

baseline for Tier 4 engines, and the control strategies being developed for highway diesel engines. We do not believe that there are any nonroad engine applications above 25 horsepower for which these highway engine approaches will not work. However, given the diversity in nonroad equipment design and application, we believe that additional time will be needed in order to match the engine performance characteristics to the full range of nonroad equipment.

We believe that given the timing of the emissions standards proposed today, and the availability and continuing development of technologies to address temperature management for highway engines which technologies are transferrable to all nonroad engines with greater than 25 hp power rating, that nonroad engines can be designed to meet the proposed standards in the lead time provided in this proposal.

b. Nonroad Operating Conditions and Durability

Nonroad equipment is designed to be used in a wide range of tasks in some of the harshest operating environments imaginable, from mining equipment to crop cultivation and harvesting to excavation and loading. In the normal course of equipment operation the engine and its associated hardware will experience levels of vibration, impacts, and dust that may exceed conditions typical of highway diesel vehicles.

Specific efforts to design for the nonroad operating conditions will be required in order to ensure that the benefits of these new emission control technologies are realized for the life of nonroad equipment. Much of the engineering knowledge and experience to address these issues already exists with the nonroad equipment manufacturers. Vibration and impact issues are fundamentally mechanical durability concerns (rather than issues of technical feasibility of achieving emissions reductions) for any component mounted on a piece of equipment (e.g., an engine coolant overflow tank). Equipment manufacturers must design mounting hardware such as flanges, brackets, and bolts to support the new component without failure. Further, the catalyst substrate material itself must be able to withstand the conditions encountered on nonroad equipment without itself cracking or failing. There is a large body of real world testing with retrofit emission control technologies that demonstrates the durability of the catalyst components themselves even in the harshest of nonroad equipment applications.

Deutz, a nonroad engine manufacturer, sold approximately 2,000 diesel particulate filter systems for nonroad equipment in the period from 1994 through 2000. Many of these systems were sold for use in mining equipment. No other applications are likely to be more demanding than this. Mining equipment is exposed to extraordinarily high levels of vibration, experiences impacts with the mine walls and face, and high levels of dust. Yet in meetings with the Agency, Deutz shared their experience that no system had failed due to mechanical failure of the catalyst or catalyst housing.¹⁷⁰ The Deutz system utilized a conventional cordierite PM filter substrate as is commonly used for heavy-duty highway truck CDPF systems. The canning and mounting of the system was a Deutz design. Deutz was able to design the catalyst housing and mounting in such a way as to protect the catalyst from the harsh environment as evidenced by its excellent record of reliable function.

Other nonroad equipment manufacturers have also offered OEM diesel particulate filter systems in order to comply with requirements of some mining and tunneling worksite standards. Liebherr, a nonroad engine and equipment manufacturer, offers diesel particulate filter systems as an OEM option on its range of construction machine models. As of January 2000, 340 Liebherr machines have been fitted with PM filter systems.¹⁷¹ We believe that this experience shows that appropriate design considerations, as are necessary with any component on a piece of nonroad equipment, will be adequate to address concerns with the vibration and impact conditions which can occur in some nonroad applications. This experience applies equally well to the NO_x adsorber catalyst technologies as the mechanical properties of DOCs, CDPFs, and NO_x adsorbers are all similar. We do not believe that any new or fundamentally different solutions will need to be invented in order to address the vibration and impact constraints for nonroad equipment. Our cost analysis includes the hardware costs for mounting and shrouding the aftertreatment equipment as well as the engineering cost for equipment redesign.

Certain nonroad applications, including some forms of harvesting

equipment and mining equipment, may have specific limits on maximum surface temperature for equipment components in order to ensure that the components do not serve as ignition sources for flammable dust particles (e.g. coal dust or fine crop dust). Some have suggested that these design constraints might limit the equipment manufacturers ability to install advanced diesel catalyst technologies such as NO_x adsorbers and CDPFs. This concern seems to be largely based upon anecdotal experience with gasoline catalyst technologies where under certain circumstances catalyst temperatures can exceed 1,000°C and without appropriate design considerations could conceivably serve as an ignition source. We do not believe that these concerns are justified in the case of either the NO_x adsorber catalyst or the CDPF technology. Catalyst temperatures for NO_x adsorbers and CDPFs should not exceed the maximum exhaust manifold temperatures already commonly experienced by diesel engines (i.e., catalyst temperatures are expected to be below 800°C).¹⁷² CDPF temperatures are not expected to exceed approximately 700°C in normal use and are expected to only reach the 650°C temperature during periods of active regeneration. Similarly, NO_x adsorber catalyst temperatures are not expected to exceed 700°C and again only during periods of active sulfur regeneration as described in Section III.F below. Under conditions where diesel exhaust temperatures are naturally as high as 650°C, no supplemental heat addition from the emission control system will be necessary and therefore exhaust temperatures will not exceed their natural level. When natural exhaust temperatures are too low for effective emission system function then supplemental heating as described earlier may be necessary but would not be expected to produce temperatures higher than the maximum levels normally encountered in diesel exhaust. Furthermore, even if it were necessary to raise exhaust temperatures to a higher level in order to promote effective emission control, there are technologies available to isolate the higher exhaust

¹⁷⁰ "Summary of Conference Call between U.S. EPA and Deutz Corporation on September 19, 2002 regarding Deutz Diesel Particulate Filter System", EPA Memorandum to Air Docket A-2001-28.

¹⁷¹ "Particulate Traps for Construction Machines: Properties and Field Experience" J. Czerwinski *et al.*, Society of Automotive Engineers Technical Paper 2000-01-1923.

¹⁷² The hottest surface on a diesel engine is typically the exhaust manifold which connects the engines exhaust ports to the inlet of the turbocharger. The hot exhaust gases leave the engine at a very high temperature (800°C at high power conditions) and then pass through the turbocharger where the gases expand driving the turbocharger providing work. The process of extracting work from the hot gases cools the exhaust gases. The exhaust leaving the turbocharger and entering the catalyst and the remaining pieces of the exhaust system is cooler (as much as 200°C at very high loads) than in the exhaust manifold.