

as a PM reduction technology is severely limited. Data presented by one engine manufacturer regarding the existing Tier 2 PM standard shows that while a DOC can be used to meet the current standard even when tested on 2,000 ppm sulfur fuel, lowering the fuel sulfur level to 380 ppm enabled the DOC to reduce PM by 50 percent from the 2,000 ppm sulfur fuel.¹⁹⁵ Without the availability of 500 ppm sulfur fuel in 2008, DOCs would be of limited use for nonroad engine manufacturers and would not provide the emissions necessary to meet the proposed standards for most engine manufacturers. With the availability of 500 ppm sulfur fuel, DOC's can be designed to provide PM reductions on the order of 20 to 50%, while suppressing particulate sulfate reduction. These levels of reductions have been seen on transient duty cycles as well as highway and nonroad steady-state duty cycles.¹⁹⁶ As discussed in section VII of this preamble, the 2008 PM standard must be met on the existing nonroad steady-state cycle, the supplemental standards (nonroad transient cycle and NTE) are not implemented until 2013 for this power category. As discussed above, 24 engine families in the 25–50 hp range are within 30 percent of the proposed 2008 PM standard and are at or below the 2008 NMHC+NO_x standard for this power range, indicating that use of DOCs should readily achieve the incremental improvement necessary to meet the proposed 2008 PM standard.

Based on the existence of a number of engine families which already comply with the proposed 0.22 g/bhp-hr PM standard (and the 2008 NMHC+NO_x standard), and the availability of well known PM reduction technologies such as engine-out improvements and diesel oxidation catalysts, we project the proposed 0.22 g/bhp-hr PM standards is technologically feasible by model year 2008. All of these are conventional technologies which have been used on both highway and nonroad diesel engines in the past. As such, we do not expect there to be any negative impacts

with respect to noise or safety. In addition, PM reduction technologies such as improved combustion through the use of higher pressure fuel injection systems have the potential to improve fuel efficiency. DOCs are not predicted to have any substantial impact on fuel efficiency.

As discussed in section III.B, we have also proposed a minor change in the CO standard for the 25–50 hp engines, in order to align it with the standard for the 50–75 hp engines. As discussed in section III.B., this small change in the CO standard is intended to simplify EPA's regulations as part of our decision to propose a reduction in the number of engine power categories for Tier 4. The current CO standard for this category is 4.1 g/bhp-hr, and the proposed standard is 3.7 g/bhp-hr (*i.e.*, the current standard for engines in the 50–75 hp range). The model year 2002 certification data shows that more than 95 percent of the engine families in the 25–50 hp engine range meet the proposed CO standard today. In addition, a recent EPA test program run by a contractor on two nonroad diesel engines in this power range showed that CO emissions were well below the proposed standards not only when tested on the existing steady-state 8-mode test procedure, but also when tested on the nonroad transient duty cycle we are proposing in today's action.¹⁹⁷ Finally, DOCs typically reduce CO emissions on the order of 50 percent or more, on both transient and steady-state conditions.¹⁹⁸ Given that more than 95 percent of the engines in this category meet the proposed standard today, and the ready availability of technology which can easily achieve the proposed standard, we project this CO standard will be achievable by model year 2008.

ii. 2013 Standards

For engines in the 25–50 range, we are proposing standards commencing in 2013 of 3.5 g/bhp-hr for NMHC+NO_x and 0.02 g/bhp-hr for PM. For the 50–75 hp engines, we are proposing a 0.02 g/bhp-hr PM standard which will be implemented in 2013, and for those manufacturers who choose to pull-ahead the standard one-year, 2012

(manufacturers who choose to pull-ahead the 2013 standard for engine in the 50–75 range do not need to comply with the transitional 2008 PM standard).

PM Standard

Sections III.E.1 through III.E.3 have already discussed catalyzed diesel particulate filters, including explanations of how CDPFs reduce PM emissions, and how to apply CDPFs to nonroad engines. We concluded there that CDPFs can be used to achieve the proposed PM standard for engines ≥75 hp. As also discussed in section III.E.2.a, PM filters will require active back-up regeneration systems for many nonroad applications above and below 75 hp because low temperature operation is an issue across all power categories. A number of secondary technologies are likely required to enable proper regeneration, including possibly electronic fuel systems such as common rail systems which are capable of multiple post-injections which can be used to raise exhaust gas temperatures to aid in filter regeneration.

Particulate filter technology, with the requisite trap regeneration technology, can also be applied to engines in the 25 to 75 hp range. The fundamentals of how a filter is able to reduce PM emissions as described in section III.E.1. are not a function of engine power, and CDPF's are just as effective at capturing soot emissions and oxidizing SOF on smaller engines as on larger engines. As discussed in more detail below, particulate sulfate generation rates are slightly higher for the smaller engines, however, we have addressed this issue in our proposal. The PM filter regeneration systems described in section III.E.1 and 2 are also applicable to engines in this size range and are therefore likewise feasible. There are specific trap regeneration technologies which we believe engine manufacturers in the 25–75 hp category may prefer over others. Specifically, an electronically-controlled secondary fuel injection system (*i.e.*, a system which injects fuel into the exhaust upstream of a PM filter). Such a system has been commercially used successfully by at least one nonroad engine manufacturer, and other systems have been tested by technology companies.¹⁹⁹

We are, however, proposing a slightly higher PM standard (0.02 g/bhp-hr rather than 0.01) for these engines. As discussed in section III.E.1.a, with the

¹⁹⁵ See Table 2–4 in “Nonroad Diesel Emission Standards—Staff Technical Paper”, EPA Publication EPA420–R–01–052, October 2001. Copy available in EPA Air Docket A–2001–28.

¹⁹⁶ “Demonstration of Advanced Emission Control Technologies Enabling Diesel-Powered Heavy-duty Engines to Achieve Low Emission Levels: Interim Report Number 1—Oxidation Catalyst Technology, copy available in EPA Air Docket A–2001–28. “Reduction of Diesel Exhaust Emissions by Using Oxidation Catalysts,” Zelenka *et al.*, SAE Paper 90211, 1990. See Table 2–4 in “Nonroad Diesel Emission Standards—Staff Technical Paper”, EPA Publication EPA420–R–01–052, October 2001, copy available in EPA Air Docket A–2001–28.

¹⁹⁷ See Tables 6, 8, and 14 of “Nonroad Emission Study of Catalyzed Particulate Filter Equipped Small Diesel Engines” Southwest Research Institute, September 2001. Copy available in EPA Air Docket A–2001–28.

¹⁹⁸ “Demonstration of Advanced Emission Control Technologies Enabling Diesel-Powered Heavy-duty Engines to Achieve Low Emission Levels: Interim Report Number 1—Oxidation Catalyst Technology and “Reduction of Diesel Exhaust Emissions by Using Oxidation Catalysts”, P. Zelenka *et al.*, Society of Automotive Engineers paper 902111, October 1990.

¹⁹⁹ “The Optimized Deutz Service Diesel Particulate Filter System II”, H. Houben *et al.*, SAE Technical Paper 942264, 1994 and “Development of a Full-Flow Burner DPF System for Heavy Duty Diesel Engines, P. Zelenka *et al.*, SAE Technical Paper 2002–01–2787, 2002.