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Briefing Particle emissions from petrol cars

Summary

Vehicle tests show that without the use of gasoline particulate filters (GPF), more particles are emitted from gasoline direct injection (GDI) engines than diesels. On the road, GDI vehicles may therefore exceed future European emissions limits – the Euro 6 standard. The cost of a filter to eliminate particle emissions is low (around €50), with no fuel economy penalty. Despite this, carmakers are declining to fit filters to GDI cars – thereby worsening urban air pollution. T&E calls upon carmakers to ensure GDI cars minimize their particle emissions by fitting filters. Carmakers should not use unreliable 'engine management' approaches to try and control emissions, as these produce much higher numbers of particles, particularly during on-road driving.

Context

Air pollution in the EU is estimated to contribute to 406,000 deaths annually and cause over 100 million lost days of work, costing the EU economy €330-940 billion per year.[1] Small particles in the air pose the greatest risk to health, penetrating deep into the lungs and being absorbed into the blood, causing a range of illnesses and even death. The World Health Organisation recently confirmed that air pollution causes cancer.[2] Over 90% of the EU population is estimated to be exposed to levels of particulate pollution that represents a risk to health, and about a third of all EU citizens are exposed to levels of particulate pollution above EU permitted levels. [3]

Particles also contribute to global warming through emissions of black carbon. EU-wide, vehicles contribute about a fifth of all fine particulates ($PM_{2.5}$)[4] with diesel exhaust, at present, the main source. A range of new evidence, however, shows that petrol cars with gasoline direct injection (GDI) engines can produce even higher numbers of particles than modern diesels.

Will particulate emissions from GDI cars meet future limits?

Limits on the amount of air pollution that can be emitted from vehicles are being progressively reduced through EU regulations. All vehicles driven in the EU must demonstrate they meet the emission limits before they can be sold. Despite these controls, real world emissions of some pollutants (notably nitrogen oxides from diesel cars) are much higher on the road than in tests, as carmakers use a range of "cycle beating" techniques to artificially lower test results.[5] Until recently petrol cars were considered to be a minor source of particles. However, the introduction of more efficient (and lower CO_2) Gasoline Direct Injection (GDI) engines is increasing the number of particles coming from petrol cars. GDI is expected to largely replace current Port Fuel Injection (PFI) gasoline engines by around 2020[6] and reverse the trend of an increasing market share of diesel cars. It has been estimated that by 2030 particle numbers from GDI vehicles will be more than those of diesels.[6] GDI engines typically emit between 10 to 40 times more particles (by mass) than PFI engines and over one-thousand times the number of particles.

Without future controls particulate emissions from GDI petrol vehicles will be more than from diesels

Diesel particulate filters (DPFs) have been in use successfully for over a decade and are used on all cars to remove particles in the exhaust. As a result they emit around ten-times less particles than GDI cars. From 2017, new Euro 6 emissions limits will also apply to GDI engine cars and particle numbers in exhaust must be less than 6 $x10^{11}$ per km. But there is a widespread concern that these cars will only meet the Euro 6 limit in official tests, using specially prepared vehicles and controlling combustion using the engine management system. In real-world operation, emissions of particles will be much higher. This is a similar problem to that with diesel NOx emissions, fuel consumption and CO_2 emissions,[7] for which test results vary widely from those achieved in normal operation.

How can GDI particle emissions be reduced?

Testing performed on behalf of T&E and others shows that without fitting a Gasoline Particulate Filter (GPF) to the exhaust, GDI cars produce large numbers of particles. GPFs are cheaper, simpler, more compact and more durable than those used in diesels, since the higher temperature of the GDI exhaust prevents an accumulation of soot and enables continuous regeneration of the filter. The use of a GPF has the potential to reduce particle numbers by a factor of 1000 or more.

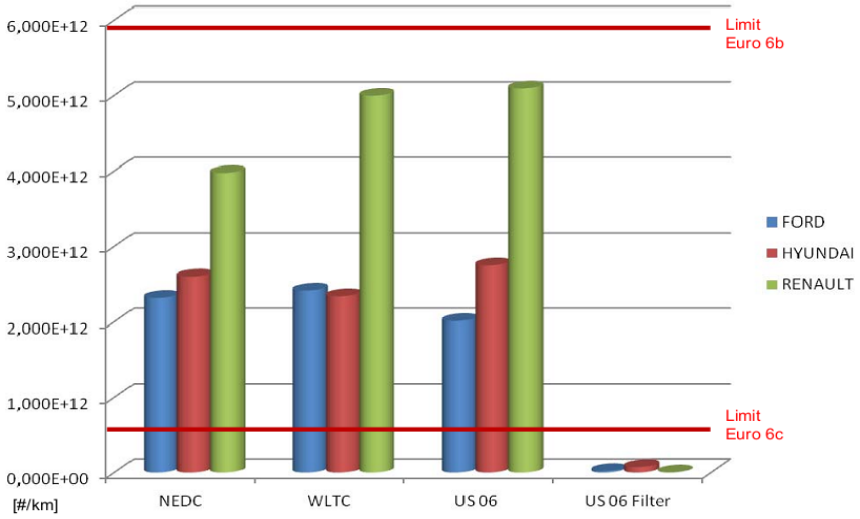
What testing has been performed?

T&E commissioned the independent vehicle study group TUV Nord to test three different GDI engine cars. Tests were performed with and without a GPF.[8]

Type No.	Manufacturer	Trade name	Trans-mission	Engine type	Engine capacity [cm^3]	Power [kW]	Emis-sion approval	Mile-age [km]	Registrati-on year
1	Ford	Forcus Tunier	Manual 6 gear	1.0l EcoBoost	998	92	Euro 5	10,681	2013
2	Hyundai	i 40 Kombi	Manual 6 gear	1.6l GDI	1591	99	Euro 5	11,000	2013
3	Renault	Megane	Manual 6 gear	1.2l Energy TCe 115	1198	85	Euro 5	14,500	2013

The vehicles were in good condition and had been maintained at appropriate intervals. The testing followed standard procedures in a laboratory using the current official system for measuring exhaust emissions - the New European Drive Cycle (NEDC). Measurements were also made using a new test scheduled to be introduced from 2017, the World Light Duty Cycle – WLTC; and the Supplemental Federal Test Procedure (US 06) that has strong accelerations and therefore representative of more typical real-world driving. Each test was conducted twice and the average taken. Particle numbers were measured using procedures specified in Commission Regulation (EC) 715/2007 using a Condensation Particle Counter (CPC).

What did the results show?



All vehicles tested complied with the required Euro 5 limits[9] during the NEDC test that is currently used. The WLTC test showed slightly higher emissions results, and the US06 cycle even higher emissions.

Vehicles met the Euro 6b standard (6,0E+12) that comes into force for all new cars in 2015; but none met the Euro 6c limit (6,0E+11) that will be introduced in 2017, and is already met by diesel cars. This indicates further emissions controls will be necessary for all these vehicles. The Ford had the lowest particle number, overall being marginally better than the Hyundai car. The Renault car particle number emissions were approximately twice as high as the Ford.

The test with the GPF fitted was conducted using the US 06 test since this, generally, produced the highest emissions. This test was repeated for each car and the average taken. With the filter fitted the mass of particles declined by a factor of 3 for the Ford and the Hyundai and a factor of 4 for the Renault. The particle number emissions were reduced by a factor of around 2000 achieving a level similar with normal (unpolluted) air.

Is it cost effective to fit a GPF?

The costs of fitting a GPF to meet Euro 6 limits have been estimated in a range of studies. The respected ADAC estimate[11] the cost is just €50, whilst the Commission[12] is more cautious with a range of €40 - 130.

	Societal benefit per GPF[10]
Small car	31-162
Medium / Large car	36-191
Van	25-130

The Commission also estimate the overall societal benefits are of the same order. The testing performed for T&E[8] shows there is no loss in efficiency through fitting a GPF, contrary to claims from carmakers. With a reduction in black carbon emissions there is likely to be a benefit in terms of overall climate forcing emissions.

Conclusions - what should be done?

A range of vehicle environmental regulations are being undermined by carmakers manipulating testing conducted in the laboratory to produce results that are much lower than those achieved by the same car on the road. These include:

- Euro 5 limits for nitrogen oxide (NO_x) emissions from diesel cars
- CO_2 limits for cars
- Noise limits for cars.

The testing performed by TUV [8] showed that all the tested vehicles met Euro 6b limits using the official NEDC test that comes into force in 2014. None of the tested vehicles met the more stringent 2017, Euro 6c limits on any test cycle. These limits are equivalent to the limits already applied to diesel cars. The results for the Renault car were significantly higher than for the other carmakers, particularly on the new WLTC and US 06 tests. In contrast, once a GPF was fitted to each of the cars, the mass of particles emitted declined by a factor of 3 to 4 and number of particles by a factor of over 1000. Whilst future developments in GDI

engines may lower particle emissions from GDI engines, there is no prospect of lowering emissions to the extent achieved with the GPF, a solution costing as little as €50.[13]

These results are consistent with a number of other published studies.[14, 15,] These highlight that GDI engines have high emissions, particularly during the "cold start" conditions at the start of the test and when the engines are used in combination with a turbocharger, which slows down how quickly the catalyst reaches a working temperature.[16] Vehicle manufacturers are clearly aware of the issue, but, to date have declined to fit a GPF to address the problem despite the overwhelming benefits and low cost.

Vehicles are the most important cause of the urban air pollution crisis in Europe. The shift to GDI engines for petrol cars offers important fuel economy and CO_2 benefits but runs the risk of worsening particle pollution, the most important cause of deaths and ill-health. A GPF is a cheap, simple and effective solution that carmakers should fit to cars with GDI engines.

Further information

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