

Future Diesel

Exhaust gas legislation for passenger cars, light-duty commercial vehicles, and heavy duty vehicles - Updating of limit values for diesel vehicles -

Summary from the UBA report “Future Diesel”, July 2003:

European legislation on exhaust emissions has made major progress with the adoption of limit value standards up to and including Euro 4 for passenger cars and light-duty commercial vehicles and Euro V for heavy-duty engines. Exhaust gas limit values need to be updated primarily for vehicles with diesel engines.

Article 3 of Directive 98/69/EC (passenger cars and light-duty vehicles), the joint position of the Council on Directive 99/96/EC (heavy-duty engines), and the conclusions of the Environment Council on 18 and 19 December 2000 on evaluation of the Auto Oil II programme contained corresponding instructions to the Commission. In a note on the topic of the “concept of the enhanced environmentally friendly vehicle (EEV) for light vehicles” dated 11 February 2003, the Commission stated that it would now attend to updating the exhaust gas limit values for passenger cars and light-duty vehicles.

The proportion of diesel passenger cars among new registrations in Germany has more than doubled in recent years and has now reached almost 40%. The trend for particulate emissions indicates that by 2020 the rapidly rising share of diesel passenger cars will lead to an increase in particulate emissions from passenger cars by a factor of 2.3 and therefore to an increase in particulate emissions from road transport by a factor of 1.6 compared with earlier assumptions. Roadside monitoring stations have shown no reduction in particulates which would correlate with the previous lowering of limit values for exhaust gases. Action is required in this area.

The problem of fine particulate emissions is currently being discussed with regard to air quality. The World Health Organisation, the EU Commission, the National Research Council, and the environmental agency in the United States are highlighting fine particulates as one of the current priorities for environmental hygiene in Europe and the United States. There are also indications of carcinogenic effects. To protect health, the technically feasible particulate reduction of well over 90% must be required for diesel engines.

A total of approximately 800,000 people die in Germany each year (all causes of death). According to an expert’s report by Prof. Wichmann of GSF Neuherberg, approximately 1 to 2% of those deaths can be classified as premature deaths due to exhaust from diesel vehicles. According to the report, reducing particulate emissions as a risk-prevention measure, for example by using particulate traps, would prevent most of those premature deaths. The use of particulate traps would lead to a mean increase in the life expectancy of everyone in Germany by 1 to 3 months compared with the current situation.

With regard to NO_x emissions, modern diesel passenger cars have a considerable disadvantage compared with cars that run on petrol. They emit eight to ten times more nitrogen oxides, thereby contributing among other things to the formation of summer smog, which is harmful to health. The NO_x limit value for diesel passenger cars in Euro 4 is about three times higher than the limit for petrol cars.

Electronic injection systems in heavy-duty vehicles – first introduced with the Euro II limit value – allow different injection strategies to be used in the various ranges of the engine's characteristic curves. More recent studies have shown that Euro II engines are often deliberately optimised outside of the range of characteristic curves run in the type approval testing cycle to improve the specific consumption. This leads to a considerable increase in nitrogen oxide emissions. The consequence: in 2003, the mean NO_x emission factor for heavy-duty vehicles is about 40% higher than previously assumed, which corresponds to an additional gap in coverage of around 115,000 t NO_x in 2010.

Directive 1999/96/EC relating to measures to be taken against emissions from heavy-duty engines specifies a Euro V standard with an NO_x limit value of 2.0 g/kWh, which will apply to the granting of operating licenses for new engine types starting in 2008. Within the framework of calculations for the planned measures to be taken by the German federal government to comply with NEC Directive 2001/81/EC, it has been shown that that limit value should be cut in half again to 1.0 g/kWh. This is the necessary measure that has the absolute maximum potential for reducing NO_x. It must be taken into account when the EU Commission examines the Euro V limit values, particularly since similar circumstances exist in other European countries. That adaptation must be followed by a further reduction in the NO_x limit value for heavy-duty engines to 0.5 g/kWh from 2010 onwards.

Particulate emissions by diesel engines in passenger cars and commercial vehicles have already been considerably reduced in the past few years by making changes to engines, i.e. improving combustion. Additional changes to engines that could reduce particulates by some 30 to 50%, depending on the current initial state, have the potential to just comply with the Euro 4/Euro IV limit values that will apply to type approval testing of diesel passenger cars and heavy-duty engines from 2005. However, as things now stand, a greater reduction in particulates is possible only with aftertreatment of exhaust gases, i.e. by using a particulate trap. The proven reduction rates are well over 90% for particulate mass and reach 99.999% for the number of particulates. This has been demonstrated for a series of different particulate trap systems.

The entry into force of the Euro 4 limit values starting in 2005 will result in the use of particulate trap technology only in certain diesel passenger cars. According to publications by German car manufacturers, small- and medium-sized diesel passenger cars with manual transmissions will be able to get by without particulate traps, while diesel passenger cars with automatic transmissions that are medium-sized or larger and all heavy diesel passenger cars will probably need particulate traps.

Toyota has been testing the combination of an NO_x storage catalyst and a particulate trap, known as DPNR, since March 2002 in several European countries and plans to begin series production during the second half of 2003. It had not yet been determined in June 2003 which emission values could be achieved using the final design of the DPNR system for the European market. The German Federal Environmental Agency assumes that the DPNR system has the technical potential to comply with the limit values proposed in this report.

The PSA Peugeot Citroën group sold approximately 135,000 vehicles with series-produced particulate traps (known as FAP technology) internationally in 2001 and around 270,000 in

2002. PSA anticipates that approximately 1 million vehicles using FAP technology will be registered in 2004-2005.

A total of 14 passenger car types using particulate traps were offered for sale by French and Italian manufacturers in May 2003. The introduction of the particulate traps for another 20 passenger car types, including those made by German manufacturers, has been announced for autumn 2003 or early 2004.

FAP technology therefore defines the state of the art and the ability to set limit values on that basis. Almost all manufacturers of diesel passenger cars have particulate trap systems that are ready or almost ready for series production. The trap systems differ less with regard to the high rate of elimination, which can be achieved without difficulty, than with regard to their regeneration processes.

Particulate trap technology is also available for commercial vehicles. In the early 1990s, seven different systems with rates of elimination of over 90% were successfully tested on 1,100 city buses as part of the large-scale soot trap test by the German Ministry of the Environment. Numerous particulate trap systems have been approved in Switzerland after comprehensive testing of their suitability by public agencies (BUWAL [Swiss Agency for the Environment, Forests and Landscape] and SUVA, a major provider of compulsory accident insurance) for equipping construction machinery and their use is now mandatory at construction sites. According to the Association of German Transport Providers (VdV), approximately 5,000 city buses use particulate trap systems in Germany. More than 50,000 commercial vehicles throughout the world use trap systems, and USD 100 million in funding has been approved to equip 900,000 diesel vehicles as part of a programme in California.

It is currently doubtful whether the intention of the European Environment Ministers to implement particulate trap technology with the limit values for heavy-duty engines in Euro IV (and Euro V), which they declared when approving Directive 99/96/EC, will be fulfilled.

Updating the particulate limit values beyond Euro 4 for passenger cars and Euro IV/V for heavy-duty engines is technically feasible and necessary to prevent risks to health.

A further reduction of the mass-based particulate limit values by a factor of 10 is sufficient in principle to achieve the objective of protecting health, if effective particulate traps or equivalent technologies with a high reduction rate over the entire size range of the particulate matter, including nanoparticles, are used. To avoid misplaced efforts in the form of technical developments aimed primarily at reducing mass, the particulate count must be controlled to support measures to limit particulate mass.

A Particle Measurement Programme (PMP) experts' group was created in 2001 at ECE-GRPE level to verify the suitability of mass-based particulate control for the future and to propose a method for controlling particulates which is more oriented to their effect. At the time of this report (June 2003), Phase II of the project was mostly complete, and the results and concrete suggestions to be made by the group were taking shape. In addition to an improved gravimetric method (U.S. 2007), the CPC (condensation particle counter) offers a system with which the particle count (more precisely: the particle concentration in $1/\text{cm}^3$) can be measured in the size range relevant to the effect of particulates, in line with the requirements of a type approval test.

The following proposals for updating the exhaust gas limit values for passenger cars as Euro 5 from 2008 and for adaptation of Euro V for heavy-duty engines can be derived from the above remarks:

The Euro 5 particulate limit value for passenger cars of 0.0025 g/km (for the time being only mass-based) should correspond to an emission reduction of 90% compared with the Euro 4 limit value. At 0.08 g/km, the NOx limit value for diesel passenger cars should correspond to the value for petrol cars in Euro 4.

As an adaptation of Euro V to come into effect from 2008, a further reduction of particulate emissions from heavy-duty engines down to the particulate trap level is also necessary for the same reasons as for diesel passenger cars. Because the Euro IV/V particulate limit values of 0.02 g/kWh in the ESC and 0.03 g/kWh in the ETC can be fulfilled even without a particulate trap, the reduction rate of 90% which can reliably be achieved using a particulate trap should be applied to those values. That results in 0.002 g/kWh in the ESC and 0.003 g/kWh in the ETC. With regard to NOx emissions, the NOx limit value in the Euro V standard should be cut in half from 2.0 to 1.0 g/kWh, and a further reduction to 0.5 g/kWh should occur from 2010.

In addition, the total number of particulates emitted by both passenger cars and heavy-duty engines limits should be limited in the size range that is relevant for health. The PMP group will propose annexes to Directives for precise definition of the improved gravimetric procedure and the CPC procedure by the end of 2003. In addition to reducing mass, that would primarily guarantee a reduction in the ultra-fine particulates that are relevant to health. Defined measurement procedures for gravimetric determination of particulate emissions at a low level are available in principle in the United States for use from 2007. Studies by the automotive industry confirm the availability and the high accuracy of this improved measurement procedure.

The additional costs for Euro 5 designs in diesel passenger cars and the appropriate combinations of measures to fulfil the aforementioned limit values are estimated to be €200 to €400 per vehicle compared with Euro 4 technology. In the case of heavy-duty engines, the additional costs for emission control going beyond the approved Euro V standard and the necessary exhaust gas aftertreatment systems, which substantially represent a further optimisation of the systems necessary for Euro V, will be negligible. The total additional costs compared with a Euro III engine will be between €1,500 and €3,000, depending on the size of the engine.

Upshot:

Updating of the emission limit values for passenger cars, light-duty commercial vehicles, and heavy-duty engines is being called for nationally and internationally.

Implementation plans are currently being developed in the United States and Japan.

The health and ecological effects of particulates and NOx emissions necessitate a considerable reduction in limit values.

Technical control measures for an advanced emission level are already available. The costs per vehicle/engine of reducing emissions are slight and reasonable in relation to the effect achieved. Measurement procedures for clear-cut verification of limit values are available.