came into effect for all cars from 2013. T&E estimates the number of registered diesel cars in the EU with a DPF filter to be almost 45 million - these were sold between 2011 and the first half of 2019.[[4]](#footnote-3) This also takes into account that some of the older models may have been scrapped. Vans and trucks may also be affected - see below.

1. **Why is it important to assess the effects of DPF regeneration?**

Cars do not currently have to meet emission limits on tests (both in the laboratory and on the road) if a DPF regeneration takes place during the test[[5]](#footnote-4),[[6]](#footnote-5), meaning that during this time diesel cars are allowed to emit a huge amount of pollution. Several previous studies have shown that the emissions of certain pollutants, particularly of the number of particles[[7]](#footnote-6), can greatly increase during regeneration, which can take up to 25 minutes[[8]](#footnote-7). According to T&E’s estimations, based on average mileage of diesel cars in Europe and the average frequency of DPF regeneration, every year approximately 1.3 billion regenerations take place on the 45 million diesel cars in Europe that have a DPF.

None of the previous studies on DPF regeneration looked at real-world driving conditions, or the latest and supposedly ‘cleanest’ EU 6d-temp diesel cars with a comprehensive look at both regulated and unregulated pollutants. Therefore, in order to better understand the impact that the DPF regeneration can have on air quality, T&E has investigated during this testing programme how much pollution is emitted during the regeneration event, how often it occurs during real-world driving as well as the duration of the regeneration itself. For one of the vehicles this information was then compared to type-approval data. For the other vehicle, the necessary official information could not be obtained.

1. **The tests were done in a lab - so, are they representative of real-world driving?**

The tests are representative of real-world driving as the test cycle used in the laboratory was developed by Ricardo, one of Europe’s leading laboratories, from a real route driven on the road which was compliant with the EU’s official Real Driving Emissions (RDE) regulation. The road loads used were obtained from each vehicle’s certificate of conformity. For both cars a DPF regeneration occurred on the first test, and the testing continued until a second consecutive regeneration had completed. This allowed for the determination of the distance between two consecutive regenerations.

The reason for conducting the testing in the laboratory and not on the road was to investigate emissions of pollutants which cannot be measured on the road at present, such as ammonia or smaller than 23nm particles. However, there is ongoing research work to make the measurement of these pollutants feasible on the road for inclusion in future emissions regulations[[9]](#footnote-8).

1. **How did T&E choose the vehicles that were tested?**

The Nissan Qashqai and the Opel/Vauxhall Astra were chosen for testing as both were already available in the latest EU 6d-temp emission standard and both were top selling car models in Europe in 2018. In that year the Nissan Qashqai was the 2nd best selling C-segment SUV and the Opel/Vauxhall Astra was the 4th best selling C-segment car[[10]](#footnote-9). The two diesel cars were independently rented by Ricardo from ProRent, Germany; a specialised rental provider.

1. **Which cars were tested and how representative are they?**

Two of the latest Euro 6d-temp cars with large market penetration were tested, a Nissan Qashqai and an Opel/Vauxhall Astra. The DPF and other emission control components used on the two vehicles are typical of the kind of technology used on the latest EU 6d-temp cars. It should be noted that the two cars tested are from two different manufacturers with two different engine and emission control technologies, yet they both produce large amounts of particle pollution, suggesting that this could be a problem for many diesel cars on EU roads today - including the latest and cleanest Euro 6d-temp diesels.

1. **What are the main findings of this testing work?**

The results suggest that even the newest diesel cars are not ‘clean’ as they emit much more pollution than reflected in official type-approval data. Although the tested cars both respected legal limits for gaseous pollutants and particulate matter, they would have failed the tests if particle number limits also applied during the regeneration of Diesel Particulate Filters. The number of particles emitted increased by more than 1,000 times during regeneration. The regeneration blind spot in regulations mean that between 60-99% of all particle pollution is ignored for the two test cars tested. Moreover, the tests found that regeneration events for the Astra occurred almost twice as often as indicated in official type-approval data.

The testing also showed that a large amount of currently unregulated particles, smaller than 23nm, were emitted on all tests, including those during which a DPF regeneration occurred. When particles of between 10-23nm in size were accounted for, the total amount of particles measured increased by between 11-183% compared to when only currently regulated particles were measured.[[11]](#footnote-10) In order to effectively reduce the amount of all particles emitted from diesel cars it is necessary to regulate particles of all sizes and this must be included in the future regulation. Finally, ammonia emissions from one of the tested cars were high, particularly on tests during which a DPF regeneration occurred, with test emissions equal to 33 mg/km. Ammonia contributes to the formation of PM2.5, thereby negatively affecting air quality. These emissions from cars are unregulated at present which allows them to emit an essentially unlimited amount of ammonia.

1. **The regenerations occurred during motorway driving in the tests. What is the effect on air quality in cities?**

One of the current arguments against more rigorously regulating DPF regeneration is that they occur mainly on high-speed roads away from where people breathe. While it is true that it is more favourable for a regeneration to occur during higher speed driving, due to a lower fuel penalty and fuel in oil issues,DPF regeneration events can and do occur in cities, towns and urban areas. Emissions Analytics have reported DPF regenerations occuring during urban driving, directly affecting air quality. This is necessary to prevent the filter clogging, especially when cars are driven exclusively in urban areas[[12]](#footnote-11).

During T&E’s testing programme, particle number emissions continued to be higher during urban driving for 30 minutes after the end of regeneration. Moreover, most cities in Europe have high speed expressways or motorways next to homes, schools and offices. Particle pollution from DPF regeneration on these roads will impact air quality next to where people live, breathe and work. Studies indicate that spikes in particle pollution can have immediate negative effects on the hearts of the people exposed.

1. **How long does a regeneration take and what is the effect on air quality?**

DPF regeneration is the dominant source of particle number (PN) emissions for the two diesel cars tested. When PN emissions from regeneration are averaged over around 400km (the distance between two regenerations found in our tests) and added to the emissions measured on non-regenerating tests the regeneration contributes between 55-99% of all particles emitted by the car. The DPF regenerations, and therefore the large spike in emissions, measured during this testing program lasted for up to 9 minutes/15 km of driving, however Opel/ Vauxhall claim on their website that DPF regenerations on their vehicles can last up to 25 minutes[[13]](#footnote-12).

1. **How are emissions from regeneration currently regulated?**

Emissions of some of the pollutants emitted during DPF regeneration are regulated, under WLTP (‘Worldwide Light Vehicle Test Procedure’) and ‘Real Driving Emissions’ (RDE) regulations, but poorly. Emission limits for all of the currently regulated gaseous pollutants, PM and PN do not need to be met on tests during which a DPF regeneration occurs unless a regeneration occurs on two consecutive tests. In that case emissions standards only need to be met on the second test. Otherwise, emissions from regeneration are regulated through the use of so-called ‘ki factors’ which essentially average the high emissions from regeneration over several hundred kilometers (the distance between two consecutive regenerations). The averaged increase is then added to the results of the regulatory tests and if the emission limits are respected then the car passes the test. When it comes to PN emission on regenerating tests, even this method of averaging does not apply. PN emissions are completely unregulated as neither PN emission standards or ki factors need to be determined or met for PN.

1. **Does this mean that DPFs should not be fitted to diesel vehicles?**

No. Diesel particulate filters (DPFs) are important in reducing the amount of particle pollution from diesel vehicles. However, these filters have to be cleaned to prevent them from clogging. When the DPF cleaning/regeneration occurs there is a large increase in the number of particles emitted, in this case exceeding the current particle number emissions limits on those tests. This means that the DPF did not reduce the number of particles emitted from diesel cars to below the legal limit during all driving conditions and large spikes in particle pollution from diesel cars still occur. Therefore, if diesel cars are unable to respect the emissions limits under all driving conditions, they cannot be referred to as ‘clean’.

1. **Could this be a problem for petrol cars fitted with gasoline particle filters?**

For petrol cars, these types of regenerations are much less likely as petrol cars generally have much higher exhaust temperatures which allow the gasoline particle filter to be regenerated almost continuously, without any change to the engine operating conditions. This continuous regeneration means emissions from GPF regeneration are captured by the current regulatory tests during which emission limits still have to be respected.

1. **Could this be a problem for heavy duty vehicles as well?**

Heavy duty diesel vehicles are also fitted with diesel particulate filters, which also require cleaning. Whether high PN emissions due to regeneration also occur will depend on the strategy that each manufacturer uses to clean the DPF. This could potentially also be an issue for heavy duty vehicles and deserves to be further investigated.

1. **Could this be a problem for vans as well?**

Yes, vans are also fitted with diesel particulate filters and it is likely that they undergo DPF regenerations in a similar way to passenger cars. Given that vans often drive many kilometers within town and city centers, for example as delivery vans, it is an issue that should be further investigated.

1. **Why did T&E investigate pollution from DPF filters when compressed natural gas (CNG) and port fuel injection (PFI)[[14]](#footnote-13) cars aren’t even fitted with filters?**

For CNG and PFI cars, the case is clear: Both produce large numbers of particles as several studies, including by the European Commission’s Joint Research Center[[15]](#footnote-14) and DownToTen[[16]](#footnote-15) projects, have shown. In future regulation, they must therefore be required to adhere to a particle number emission limit which is not the case today. However, with diesels fitted with DPFs there are many car manufacturers that are claiming diesel cars are now ‘clean’[[17]](#footnote-16),[[18]](#footnote-17),[[19]](#footnote-18),[[20]](#footnote-19) and that, thanks to DPFs, particle pollution is no longer a problem from diesel cars. This study by T&E shows that these claims are not true and only exist due to loopholes in the current regulation.

1. **Why are these small particles unregulated, and can we regulate them now?**

At the time of the formulation of the last Euro emission standard the technology was not yet mature to measure particles smaller than 23nm reliably. However, three EU funded projects as well as the PMP working group have been working on developing the technique for measuring particles down to 10nm both on the road and in the laboratory. The Clove consortium, tasked by the European Commission to work on the future post-Euro 6 emission standard, has stated that measurement of emissions down to 10nm is ready for inclusion in future emissions regulations[[21]](#footnote-20). Horiba, a company specialising in emission analysis equipment is also about to start selling/offering upgrades of laboratory-based particle emissions equipment in this size range[[22]](#footnote-21) indicating that the technology is mature for commercial and regulatory deployment. Accurate measurement of particles smaller than 10 nm still requires further development.

1. **Is transport a major source of ammonia emissions compared to other sources like agriculture?**

The Clove consortium, tasked by the European Commission to work on the future post-Euro 6 emission standard, as well as several other studies have presented evidence to show that transport is often the dominant source of ammonia emissions in cities[[23]](#footnote-22),[[24]](#footnote-23). A study by Ricardo has also shown that the emissions of ammonia from diesel cars has been steadily increasing in recent years due to the increased use of selective catalytic reduction (SCR) technology[[25]](#footnote-24). This technology uses ammonia to reduce the amount of nitrogen oxides (NOx) emitted out of the tailpipe However, if the system is not designed properly, ammonia can slip out of the tailpipe in sometimes very large amounts, as was the case for the Opel/Vauxhall Astra tested.

1. **Why is the conformity factor of 1.5 not applied to PN emissions from these tests?**

The conformity factor for PN of 1.5 applies to RDE tests conducted on the road with a portable emissions measurement system (PEMS). The conformity factor is not to be confused with the Ki factor: The Ki factor is a method to account for emissions from regeneration (see question 13). The conformity factor exists only to account for the larger measurement error associated with the measurement of particle number emissions using PEMS equipment compared to laboratory based equipment. While the test cycles used in this programme were based on RDE drives, laboratory equipment was used for the measurement of particles. As such, no conformity factor should be applied.

1. The Telegraph, David Motton, [‘Emission tests ‘substantially underestimate’ pollution pumped out by diesels’, 29th May 2014](https://www.telegraph.co.uk/motoring/news/10862975/Emission-tests-substantially-underestimate-pollution-pumped-out-by-diesels.html) [↑](#footnote-ref-0)
2. Air Quality Expert Group, [‘Fine Particulate Matter (PM2.5) in the United Kingdom’, 2012](https://uk-air.defra.gov.uk/assets/documents/reports/aqeg/pb13837-aqeg-fine-particle-matter-20121220.pdf) [↑](#footnote-ref-1)
3. AA, ‘DPFs can be problematic’ accessed 16/10/2019 <https://www.theaa.com/driving-advice/fuels-environment/diesel-particulate-filters> [↑](#footnote-ref-2)
4. Estimation based on data from ICCT’s Pocketbook, Element Energy and ACEA. Some manufacturers implemented DPFs on diesel vehicles before the Euro 5b legislation came into force, however these were not included in the total DPF fleet figure due to the difficulty associated with obtaining data for which vehicles were and were not fitted with a DPF and detailed enough EU-wide registration data per model. [↑](#footnote-ref-3)
5. [Commission Regulation (EU) 2018/1832](https://eur-lex.europa.eu/eli/reg/2018/1832/oj) [↑](#footnote-ref-4)
6. Unless a DPF regeneration occurs on two consecutive tests, in this case the emission limits have to be respected on the second test. [↑](#footnote-ref-5)
7. M. Leblanc, L. Noël, B. R’Mili, A. Boréave, B. D’Anna, S. Raux, [‘Impact of engine warm-up and DPF active regeneration on regulated & unregulated emissions of a Euro 6 Diesel SCR equipped vehicle’, Journal of Earth Sciences and Geotechnical Engineering, 2016](http://www.scienpress.com/Upload/GEO/Vol%206_4_3.pdf) [↑](#footnote-ref-6)
8. Vauxhall website, ‘How do I clean my diesel particulate filter?’ Accessed 22/10/2019, <https://www.vauxhall.co.uk/help-centre/owners/cleaning-my-diesel-particulate-filter.html> [↑](#footnote-ref-7)
9. CLOVE, ‘Study on post-EURO 6/VI emission standards in Europe, Progress in task 2.2: Development of a new array of tests’, Presentation to the Advisory Group on Vehicle Emission Standards (AGVES), Brussels, October [↑](#footnote-ref-8)
10. JATO Dynamics, [Data for Automotive News Europe, Volume 10, Issue 2, February 2019](https://www.jato.com/tag/european-car-registrations/) [↑](#footnote-ref-9)
11. The large variations result from the fact that contrary to NOx emissions, absolute numbers of particles emitted per kilometre are much larger (hundreds of billions instead of hundreds for NOx), which means variations of PN emissions in percentages also result in a wider range. [↑](#footnote-ref-10)
12. The Telegraph, David Motton, ‘Emission tests ‘substantially underestimate’ pollution pumped out by diesels’ 29th May 2014 [↑](#footnote-ref-11)
13. Vauxhall website, ‘How do I clean my diesel particulate filter?’ Accessed 22/10/2019, <https://www.vauxhall.co.uk/help-centre/owners/cleaning-my-diesel-particulate-filter.html> [↑](#footnote-ref-12)
14. In PFI cars the fuel is injected prior to the valve and cylinder, where the combustion happens. Alternatively, many petrol cars now use direct injection where instead of having the fuel mixed in with the air prior to the valve, the slurry of fuel is put directly into the combustion chamber. See Autonation Drive: [Direct Injection versus Port Fuel Injection](https://www.autonationdrive.com/blog/2016/July/05/direct-injection-versus-port-fuel-injection.htm), accessed 11/12/2019 [↑](#footnote-ref-13)
15. Ricardo Suarez-Bertoa, Victor Valverde, Michael Clairotte,Jelica Pavlovic, Barouch Giechaskiel,Vicente Franco, Zlatko Kregar, Covadonga Astorga, [‘On-road emissions of passenger cars beyond the boundary conditions of the real-driving emissions test’, Environmental Research, 2019](https://reader.elsevier.com/reader/sd/pii/S001393511930369X?token=4935D43FB17F18974A6C5E56AA8CB5F45BD984A363A95FED4CB9E52D1A506C810F0ABB1BF171367B810FB8C6FBD4F918) [↑](#footnote-ref-14)
16. Down to ten, ‘particle emissions measurement on CNG vehicle focusing on sub-23nm’, TAP conference 2019 [↑](#footnote-ref-15)
17. CNN Business, Ivana Kottasová, [‘Volswagen nearly killed diesel cars. Now it says they’re back’, 30th of January 2019](https://edition.cnn.com/2019/01/30/business/diesel-volkswagen-sales/index.html) [↑](#footnote-ref-16)
18. [www.peugeot.co.uk/bluehdi](http://www.peugeot.co.uk/bluehdi) accessed 18/11/2019 [↑](#footnote-ref-17)
19. <https://www.spokanemercedes.com/mercedes-benz-clean-diesel/> accessed 18/11/2019 [↑](#footnote-ref-18)
20. <https://www.vauxhall.co.uk/fleet/range/ecotec/diesel-engines.html> accessed 18/11/2019 [↑](#footnote-ref-19)
21. CLOVE, ‘Study on post-EURO 6/VI emission standards in Europe, Progress in task 2.2: Development of a new array of tests’, Presentation to the Advisory Group on Vehicle Emission Standards (AGVES), Brussels, October [↑](#footnote-ref-20)
22. Horiba, Marcus Reiker, ‘Pems4Nano-project overview presentation,PaREGENn and PEMs4Nano joint final event, 12th &13th of November 2019, Santa Olivia, Spain [↑](#footnote-ref-21)
23. C. Livingston, P. Rieger and A. Winer, [‘Ammonia emissions from a representative in-use fleet of light and medium-duty vehicles in the California South Coast Air basin’, Atmospheric Environment, 2009](https://ui.adsabs.harvard.edu/abs/2009AtmEn..43.3326L/abstract) [↑](#footnote-ref-22)
24. W. Battye, V.P. Aneja and P.A. Roelle, [‘Evaluation and improvement of ammonia emissions inventories’, Atmospheric Environment, 2003](https://meas.ncsu.edu/airquality/pubs/pdfs/Ref%20100.pdf) [↑](#footnote-ref-23)
25. [Ricardo, Rebecca Rose, ‘Real world measurements of ammonia emissions from vehicles’, routes to clean air , 30th October 2018.](https://www.slideshare.net/ies-uk/real-world-measurements-of-ammonia-emissions-from-vehicles-rebecca-rose) [↑](#footnote-ref-24)