The Netherlands is having trouble with the EU standards for respirable dust (PM 10). The Dutch Council of State recently blocked a number of residential development projects because local conditions failed to meet the PM 10 standard. Research by the Nano Structured Materials group at TU Delft shows that some 5% of the seven or so million motor vehicles currently on the road in the Netherlands are responsible for over 40% of all respirable dust emitted by traffic. Although most of these super polluters are diesel-engined, they also include vehicles using lean-burn engines with direct fuel injection from Volkswagen, Mercedes, BMW, Mitsubishi, and Honda. The TU Delft nanotechnologists have developed a respirable dust meter that can be used to locate the worst offenders in moving traffic.
The Netherlands, once a shining example in environmentally-conscious Europe, seems to have gone downhill a bit to its current status of Europe’s tramp. One of the most recent environmental problems dogging the country is that of respirable dust. The Dutch Council of State recently blocked a number of building plans because local respirable dust conditions did not meet EU-wide standards. At the European Commission, Dutch State Secretary Pieter van Geel of the ministry of Housing, Spatial Planning, and the Environment argued for emission controls at source in the form of soot filters on diesel engines. To date it remains unclear whether the European Commission will grant permission for this partial solution. Whatever happens, vehicles with direct fuel injection engines producing respirable dust would also have to be fitted with filters. Fortunately, the Dutch government now appears to have been presented with the ideal solution by the nanomaterial scientists at the Delft ChemTech department. Professor Dr Andreas Schmidt-Ott of the Nano Structured Materials section considers respirable dust a somewhat neglected subject.

“Some estimates put the annual number of deaths caused by respirable dust as high as 10,000 to 15,000 in the Netherlands alone. Those numbers far exceed the number of traffic deaths, which always hit the headlines. Traffic is the main producer of respirable dust in the form of soot particles, which in this case are ultrafine in size, less than 0.1 micrometres across. All in all, some 3% of the mortality rate can be attributed to the respirable dust emissions of motor vehicles.”

It’s not so much the age of a motor vehicle that causes problems as a lack of proper maintenance. At least, Schmidt-Ott suspects as much, based on a Californian study from 1995 in which CO and hydrocarbons were measured (i.e. no soot particles) and which also showed that a relatively small number of super polluters are responsible for a considerable part of the total emission.”

**By the roadside** Until recently, the emission of respirable dust (which in the case of traffic amounts mostly to soot) could only be measured as an overall value, or by inserting a probe into a vehicle’s exhaust pipe, as is done at the annual MOT test. There were no reliable methods for measuring the soot emission of individual vehicles as they pass on the road. Helped by previous research by German professor Schmidt-Ott and with the perseverance of Indonesian student Andy Kurniawan, we now have a system that can measure the soot emission of individual vehicles from the roadside, albeit in rather embryonic form.

“The measuring setup,” Schmidt-Ott explains, “consists of a carbon sensor and a carbon dioxide sensor. The carbon sensor is a further development of some of my earlier work I did at the ETH in Zurich. The principle of the sensor is that you charge the carbon particles by means of an ultraviolet light source. Carbon particles are highly selective for a certain photoelectrical effect. The charge can be measured and forms an indication of the amount of elementary carbon (EC); in other words, soot. At the same time you measure how much carbon dioxide is emitted from the exhaust pipe. The relative quantities of carbon and carbon dioxide form a measure of the amount of carbon particles emitted per litre of fuel. As both of these materials are so easy to detect, there is no need for an exhaust probe, and you can simply sit by the roadside with your equipment. Ambient factors such as wind velocity have little or no effect on the measurements, as the minute soot particles behave like a gas. The only time you cannot use the system is when it rains, for then the carbon and gas particles will behave differently, which would affect the readings.”

Of course, you cannot measure too far away from the exhaust pipes of passing vehicles if you want to avoid blurring the separate peak readings, which would make it very difficult to attribute readings to individual motor vehicles. Schmidt-Ott: “Our method already is more sensitive and faster than the measuring equipment used in the United States to monitor passing motor vehicles.”

The soot meter has been tested under field conditions, with Kurniawan limiting the test to passenger cars. He measured the emissions of some 1250 vehicles.

Although knowledge about the noxiousness of soot emissions has grown, the relative number of diesel-powered cars has increased. In part this may be attributable to the fact that over the past years diesel engines — which have always been more economical to run — have become even more fuel-efficient and less polluting. Diesel-engined cars have been fitted with catalytic converters for some years now, and they recently became available with a soot filter. Nonetheless, in the Netherlands the diesel fleet as a whole accounts for a major contribution to the total quantity of respirable dust in towns. Elsewhere in Europe, diesel emissions in towns have also become a problem.
Petrol-engined cars with direct fuel-injection have been being marketed for quite some time now. These engines produce soot that is many times finer than the type of soot from diesel engines. Recent epidemiological studies show that this finer soot poses an even greater danger to public health.

**Direct-injection petrol engines**

The current discussion about the reduction of respirable dust focuses on diesel-engined vehicles (which is hardly surprising, considering the number of diesel cars). Nonetheless, cars fitted with lean-burn petrol engines, in which the fuel is injected directly into the cylinders, also produce considerable quantities of respirable dust, tending to close the gap with modern diesel-powered vehicles. Although diesels produce about ten times as much respirable dust by mass as do direct-injection lean-burn engines, the number of particles is practically the same according to Dr Michiel Makkee, a lecturer at ChemTech. As an exhaust gas specialist he pioneered the soot filters currently fitted to the products of French car maker Peugeot. This means that the respirable dust emitted by direct-injection petrol engines is of a lower magnitude of size than its diesel counterpart, and the smaller dust particles are the most lethal to our health. The larger particles tend to be filtered out by our nose and bronchial tract, but the smallest particles can travel down to the remotest parts of our lungs.

The European Commission is proposing that as of 2008 new direct-injection lean-burn petrol-engined cars should be fitted with a closed soot filter, but so far the measure is still awaiting approval by the European Parliament. The current number of cars fitted with a lean-burn engine is relatively low, which is why the Dutch environment minister is not unduly concerned about the respirable dust standard for such engines. However, the number of these cars is expected to increase rapidly. Direct-injection engines are the automotive industry’s answer to the covenant between the European industry and the European Commission to limit the carbon dioxide emission of cars to 140 grams per kilometre. Although direct-injection engines are much more fuel-efficient than standard petrol engines, the latter, if properly maintained, produce practically no respirable dust at all.

**Politics and legislation**

None of this means that State Secretary van Geel will be able, any time soon, to send out his minions to track down super polluters, armed with an off-the-shelf respirable dust meter complete with data processing unit.

“This is just an experimental setup,” Schmid-Ott says. “The conversion of field readings to useful pollution concentrations still has to be done by hand, which has kept Andy very busy. Nonetheless, these are matters for further development.”

Schmid-Ott has been getting a lot of response at conferences, and he expects that many more people will become interested and contact TU Delft when an article by himself and Andy Kurniawan is published in the highly regarded Environmental Science and Technology magazine.

“At a conference in Canada I had some interesting contacts with scientists from Japan, where respirable dust is also a problem. It would be nice if the Delft measuring method were to prove a breakthrough in this field. But funding is needed to develop the equipment into a commercially viable, portable device. Perhaps we the industry will help, but for the time being no one has made any concrete moves. We will simply have to wait for politicians’ interest being aroused in the possibility of in situ soot emission monitoring.”

“Current legislation is concerned solely with the standards for new motor vehicles, and these will become increasingly strict. However, if you fail to maintain a motor vehicle properly, within a few years its emission of respirable dust may have increased manifold, and will keep climbing. You won’t even hit the MOT limit before the emission is a thousand times as much as the original value. If you want to be serious about solving the respirable dust problem, you should start by measuring the emissions of individual motor vehicles. This measuring system lets you easily spot the most polluting cars, but it takes legislation to actually make it work. The first step might be to check whether the cars actually meet the MOT standard.”

Linking the system to a camera and a registration number recognition system would enable a summons to be sent to each polluting motorist to have a new MOT test done at short notice. All it takes now is for The Hague (or Brussels) to act.

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Air from the street is continuously sucked in through a tube connected to a carbon sensor and a CO₂ sensor, the signals of which are fed to a data recorder. The measuring location is 60 metres before a crossing, in other words a point at which most of the traffic will be decelerating. This avoids unrealistically high emission readings from cars that might otherwise be accelerating. The current measuring setup is capable of distinguishing between exhaust plumes of cars passing at intervals of at least 8 seconds.