

**EPA Answers to Questions from March 22, 2004 NTE Presentation
London Off-Cycle Working Group Meeting
May 25, 2004**

Question 1

- a. **What was the rationale of EPA to design the NTE/MAEL concept this way ?** The rationale was two-fold. First, to expand the range of operating conditions covered by EPA's official emissions tests known as the Federal Test Procedure (FTP) which shrinks off-cycle operation and reduces EPA's reliance on the defeat device prohibition. Second, to enable testing to be moved out of the lab and onto the road where testing is much cheaper and actual real world emissions can be evaluated.
- b. **What is the experience of EPA with the voluntary application (type approval/ in use) in advance of the 2007 requirements?** EPA issued guidance in advance of the NTE regulations which established the Euro III/MAEL and NTE as objective, quantitative screening tools to evaluate Auxiliary Emissions Controls Devices (AECs) for compliance with EPA's defeat device prohibition. The guidance established that any manufacturer voluntarily demonstrating compliance with the quantitative screening thresholds associated with each test would not have its AECs undergo any further evaluation for defeat devices, assuming the AECs are substantially included in one or more of these supplemental screening tests. A handful of manufacturers voluntarily submitted data and compliance statements prior to the 2004 EPA emissions standards. As more manufacturers have had to comply with the 2004 standards, there has been an increase in voluntary statements. This has reduced EPA's workload in reviewing AEC descriptions. However, EPA still evaluates strategies that operate outside the suite of these tests.
- c. **Is it necessary to have a NTE requirement as well as a MAEL requirement in parallel ?** EPA believes the traditional transient FTP, steady-state Supplemental Emissions Test (SET) and NTE are a complementary suite of emissions testing requirements designed to reduce offcycle operation¹. The traditional FTP and steady-state SET capture city and highway cruise operation, respectively. Both tests require emissions data at the time of certification. The NTE is designed as an in-use test and only requires a statement of compliance at the time of certification. As a part of the certification process, EPA may ask the manufacturer to provide information which substantiates the NTE compliance statement. That information does not have to be generated from on-road testing. The NTE Q&A guidance document (see attached) elaborates on the type of information a manufacturer could provide to substantiate its NTE compliance statement.

¹ The Euro III test was essentially renamed the SET in EPA's 2004 heavy-duty diesel rule.

The MAEL is a useful check to ensure appropriate emissions control is employed during operation in between the Euro III or SET test modes. The premise is that control between test modes should be somewhat linear. The need for such a check becomes less important as emissions standards become more stringent. For this reason, the MAEL is no longer required when EPA's 2007 Phase II standards become effective.

As the standards become more stringent, there is less opportunity for a discrepancy in emissions performance during operation between test modes within the Euro III/SET control zone. For example, when the Euro III NO_x limit was at 4.0 g/bhp-hr, the NTE limit was 5 g/bhp-hr (1.25 X 4.0) for certain engines covered by consent decrees. For these engines, the MAEL was useful in ensuring manufacturers did not indiscriminately raise emissions up to the consent decree NTE limit during operation between test modes within the Euro control zone when emissions at nearby Euro test modes were significantly below 5 g/bhp-hr. In contrast, the 2007 0.2g/bhp-hr NO_x standard has an associated 0.3 g/bhp-hr (1.5 X 0.2) NTE standard. There is only a tenth of a gram difference between the 0.2g/bhp-hr NO_x standard and its associated NTE standard whereas there is a full gram difference at the 4.0 g/bhp-hr NO_x level.

We also anticipate the more stringent standards will drive manufacturers to employ more homogeneous emissions control maps which will result in a more homogeneous emissions profile over the range of operation covered by the emissions tests. As a result, there will be less need to check emissions control in between the SET/Euro III test modes.

- d. **Are there reasons to limit a NTE and/or MAEL control area to certain speed and torque values ? If YES, is this dependant on certain technologies or engine layout?** Yes, the NTE control area is defined or limited by the capabilities of engine technology as well as the nature of the brake-specific emissions standards. We selected the 30 percent torque and 15 percent ECS speed limits to maintain homogeneous emissions standards over the NTE control zone. During the heavy-duty diesel settlement when the NTE was first established, it was widely recognized that brake-specific emissions rapidly increase at low torque or power values as a product of the method used to calculate the emissions (dividing by an ever decreasing number). Extending the zone below the 30 percent torque and 15 percent ESC speed limits would require increasingly less stringent standards in those ranges of operation. Such an approach would run contrary to EPA's goal of homogeneous standards.

Operation below 15 percent ESC speed also presents technical challenges for emissions control. For example, using EGR to control NO_x during high load, low speed operation can cause turbomachinery to operate outside of its surge design limit. Addressing these technical challenges must be considered in light of the frequency with which highway engines operate in this regime, which is not significant. These limitations could change or be overcome as technology evolves. To the extent the shape of the NTE zone is technologically based, it will be reviewed as technology advances.

Technology limitations also played a part in shaping the NTE zone carve-outs. For example, the technology used to comply with the 2004 EPA emissions standards resulted in the need for a PM carve-out. Specifically, piston rings do not seat well during high speed, low load operation because cylinder pressure is low. The ring seating issue presented a challenge to PM compliance. However, any increase in PM emissions associated with this operating regime will be controlled by the aftertreatment used to comply with the 2007 PM standard. The carve-out has been eliminated from the 2007 requirements.

- e. **In use data of HDV indicates that a relevant proportion of driving events occurs outside the US NTE 2007 control area. What does it mean in terms of emissions (NOx and PM) of future engines ?** The NTE captures a significant portion of typical highway cruise operation where NOx emissions are usually the highest. The NTE captures significantly less of the transient operation commonly associated with stop-and-go city driving. It is under these transient conditions where PM control is most challenging. The NTE does not capture a significant amount of transient operation because the engine frequently drops below the 30 percent torque and 15 percent ESC boundaries of the NTE zone. However, the transient FTP complements the NTE because it well represents city operation and any AECDs that activate under these conditions.

EPA has considered options for revising the NTE so it captures more transient operation. For example, a fuel consumption specific standard would allow the NTE zone to extend below the 30 percent torque limit while maintaining a homogeneous standard throughout the NTE zone. Another means to lower the minimum torque limit might be to lengthen the minimum 30 second averaging window. However, significantly lengthening the NTE sampling window would likely affect the appropriate NTE standard. EPA has no immediate plans to revise the NTE, but may further explore such options in the future.

- f. **Are emissions maps of modern/future engines available?** EPA has both emissions control calibration maps and emissions performance maps from current technology engines. This information is submitted by the manufacturers, but is considered confidential business information and can not be released without the manufacturers' permission. The most effective approach to gather this information might be for companies to explain their general approach for emissions control and how those approaches might be affected by the NTE requirements.
- g. **Are driving frequency maps of modern/future engines available or predictable?** The operating frequency of heavy-duty trucks in the U.S. has been modeled by Tom Darlington of Air Improvement Resources, Inc. Frequency of operation is described in terms of vehicle miles traveled as a function of ambient temperature and altitude bins. Vehicle operating frequency is not assumed to significantly vary as emissions standards change. Manufacturers may be able to add additional information to Darlington's work.

Question 2

- a. **If a NTE control area is defined, is there a need for technology specific or emission specific carve outs ?** Yes, see answer to Question 1d. above and 2c. below on the rationale for the shape of the NTE zone and need for NTE carve-outs, respectively.

- b. **Have the 30s windows proven to be appropriate?** Yes, but EPA also considers emissions performance over periods greater than 30 seconds. The Agency has addressed minimum averaging windows in a negotiated settlement to a dispute over EPA's NTE requirements. One element of the settlement outlines the establishment of a manufacturer-run in-use testing program (see attached). In the context of the manufacturer in-use testing program, EPA looks at the NTE slightly differently than in the regulation. The settlement has defined an NTE sampling event, which begins when the engine operates within the NTE zone for 30 consecutive seconds and ends when that operation first falls outside of the NTE zone. Emissions are averaged over that NTE sampling event. As such, the averaging period for an NTE event under the manufacturer in-use testing program could be as short as 30 seconds, but is expected to typically exceed the 30-second minimum (we expect a typical sampling period to be in the range of a couple of minutes). Longer averaging periods dampen infrequent, instantaneous emissions spikes. The smoothing of these short-lived emissions peaks serves two purposes. First, it reduces the likelihood of having NTE exceedences which are environmentally insignificant. Second, it better tailors the NTE test to the current capabilities of portable emissions measurement systems.

- c. **In the US 2007 regulations several specific exceptions of operating modes are possible on petition of the manufacturer. What is the rationale, are they really necessary?** As mentioned previously, the NTE zone was defined by a desire to have a homogeneous emissions limit. Carve-outs within that zone exclude certain areas of operation from NTE consideration or limit how much emissions from that operation can contribute to an NTE result. Deficiencies allow temporary exceedences of the NTE standards due to technical limitations under limited operating conditions. The purpose of these allowances is to avoid holding the manufacturer responsible for NTE compliance during modes where the engine is not capable of operating or where it is not technically feasible to meet the NTE standards. In general, EPA has sought to avoid overemphasizing operating conditions which have a nominal effect on overall emissions performance or the environment. To the extent where a carve out is technologically based, the need for it will be reviewed as technology advances.

- d. **Definition of NTE/MAEL limit level may be discussed later, but has an interrelation with the definition of the control area and other boundary conditions.** Yes, the appropriate NTE limit is inextricably linked to defined NTE zone and other boundary conditions such as altitude and the minimum emissions averaging period. See answers to question 1d. and 1e above.