MEMORANDUM

DATE: June 4, 2002

SUBJECT: Comments On Nonroad Diesel Emissions Standards Staff Technical Paper

FROM: Chet France, Director,
Assessment and Standards Division

TO: Margo Tsirigotis Oge, Director,
Office of Transportation and Air Quality

Attached is a summary and discussion of comments we received on the staff technical paper, "Nonroad Diesel Emissions Standards". We received comments from a wide range of interested parties, including engine manufacturers, equipment manufacturers, oil refiners, States, environmental groups, and equipment users. Commenters addressed two broad areas: (1) the technical feasibility of Tier 3 emissions standards (and Tier 2 standards for engines under 50 hp), which was the primary focus of the staff paper, and (2) Agency considerations for emissions control beyond Tier 3, which were briefly discussed in the paper as well. All comments on the latter topic have been provided to and read by the team developing the proposal for future nonroad diesel emission standards.

A careful review of the comments on the technical feasibility of the Tier 3 standards (and Tier 2 standards for engines under 50 hp) has led us to conclude that the staff paper findings on the technical feasibility of these standards remain appropriate. No information was provided to cause us to conclude that these standards cannot be achieved in the timeframes established in the 1998 final rule and, in fact, some comments and more recently obtained information have bolstered the view that the standards are feasible, as discussed in the attachment. Included in this recent new information is material provided by Cummins about combustion technology Cummins has developed that meets the Tier 3 requirements without the need for exhaust emission control devices or changes to nonroad fuel sulfur levels, and indicating that it plans to launch engines using this technology prior to Tier 3 start dates. We also do not believe that the standards should be made more stringent or that compliance dates should be moved forward. We therefore are not recommending Agency action to reopen the 1998 rulemaking that established the Tier 3 standards (and Tier 2 standards for engines under 50 hp).

We are placing a copy of this memorandum, with attachments, in Docket A-2001-28,

along with the staff technical paper, comments received, and additional supporting documents. This memorandum will also be posted on our web site.

Attachment 1: A Summary and Discussion of Comments Received on Staff Technical Paper EPA420-R-01-052, "Nonroad Diesel Emissions Standards"

Attachment 2: EPA Memorandum from Cleophas Jackson to U.S. EPA Air Docket 2001-28, "Caterpillar ACERT Engine Testing", May 30, 2002

Attachment

A Summary and Discussion of Comments Received on Staff Technical Paper EPA420-R-01-052, "Nonroad Diesel Emissions Standards"

We received comments on the EPA staff technical paper "Nonroad Diesel Emissions Standards" from a wide range of interested parties, including engine manufacturers, equipment manufacturers, oil refiners, States, environmental groups, and equipment users. A list of commenters is included at the end of this summary. The staff paper primarily concerned the technical feasibility of the Tier 3 nonroad diesel emission standards (and Tier 2 standards for engines under 50 horsepower (hp)). As a result, most of the comments focused on this topic. However, the paper also briefly discussed Agency considerations for emissions control beyond Tier 3, and many commenters took the opportunity to address this topic as well. The discussion below is divided according to these two major topic areas, and further divided by specific issue areas addressed by commenters.

Tier 3 (and Tier 2 for Engines Under 50 hp)

Feasibility of Tier 3 Standards

The staff technical paper described a number of technologies we believe can be applied in nonroad engines to achieve the Tier 3 standards, including cooled exhaust gas recirculation (EGR) with optimized engine systems, hot EGR with combustion system optimization, and refinement of existing combustion and air-handling technologies, with exhaust emission control devices (e.g., diesel oxidation catalysts), such as Caterpillar's ACERT technology package. The staff paper presented test data for these technologies demonstrating that emissions below or near the Tier 3 standards have already been achieved.

A number of respondents expressed opinions on the technical feasibility of meeting the Tier 3 emission standards, including the Tier 2 particulate matter (PM) standard that carries through into the Tier 3 timeframe. Engine manufacturer views on Tier 3 feasibility varied from strongly positive, to guardedly positive with reservations, to deeply concerned about matters such as the potential for additional costs for improved materials, the ability of all manufacturers to apply the varied technologies across all engine lines, and their ability to apply highway designs directly to nonroad applications. Some engine and equipment manufacturers expressed the view that Tier 3 standards for engines in the 50 to 100 hp category were not feasible or would not allow the engines to remain commercially viable. Some of these commenters emphasized the qualifications expressed by Caterpillar up to the time that the staff paper was written about the application of its technology to smaller engines. In general, commenters raised concerns about the data presented in the staff paper but did not provide new data for the Agency to consider.

Commenters agreed that cooled EGR could be applied to engines to achieve the Tier 3 standards, but many of these commenters claimed low-sulfur fuel would be necessary to ensure

the durability of these engines. Commenters did not offer data explaining why the effects of high sulfur fuel could not be addressed using different materials in key engine components. One commenter, Deutz, identified a number of changes to engine component materials or coatings which would have the potential to address corrosion issues related to sulfur in diesel fuel. Although the commenter could not at this time conclude definitively that these changes would solve all of the issues surrounding sulfur in diesel fuel, we continue to believe that technology solutions such as new materials and better material coatings can address the durability concerns related to sulfur in diesel fuel, as explained in the staff paper.

One commenter questioned the appropriateness of relying on Cummins' on-highway test data to demonstrate feasibility because of differences between on-highway and nonroad aftercooling. Although the Cummins data mentioned in the staff paper was based upon an assumed level of aftercooling appropriate for on-highway diesel engines, we believe that it is still informative with regards to the feasibility of the technology for nonroad diesel engines. We believe that most nonroad engines will use air-to-air aftercooling in order to benefit from the fuel economy and oxides of nitrogen (NOx) reduction benefits that it provides. This approach will narrow the gap in aftercooling efficiency between highway and nonroad diesel engines. Also given the performance of the Cummins engine mentioned in the staff paper over the Supplemental Emission Test (SET), also called the 13 mode test, we believe that compliance over the nonroad test cycle will be possible.

We also continue to believe that engine manufacturers have a number of options other than cooled EGR that can achieve the Tier 3 standards notwithstanding the sulfur level in nonroad diesel fuel. We have recently placed four documents in the docket that add support to the staff paper's conclusions regarding Tier 3 standards feasibility without cooled EGR. The first of these is a letter from Cummins, providing information on its successful demonstration of new combustion technology that meets the Tier 3 requirements without the need for exhaust emission control devices or changes to nonroad fuel sulfur levels.[1] The second document is a March 19, 2002 Cummins press release announcing this new technology and indicating that Cummins plans to launch engines using this technology prior to Tier 3 start dates.[2] The Cummins material includes test results showing Cummins' Tier 3 combustion technology achieves emission levels of 2.5 to 3.0 grams per horsepower-hour (g/hp-hr) NOx, and 0.12 to 0.15 g/hp-hr PM on a variety of engine sizes, within the range of NOx and PM levels needed to meet the Tier 3 standards. It also indicates that this technology will have the same reliability as Tier 2 technology, and only a slight relative fuel penalty.

The third newly docketed document is a technical paper published by AVL List, an independent, internationally recognized diesel engine technology company. This paper concludes that cooled EGR is not the only available technology to comply with Tier 3, and in fact

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[1] Letter from John A. Rubino, Cummins Inc., to Don Kopinski, U.S. EPA, Re: Cummins Non-road Tier 3 Technical Data, May 30, 2002.

[2] "Cummins To Meet Tier 3 Off-Road Emissions Standards With Current Engine Platforms", Cummins Press Release dated March 19, 2002, Las Vegas.

the authors recommend that internal EGR combined with an electronically controlled fuel system be considered as a reasonable alternative to cooled EGR for Tier 3.[3] The fourth document is an EPA memorandum that summarizes new test results on the emission performance of Caterpillar's ACERT technology. This report concludes that the diesel engine that Caterpillar made available for EPA testing can in fact achieve the Tier 3 standards.[4]

The widening of Tier 3 technology options beyond EGR comes from the progress of development since 1998, but is also due to the fact that, although the feasibility of the Tier 3 standards was established in the 1998 final rule based on the program finalized in that rule, EPA expected at that time that the Tier 3 program would be revised for purposes of the technology review to more closely align with future highway standards, in particular including comparable control of PM. This frame of reference implied a more limited choice in the technology direction Tier 3 engine designers would likely take. The realization that this expectation does not apply for purposes of this technology review has opened new technology development pathways to innovative designers.

The concerns expressed by commenters regarding the application of the ACERT technologies to smaller engines have been largely addressed by additional information provided by Caterpillar indicating that its technology can be effectively applied to direct injection diesel engines below 75 hp. Although Caterpillar did not extend this statement to indirect injection (IDI) diesel engines, we believe that the low NOx emissions levels inherent in IDI technology will allow compliance with Tier 3 standards. This belief is supported by certification data on IDI engines provided to EPA. For example, the EPA memo referenced in the staff paper that presents emissions data on certifying engines rated at less than 50 hp includes several IDI engines in the 30 and 40 hp range with emissions below or very near the Tier 3 standards levels for 50-100 hp engines, well before these standards apply. We see no reason to believe that manufacturers could not achieve these results or better for the larger IDI engines.[5]

We further believe, based upon the information shared with the Agency, that refinement of existing combustion and air handling techniques and exhaust emission controls, if needed, can be applied across the full range of diesel engine size categories. There remains some question regarding the ability of the technology to be applied to naturally aspirated diesel engines. This may lead to an acceleration of an existing trend for the application of turbochargers to smaller diesel engines due to the fuel economy and power density benefits to the consumer.

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[3] "Potential of Internal Engine Measures to Reach Low Emission Levels for Medium and Heavy-Duty Diesel Engines", W. Cartellieri, D. Gill and F Chmeia, AVL List. Presented at AVL International Commercial Powertrain Conference, October 18-19, 2001.

[4] EPA Memorandum from Cleophas Jackson to U.S. EPA Air Docket 2001-28, "Caterpillar ACERT Engine Testing", May 30, 2002.

[5] Memorandum from William Charmley, U.S. EPA, to EPA Air Docket A-2001-28, "Summary of Model Year 2001 Certification Data for Nonroad Tier 1 Compression-ignition Engines with rated power between 0 and 50 Horsepower", October 2001.

The staff paper also described advancements that have been made with combustion system optimization and the use of hot EGR. Commenters claimed that hot EGR alternatives may not be feasible because of the potential for reduced power density and the impacts on fuel economy. Other commenters pointed out that the data from Southwest Research Institute presented in the staff paper was not adequate to demonstrate that this technology could be applied to smaller engines. We believe that there are a number of tradeoffs between hot and cooled EGR technologies that engine manufacturers will have to weigh when selecting the technology most suitable for their applications. Cooled EGR systems should offer the best tradeoff with regards to fuel economy and power density as noted by a number of commenters. Hot EGR will offer a lower initial cost and potentially easier system packaging. We believe that engine manufacturers will weigh all of these tradeoffs and will select the technology which they believe will deliver the best value to their customers.

Several commenters suggested that we should tighten the Tier 3 standards or advance the compliance date for these standards. The commenters believe that given EPA's finding that several technologies have already been applied to achieve the Tier 3 standards, more stringent standards are appropriate. While we believe the Tier 3 standards are technologically feasible, we believe there is still refinement that will be required for certain engine families to meet the Tier 3 standards. We believe the level of the standards and the compliance timeframes established in the 1998 rulemaking continue to be appropriate.

Almost all of the commenters acknowledged that changes to diesel fuel quality would be valuable for a number of reasons, including improving engine durability, allowing for the introduction of additional advanced technologies, and providing additional reductions in emissions from new and existing nonroad diesel engines. However, the recommendations for timing and degree of these fuel changes varied, with engine manufacturers, States, and environmental groups arguing for prompt across-the-board implementation of stringent requirements, and refiners arguing for later or more gradual implementation. Comments about changes in diesel fuel quality are discussed further below.

Feasibility of Tier 2 Standards for Engines Below 50 hp

We received no substantive comments from engine manufacturers on this portion of the staff paper. Equipment manufacturers questioned the paper's discussion of feasibility for small direct injection engines, claiming that the majority of the engines below 50 hp that are already achieving Tier 2 emission levels use indirect injection.

In response to the equipment manufacturers' comments, we note that the staff paper summarized certification data showing that some of today's direct injection engines are already meeting the Tier 2 standards, and many others are very close. Commenters provided no new information contradicting this data or the resulting staff paper conclusions.

Cost, Cost Effectiveness, and Cost-Benefit Analyses

The staff paper did not evaluate the costs or cost-effectiveness of the various control

options described in the paper, because these technologies were in essence the same as, or simpler from a hardware standpoint than, the technologies analyzed in the 1998 final rule, thus not indicating that new concerns over costs should be expected to arise, and furthermore because no new cost information that would likely alter the feasibility conclusions had been provided to the Agency up to that time. In the open comment period on the staff technical paper, a number of respondents called for the Agency to conduct additional cost-related analyses, beyond what was contained in the 1998 final rule. None of the comments included any new cost information.

All of the technologies identified in the staff paper have been demonstrated on actual diesel engines; our conclusions regarding technical feasibility do not rely on assumptions regarding the development and application of advanced technologies that have not been demonstrated. In fact, the essential hardware used in the demonstrated technologies does not depart fundamentally from that evaluated in the 1998 final rule. This is further supported by the information recently provided by Cummins, indicating that its demonstrated Tier 3 technology relies on an in-cylinder solution that does not involve the addition of costly or unavailable hardware. Furthermore, as already mentioned, the 1998 final rule envisioned a Tier 3 program more closely aligned with future highway standards, in particular including comparable control of PM, rather than the less demanding, and therefore less expensive, set of Tier 3 standards that were actually adopted at the time, and that are the subject of the feasibility assessment. For these reasons, we did not believe there is sufficient cause to revisit our 1998 costs conclusions.

Additional Flexibility for Equipment Manufacturers

The 1998 rule included a number of flexibility measures for original equipment manufacturers (OEMs), by which they could exempt a certain portion of their production from the need to use engines meeting the new standards. Because two full tiers of regulations were being adopted in that rule with varying impacts in each tier on the OEMs, we carefully balanced this exemption allowance to span seven years in order to cover both Tier 2 and Tier 3 product introductions. However, equipment manufacturers commented that many will be using a majority of the Tier 2/Tier 3 flexibility allowances in complying with Tier 2 requirements, and additional Tier 3 flexibility allowances will be needed.

We clearly intended the existing flexibilities to suffice for both tiers of standards, and we spent considerable time and effort in the 1998 rulemaking working with the industry to design an adequate flexibility program. The industry is currently only partway through the Tier 2 phase-in period and nearly four years from the start of the Tier 3 phase-in. We believe it is too early to evaluate the equipment manufacturer flexibility provisions, especially considering that none of the commenters provided any details of their past or planned use of the allowances, or any sort of evidence that adjustments are needed. However, this is a new program for the Agency and we believe that it is prudent to follow it closely, and to consider making adjustments in the future if warranted. It should be noted that recent engine-based technology advances such as those made by Caterpillar and Cummins are expected by these manufacturers to impact equipment designs less than EGR-based technology solutions. In the information it recently provided, Cummins indicates that its Tier 3 product will involve minimal equipment impacts to the equipment

manufacturers.[6]

The Need for Low-Sulfur Fuel In Tier 3

The staff technical paper included a discussion of how fuel sulfur levels can affect emission control durability, and means by which potential detrimental effects can be addressed. In considering the feasibility of Tier 3 standards, the paper presumed no change in nonroad diesel fuel. Some engine and equipment manufacturers argued that the regulation of nonroad diesel fuel sulfur content is needed in the Tier 3 timeframe, primarily because of concerns about cooled EGR durability. The degree to which this view was expressed as essential for Tier 3 feasibility, rather than simply desirable, varied, and one manufacturer (Caterpillar) stated that current fuel has sufficiently low sulfur content to enable the Tier 3 regulations as written. Refiners supported this conclusion as well. States and environmental groups called for fuel regulation (and more stringent standards beyond the existing Tier 3 standards) to achieve emission reductions as early as possible, though they did not specifically address the connection to Tier 3 feasibility.

The concerns raised about EGR durability with current fuel have been raised previously, and no new data or relevant issues were submitted that would warrant a re-examination of the conclusions made in the staff paper regarding Tier 3 feasibility without a fuel change. Since the close of the comment period, Cummins has also added support to the view expressed by Caterpillar that fuel changes are not needed for Tier 3, indicating that Cummins' Tier 3 technology experiences no impact of high sulfur fuel.[7] As discussed below, we do agree that low sulfur nonroad diesel fuel may be highly beneficial in controlling emissions from nonroad diesels in the future, beyond Tier 3.

Auxiliary Emission Control Device Guidance for Tier 3 Technologies

The Engine Manufacturers Association (EMA) and two engine manufacturers (John Deere and CNH) suggested that Tier 3 technology engines would require engine protection strategies which are different compared to today's nonroad diesel engines. For example, EMA suggested that engines equipped with EGR would require auxiliary emission control devices (AECDs) in order to protect the engine from corrosion due to sulfuric acid. The commenters recommended that EPA provide manufacturers with sufficient guidance so that manufacturers will understand how EPA intends to evaluate AECDs for Tier 3 engines.

We have recently issued guidance to engine manufacturers regarding the review of AECDs for highway heavy-duty diesel engines subject to the 2004 standards (EPA Advisory Circular 24-3). As we move closer to the Tier 3 phase-in start in 2006, we intend to

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[6] Letter from John A. Rubino, Cummins Inc., to Don Kopinski, U.S. EPA, Re: Cummins Non-road Tier 3 Technical Data, May 30, 2002.

[7] Letter from John A. Rubino, Cummins Inc., to Don Kopinski, U.S. EPA, Re: Cummins Non-road Tier 3 Technical Data, May 30, 2002.

issue guidance regarding the use of AECDs for Tier 3 engines.

Specifying Fuels in Warranties

Engine manufacturers asked that they be allowed to specify, as part of their warranty requirements, the fuels which they think their customers should use in their engines, and that EPA commit itself to use the same specified fuel for any compliance testing. Of particular interest is the specified use of fuel that meets the 500 parts per million (ppm) sulfur limit imposed on highway diesel fuel, and is therefore widely available.

We recognize that the use of highway diesel fuel can provide some environmental and engine maintenance benefits. Manufacturers are free to specify the use of highway fuel in their mechanical warranties. We do not believe, however, that specifying the use of this fuel for Tier 3 nonroad engines in warranty documents will ensure that operators will use this fuel throughout the useful life of the engine, and that it might therefore justify use of this fuel in all compliance testing, or justify making the use of this fuel a basis for proper maintenance under the emissions warranty required by 40 CFR 89.1007. EPA useful life requirements typically extend well past manufacturer mechanical warranty periods. Furthermore, we strongly encourage manufacturers to design emission controls for robust operation throughout an engine's actual operating life, which can extend beyond the regulatory useful life periods, on any fuels that the engine is likely to use during its operating life. Second and third owners and equipment renters may have no incentive, or perhaps even knowledge of the need, for using a specified fuel, especially if this fuel is more expensive or locally less available than nonroad fuel.

As we have shown in other areas where this issue has been addressed, any such provision involving an Agency commitment to test only with higher quality fuels or involving a change in emissions warranty requirements would have to involve a high level of assurance that such fuels would indeed be used. An example of similar "high level of assurance" requirements is the provision in place for maintenance on critical emission-related components (see 40 CFR 89.109(h). Manufacturers must show reasonable likelihood that any manufacturer-specified maintenance for components such as catalytic converters, EGR systems, and electronic engine control units and sensors, will indeed be performed in-use. Under that provision, such assurance could, for example, take the form of a clearly displayed visible signal to alert operators that maintenance is due, or free-of-charge manufacturer-performed maintenance. EPA would not consider allowing manufacturer-specified fuel use requirements that included an Agency commitment to test only with higher quality fuels or involving a change in emissions warranty requirements, unless a clear and compelling case was made that the fuel would indeed be used.

Maximum Sulfur Specification for Test Fuel

EPA adopted a provision in the 1998 final rule to limit the maximum test fuel sulfur level in its own compliance testing to 2000 ppm. This provision was made applicable only to Tier 2 engines above 50 hp and Tier 1 engines under 50 hp, under the assumption that it would be re-evaluated as part of the Tier 3 technology review for possible continuation beyond Tier 2. Engine manufacturers commented that EPA has not yet performed the promised re-evaluation,

resulting in continued uncertainty about the Tier 3 PM program stringency relative to Tier 2. They called for a continuation of the 2000 ppm compliance testing sulfur limit into Tier 3. Cummins argued that it should be set even lower, at 500 ppm, based on a downward trend in nonroad fuel sulfur and an increase in the use of low-sulfur highway fuel in nonroad engines.

We understand that the sulfur specification for compliance test fuel is of special interest to Tier 3 engine designers, especially those considering the use of catalytic exhaust emission control devices, as they prepare to market these engines in 2006. The engine manufacturers provided no new information on in-use fuel sulfur levels to justify their request. At the same time, we are also not aware of any other information that would lead us conclude that fuel sulfur levels will change for Tier 3 relative to Tier 2. We believe it may be reasonable to extend the use of 2000 ppm maximum sulfur diesel as the test fuel for Tier 3 compliance testing. We will explore options to formalize this requirement for Tier 3 test fuel in the near future.

Nonconformance Penalties

EMA and Caterpillar commented that EPA should establish nonconformance penalties (NCPs) for the Tier 3 standards. Caterpillar commented that, with multiple technology solutions across the industry, some technologies may not be as complete as others, and NCPs should be offered as an option for manufacturers to comply. EMA stated that the Tier 3 standards require and justify the establishment of NCPs, and such NCPs should be established in a timely manner.

We believe it is premature to assume NCPs should be provided for the Tier 3 standards, given that the first horsepower categories aren't required to comply with the standards until 2006, and some categories not until 2008. We have made it clear for highway heavy-duty engines and vehicles that it is not appropriate for manufacturers to plan on using NCPs rather than investing in the research necessary to meet a new emissions standard. Therefore NCPs do not need to be established well in advance of the emission standards. NCPs for highway heavy-duty engines and vehicles are established when there are manufacturers who have attempted to comply with the new standard but who have fallen short, the so-called "technological laggards". We believe this same principle is appropriate for nonroad. We will continue to monitor the manufacturers' progress towards compliance with the Tier 3 standards and we will consider whether or not to establish NCPs for Tier 3 if deemed appropriate.

Emissions Control Beyond Tier 3

Although the staff technical paper was primarily focused on Tier 3 feasibility, we also briefly outlined the need for additional controls beyond Tier 3, and possible approaches to addressing this need. We received comments on a number of associated topics, and they are only briefly summarized here. All of these comments have been provided to the team developing a proposal for future nonroad diesel engine and fuel standards. They are also available in the public docket of correspondence and other documents for both this staff technical paper and the upcoming rulemaking, Docket A-2001-28.

The Need for Additional Emission Controls

A number of commenters argued that further control of emissions from nonroad diesels, beyond that afforded by the Tier 2 and Tier 3 standards, is needed to improve the nation's air quality. States and environmental groups argued for the inclusion of locomotives and marine vessels in Agency action on nonroad diesels. Several industry commenters expressed the view that EPA should begin a rulemaking activity on emissions standards beyond Tier 3 soon, in order to provide adequate leadtime. One manufacturer has provided a proposal for levels and timing of these standards.[8]

We agree that additional action by the Agency is appropriate and are now developing a proposal that would take a "systems" approach, regulating nonroad diesel engines and fuel in a single coordinated program, similar to the approach recently taken to controlling highway vehicle emissions. This proposal is expected to be developed and sent for inter-agency review by the end of this year.

The Need for Harmonization

Commenters expressed a strong desire for standards that are harmonized within the U.S. and with Europe and Japan, due to the global nature of the nonroad engine and equipment market.

We have worked successfully with the California Air Resources Board, the European Commission, and other governmental units, in developing past standards, and continue to work closely with them in developing new standards today, as, for example, the current collaboration on development of a transient test cycle for nonroad diesel engines. We recognize the importance of harmonized standards within the larger context of achieving the air quality improvement goals of the Clean Air Act.

Nonroad Diesel Fuel Regulation and Engine Test Procedure Changes

Many commenters supported the regulation of nonroad diesel fuel, including locomotive and marine fuel, to reduce emissions from nonroad engines. Their reasons included the achievement of immediate and long-term environmental benefits, and the beneficial effects on engine durability. States recommended early Agency action, including a 30 ppm sulfur requirement in 2004, and lower levels by 2007. Refinery industry commenters supported the assessment that fuel changes are not needed for Tier 3, and offered ideas for ways to implement an ultra-low sulfur fuel requirement as part of a Tier 4 program, including a two-step sulfur reduction scheme (Chevron), and a need-based program that would rely on the availability of ultra-low sulfur fuel produced for the highway diesel market in the early years of the nonroad Tier 4 program (the American Petroleum Institute and ExxonMobil). The National Petrochemical and Refiners Association recommended that changes in nonroad diesel fuel

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[8] Letter from Bill Passie, Caterpillar, Inc., to William Charmley, U.S. EPA, August 9,2001.

quality not be implemented before mid-2010. EMA called for mandating sulfur reduction at the earliest possible date to levels below a 15 ppm cap level without a phase-in. Cetane number and lubricity were also mentioned as potentially in need of improvement (CNH). The Associated General Contractors of America expressed concerns about ultra-low sulfur fuel supply, price, and quality.

NESCAUM commented that prompt action is needed to establish a more representative test cycle and a more effective PM control program. Caterpillar argued that it is too late and unnecessary to adopt a transient test cycle or supplemental off-cycle test in the Tier 3 timeframe, and that any such action in the future must consider the technology context. EMA stressed the need for continuing industry/government cooperation in the development of any future transient cycle, including the expected work needed to assess the need and appropriateness of such a cycle in the context of a technology solution based on the use of exhaust emission control devices.

All of these comments have been provided to the team developing a proposal for future nonroad diesel fuel and engine standards for consideration in that effort.

Additional Flexibility for Equipment Manufacturers

In addition to requesting additional equipment manufacturer flexibility allowances for Tier 3, equipment manufacturers expressed the view that these flexibility provisions have been helpful in meeting their compliance mandates, and are needed for any new standards beyond Tier 3 as well.

We acknowledge that the emission controls needed beyond Tier 3 may have an impact on equipment designs and plan to engage the industry in discussions on what flexibility provisions will be needed, if any, prior to making a proposal. These discussions will be informed by experience being gained with the flexibility provisions in the Tier 2/ Tier 3 program.

Use of Metric Units

One commenter recommended that EPA reference only metric-based power categories and emission standards in all discussions and documents, to avoid the confusion that results from the use of English units in these situations while all regulatory language is metric.

We too regret the long-standing confusion caused by the use of two sets of units. However, the widespread use of English units in many U.S. engineering disciplines remains a fact of life and it is simply not possible for us to declare an end to it and still communicate effectively. It is likely that any future rulemaking will use some subset of power categories used in the 1998 rulemaking, and so accurate power category conversions can be referenced there, as can discussion of the accepted conversion factor for emission standards: 0.7457 with ASTM rounding protocol (see Section 8.j of the Summary and Analysis of Comments document for the 1998 final rule).

List of Those Who Submitted Comments
On EPA Staff Technical Paper
Nonroad Diesel Emissions Standards

Engine and Equipment Manufacturers and Engineers
Association of Equipment Manufacturers
Caterpillar Inc.
CNH Global, N.V.
Cummins Inc.
Deutz
Deere & Company
Engine Manufacturers Association
Ingersoll-Rand Company
Komatsu Ltd.
Lister-Petter
Sonex Research, Inc.

Refiners and Fuel Suppliers
American Petroleum Institute
Chevron
ExxonMobil
National Petrochemical & Refiners Association

States and Environmental Groups
American Lung Association
California Air Resources Board
Clean Air Task Force and
- American Lung Association of Metropolitan Chicago
- American Lung Association of New York State
- Izaak Walton League of America
- Ohio Environmental Council
- Southern Alliance for Clean Energy
- Southern Environmental Law Center

Environmental Defense
NESCAUM
Ozone Transport Commission
Puget Sound Clean Air Agency
STAPPA/ALAPCO

User Groups
National Association of Home Builders
Associated General Contractors of America

MEMORANDUM

DATE: May 30, 2002

SUBJECT: Caterpillar ACERT Engine Testing

FROM: Cleophas Jackson

TO: United States Environmental Protection Agency Air Docket A-2001-28

The purpose of this memorandum is to provide a summary of the test data generated using a prototype Caterpillar ACERT engine at Caterpillar's Peoria Engine Test Facility. The data was generated using a C-15 prototype engine exercised over the modes selected from the ISO 8178-4 Universal Test matrix. Engine specifications are shown in Table 1. The test modes are listed in Table 2. In addition to the operating conditions, the resulting NOx and PM emissions are also shown. Data sets provided by Caterpillar may be seen in Tables 5 and 6. The data sets in the table give a clear indication of the ability of the Caterpillar technology to easily meet the Tier 3 standards as promulgated in 1998. The following is a summary of testing conducted on-site at Caterpillar's Peoria Test Center by Caterpillar personnel and observed by EPA staff engineers. Prior to the start of the test sequence used to generate this data, EPA engineers conducted an extensive calibration check of emissions measurement systems and reviewed calibration records at the Caterpillar facility.

Engine	C-15
Rated Power	317 kW (425 bhp) @ 1800 rpm
Peak Torque	1854 N-m (1367 lb-ft) @ 1200 rpm
Aspiration	Turbocharged, aftercooled
Fuel System	HEUI C
Displacement	~15 L

Table 1: Major specifications for the engine used in this study

Mode Number (cycle B)	1	2	3	4	5	6	7	8	9	10	11
Mode Number (cycle C1)	1	2	3		4	5	6	7			8
Speed	Rated Speed					Intermediate Speed					Low-idle Speed
Torque	100	75	50	25	10	100	75	50	25	10	0
C1 Weighting Factor	.15	.15	.15		0.1	0.1	0.1	0.1			.15

Table 2 Test Modes

The base engine has a rated power of 268 kW (359 hp). This engine was equipped with the HEUI-C fuel system. Peak injection pressure and crank angle degree resolved cylinder pressures were not provided.

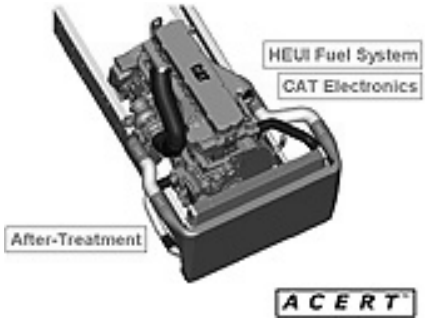

Figure 1. Schematic of Caterpillar ACERT System[1]

1 http://www.cat.com/products/engines_n_power_systems/shared/truck_engines/01_truck_engine_info^specs/03_electronics/acert/images/acertegrsm.jpghttp://www.cat.com/products/engines_n_power_systems/shared/truck_engines/01_truck_engine_info^specs/03_electronics/acert/images/acertegr-sm.jpg

MODE		NOx (g/hr)	NOx (g/hp-hr)	PM (g/hp-hr)
Mode Number	C1 Mode			
1	1	1401.12	3.90	0.09
2	2	492.12	1.83	0.07
3	3	254.76	1.42	0.12
4	4	108.13	3.00	0.99
5	5	1054.34	3.34	0.13
6	6	514.46	2.17	0.06
7	7	262.40	1.66	0.05
8	8	25.94	6.48	1.25
9	N/A	144.95	1.83	0.13
10	N/A	791.00	8.79	0.19

Table 3 Summary of First Run of Emissions Data from On-Site Engine Testing

MODE		NOx (g/hr)	NOx (g/hp-hr)	PM (g/hp-hr)
Mode Number	C1 Mode			
1	1	1274.30	3.17	0.11
2	2	457.25	1.52	0.06
3	3	243.97	1.21	0.16
4	4	109.90	2.76	0.77
5	5	1003.97	2.83	0.13
6	6	505.87	1.91	0.06
7	7	274.65	1.55	0.04
8	8	26.11	6.85	1.49
9	N/A	146.53	1.66	0.11
10	N/A	786.03	7.87	0.18

Table 4 Summary of Emissions of Second Run Data from On-Site Engine Testing

Emissions Units	NOx	HC	PM	Corrected PM	CO	CO_2
g/hr	488.70	26.14	22.71	22.68	128.37	108104.76
g/kW-hr	3.39	.18	.16	.16	.89	749.2
g/hp-hr	2.52	.14	.12	.12	.66	558.7

Table 5 Caterpillar Reported Set A (First Run) Composite Results Corrected for CO2 Quench

Emissions Units	NOx	HC	PM	Corrected PM	CO	CO_2
g/hr	519.22	38.35	21.68	21.67	126.73	106609.65
g/kW-hr	3.60	.27	.15	.15	.88	738.4
g/hp-hr	2.68	.20	.11	.11	.67	550.6

Table 6 Caterpillar Reported Set B (Second Run) Composite Results Corrected for CO2 Quench

Test Run	NOx g / kW-hr	PM g / kW -hr
First Run	3.33	.15
Second Run	3.53	.16

Table 7. EPA Calculated ISO 8178 C1 Composite Emissions

In previous public comments to the Agency, Caterpillar has provided data for a mid-range industrial engine (Caterpillar 3126) that meets the Tier 3 standards. This testing effort focused on a second Tier 3 capable engine (Caterpillar C-15, 317 kW) identified by Caterpillar as having successfully demonstrated emissions of 3.8 g/kW-hr NOx and 0.16 g/kW-hr PM). As indicated by the data in the tables above, emissions from the Caterpillar ACERT C-15 engine were lower than the target Tier 3 emissions standards. The prototype used a diesel oxidation catalyst on test fuel with a sulfur content of 2,000 ppm S. Caterpillar describes ACERT as a combination of proven hardware components integrated in a systems approach to meet emissions and performance goals. The prototype engines use open-loop electronic engine controls, an advanced HEUI fuel system, and a diesel oxidation catalyst (DOC).