Summary of Engine/Equipment Issues
As Discussed Within the EPA Nonroad Work Group

Submitted October 15, 2001

This paper is designed to capture the principle issues pertaining to engine and equipment manufacturers as discussed within the EPA Nonroad Work Group sessions. We believe that all stakeholders were in general agreement on these issues, and they formed the basis of many of the Tier 3/Tier 4 scenarios that were developed for modeling purposes.

1. Leadtime

Leadtime refers to the amount of advanced notice afforded engine and equipment manufacturers prior to the implementation of a new standard. A sufficient period of time is necessary to allow adequate time to research, design, and develop new engines, and to successfully incorporate (research, design, and develop) these new engines into machines. The amount of leadtime required depends upon the magnitude of the engine and machine changes that are needed, and the state of 'readiness' of the technology that will be applied to meet the standards. In general, each successive tier of standards requires more leadtime than did the previous one. It was acknowledged that equipment manufacturers had a separate need for leadtime, over and above that of the engine supplier, to integrate these new engines and technologies into the equipment design and function.

2. Stability

Stability refers to the period of time between changes in standards that an engine and equipment manufacturer needs to recoup its investment in product design changes. Once again the number of years of stability needed depends upon the magnitude of the changes needed to comply, and the capital cost of making those changes. The Nonroad Workgroup agreed that 5 years was an appropriate period of stability for the Tier 3 and 4 standards and the associated technologies that were under consideration to meet those standards. The necessary period of stability for nonroad applications was analyzed during the development of the nonroad Statement of Principles (SOP). In the SOP the shorter period of stability agreed to between Tiers 2 and 3 was predicated on only minor machine changes being required. This is proving not to be the case.[1] The period of stability must also take into account an application's product cycle that defines when the manufacturer schedules major redesigns to a particular product line. Some sort of equipment flexibility program is useful in addressing machines that will incur particularly significant changes, experience exceptional performance impacts, are produced in very low volumes, or face other unique situations.

Some manufacturers have concluded that Tier 3 and its requirement for cooled-EGR technology results in a significant heat rejection increase, and that the equipment will require a major redesign for Tier 3. A Tier 4 requirement to add exhaust aftertreatment will cause another major redesign to follow that. The appropriateness and/or adverse impacts of requiring multiple engine and equipment redesigns back-to-back must be studied for their economic repercussions on these industries and the user community.

3. Staggered Implementation

Separate and distinct from the need for adequate leadtime and stability for each individual engine and machine model is the difficulty that many manufacturers have in dealing with tens if not hundreds of

[1] The Joint European Industry Group has called for 7 years time between stages in order to accommodate the additional noise directive imposed in the EU.

different models. Different emissions standards have been established for various power levels of engines, reflecting different emissions capabilities either in terms of the types of technologies that are available or the cost-effectiveness of those technologies. These different categories must be implemented over a three to four year period of time to allow the broad-line engine and/or equipment manufacturer to properly manage its resources. The exact number of years of phase-in depends upon the breadth of power categories under consideration. The original Tier 1 standards promulgated in 1994, and Tier 3 as it is known today, spanned 37 to 560 kW and a three-year implementation was acceptable. Tier 2 spanned all power levels and its implementation spanned six years, partially as a result of the need to manage the workload and partially as a result of the need to maintain an adequate period of stability.

4. Technology Transfer Timing (2+ years)

Practical experience has shown that it takes a minimum of 2 years to transfer on-highway engine technology to nonroad engines, and to then design those nonroad engines into nonroad machines. There is only a very limited power range of on-highway engines that have off-highway counterparts (130 – 450 kW) and engines that do not have on-highway counterparts typically require more than a two-year lag. Also, it was noted that adopting advanced emission control measures for engines <75 kW and >450 kW raise unique challenges compared to engines within the power range of 75 to 450 kW. Since EPA has not adopted any emission standards beyond the current Tier 2 standards for engines <37 kW and ≥560 kW, there has been no Tier 3 or 4 development work started on these engines and machines. Engine builders have identified technical issues regarding the ability to reduce emissions from small engines and from very large engines. The transferability of on-highway-like technologies to small engines and to very large engines has not been investigated, and it may not be feasible or cost-efficient to address these categories which represent very low populations and may contribute a minimal amount of emissions inventory due to their low operating hours or remote locale of operation. Finally, many of the nonroad engine suppliers have no on-highway product lines to gain experience from, and no opportunity to spread the development costs over both sets of engine lines.

The effective date for implementation is thus a function of four somewhat-independent variables: lead-time, stability, implementation stagger, and the time needed for technology transfer. The implementation date for each power category must satisfy each of these four criteria.

Adoption of the On-Highway Model for NOx Aftertreatment Phase-In Period

Much discussion was devoted to the schedule for implementation of exhaust aftertreatment controls in a future Tier 4 nonroad rulemaking. It was agreed that the "HD Diesel On-Highway Model" established in the 2007 Final Rule would apply to the transfer of aftertreatment technology to nonroad. The on-highway rule begins in 2007, and is expected to require both PM and NOx aftertreatment. This will be the first large-scale experience for these technologies. However, the on-highway applications will not be required to introduce, nor are they expected to introduce, any 90% efficient NOx catalysts in 2007. EPA's final rule allows an averaging phase-in for NOx control, and does not require meeting the 0.2 g/bhp-hr NOx limit until 2010. On-highway engine manufacturers appear to be planning on a strategy of using 40% efficient NOx catalysts in 2007 followed by 90% efficient NOx catalysts in 2010. Any nonroad implementation of NOx aftertreatment should be based upon this expected on-highway implementation strategy. Furthermore, the EPA will need to keep in mind that all on-highway experience with the operation of NOx catalysts will be for only a limited power band of 130-450 kW.

5. **Necessity for Providing Low Sulfur Diesel Fuel to Support New Standards**

Any change from existing Tier 2 standards will require at least one fuel change, and perhaps multiple changes, from the existing non-road diesel fuel sulfur levels.[2] Engine manufacturers have reported that the Tier 3 standards as published will require the use of 500 ppm (or less) sulfur fuel. This reduced sulfur content fuel is needed to insure emissions compliance in-use with the Tier 3 cooled-EGR-equipped engines, as well as to protect the durability of the emission control hardware. All aftertreatment-forcing standards will require the use of 15 ppm (max.) sulfur fuel. It was also pointed out that nonroad fleet operators will not likely want to deal with multiple fuel specifications due to the high cost of investment for multiple fuel storage tanks and the additional time and labor in handling more than one fuel. Issues surrounding the implementation of fuel changes and the benefits associated with a mandated fuel change versus the obstacles that must be overcome with a market driven approach must be addressed. The existence of higher sulfur diesel fuels heightens the opportunity for the accidental or purposeful misfueling of the new equipment.[3]

6. Concern Over Increased Equipment Initial Cost and Life Cycle Operation

Attention must be given to all issues surrounding aftertreatment technology that might pose as a deterrent to the purchase of new equipment (e.g., transferability, increased equipment cost, increased fuel price, higher maintenance, uncertain availability of the 15 ppm fuel, incidence for misfueling and damage to engine systems). It was feared that these considerations would provide ample reasons for operators to rebuild their old engines and effectively prevent the realization of the expected benefits from a new tier of emissions standards. A separate sub-working group was established to investigate various incentives to promote the turnover of old equipment and spur the demand for purchasing new equipment. Most of the incentives measures suggested required some source of economic relief. It appeared that this economic relief was outside the scope of anything that the EPA could address in their rulemaking, yet was crucial to obtaining the benefit that they were seeking from the rulemaking. This 'Catch-22' must be addressed before the rule can be finalized.

7. Importance of Harmonization

Harmonization is critically important to nonroad engine and equipment manufacturers because of the low volumes involved and the international nature of the industry. Harmonization will allow manufacturers to amortize their investments across all markets, resulting in more cost-effective regulations. From an equipment manufacturer's standpoint there are three main priorities for harmonization: 1) engine standards must be harmonized to enable the purchase and packaging of a single engine design that will comply in all markets; 2) harmonization of introduction dates are needed to ensure a level competitive playing field; and 3) harmonization of fuel quality standards is needed so that the performance and durability is assured. EPA must take these harmonization considerations into account when developing future rules, and make every effort to assure there will be equivalent fuels and alignment of limit values and introduction dates in all major markets.

---

[2] Current regulation specifies that diesel fuel with a sulfur content of no more than 5000 ppm may be used in nonroad equipment. This '5000 ppm max.' fuel has an average sulfur level of approximately 3300 ppm. There is some documented nonroad usage of '500 ppm max' on-highway diesel fuel, but it is not the majority fuel of choice in the nonroad market. It has been reported that the actual usage of 5000 ppm max and 500 ppm max fuels equates to an effective average value of 2000 ppm sulfur across the existing fleet.

[3] The concern surrounding misfueling is exacerbated when the higher sulfur diesel fuel will likely be marketed at a lower price than the appropriate low sulfur diesel fuel.