NMMA® National Marine
Manufacturers Association

April 9, 2009

Mr. Michael Carter
California Air Resources Board
9528 Telstar
El Monte, California 91731

Dear Mike:

The National Marine Manufacturers Association (NMMA) has completed its
review of the 15-day notice of Staff's Modifications to the Proposed Regulation Order for
Marine Engines and Vessels. We appreciate the efforts of the CARB staff to work with
us on these modifications. If we could have a look at the draft final changes it would be
greatly appreciated and might help us both avoid questions or problems with
implementation. NMMA offers the following comments regarding the draft and strongly
urges CARB staff to make the following changes in the final rule.

- **Maximum Engine Power**- In the definition for maximum engine power,
  the CARB draft harmonizes with the EPA language in 40 CFR Part 1045.
  140 (a) which states that

  "the power value should be rounded to the nearest whole kilowatt."

  If you look at 40 CFR Part 1054.140, the EPA small engine rule it states;
  "Round the power value to the nearest 0.1 kilowatts for non-handheld
  engines and to the nearest 0.01 kilowatts for handheld engines."

  EPA staff recognizes that the final marine rule should have required power
  values for marine engines be rounded to the nearest 0.1 kilowatts for the
  purpose of accuracy when averaging emissions for small outboards. EPA
  plans to make this change in a future rulemaking. NMMA urges CARB
  staff to make this change in the draft modification.

- **NTE Zone-** The CARB draft modification does not include the exception for delayed compliance with not-to-exceed (NTE) emission standards for carry over engines as EPA provides in 40 CFR Part 1045.145 (g). The EPA rule states that;

  > "The not-to-exceed standards specified in § 1045.107 do not apply in the 2010 through 2012 model years for engine families that are certified based on carry over emission data from 2009 model year. This includes models that were certified only in California as long as no new testing is otherwise required to get a new certification."

  Due to the large number of engines and the excessive burden of testing engines for NTE compliance, NMMA urges CARB to harmonize the EPA NTE carry over provision with the CARB rule

- **Supercharged Engine Modification-** The CARB draft modification does not include the adjusted NTE subzones for non-catalyzed four-stroke outboard engines as EPA provides in 40 CFR Part 1045. 145 (j). The EPA rule states:

  > "For supercharged four-stroke outboard engines above 150 kW without catalysts, you may divide the NTE zone specified in § 1045. 515 (c) (6) based on a speed cut point of 70 percent of the maximum test speed instead of 50 percent of the maximum test speed through 2014 model year."

  This will allow for harmonization with the EPA rule.

- **High Performance NTE Engine Exemption-** The EPA rule allows for an NTE high performance exemption in 40 CFR Part 1045.105 (c). NMMA urges CARB to harmonize this section with the EPA rule.

- **NTE Graphs and EPA Guidance Document-** The CARB draft modifications refer to, but do not include the following EPA NTE Graphs:

  - Figure 1 of § 1045.515- NTE Zone and Subzones for Catalyst-Equipped Engines.
  - Figure 2 of § 1945.515- NTE Zone and Subzones for Two Stroke Engines without Catalyst
  - Figure 3 of 1045.515- NTE Zone and Subzones for Four-Stroke Engines Without Catalyst.

  Although CARB identifies the NTE compliance requirements in charts, the rule still needs to specify the test parameters in graphs. Also EPA has developed an NTE guidance document for marine applications. I have attached a copy for your information.

- **Rebuilt vs. Remanufactured Engine Recordkeeping Requirements-** NMMA recommends that the CARB definition for rebuilt engines in Appendix II of the test procedures be expanded so it recognizes that it does not include remanufactured engines. Remanufactured engines are where the manufacturer receives engine cores and proceeds to build remanufactured engines from those cores. The problem with the current CARB language is that for remanufactured engines, unlike rebuilt engines, there is no traceability as to where the engine cores came from or how many hours were put on it. Further, the remanufactured engines will contain parts from several original engines.

  NMMA recommends that CARB add the following language to the rebuilt engine definition. "A rebuilt engine does not include a remanufactured engine where the entire engine is manufactured from used engine cores."

- **Harmonizing the Emission Test Requirements and Timing with EPA-** NMMA recommends that in the case of new engines, CARB adopt the EPA test procedures in 40 CFR Part 1065, but for those engines where the certification will be carried over until 2013, CARB recognize the test procedures in 40 CFR Part 91. Stating this in the CARB rule will hopefully avoid future confusion and will insure that the test procedures are harmonized with EPA.

Thank you for the opportunity to provide comments on the 15 day notice. If you have any questions, please do not hesitate to call me at 202-737-9757 or jmcknight@nmma.org.

Sincerely,
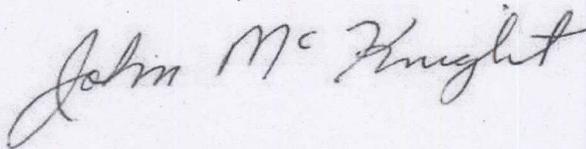
John McKnight, Director
Environmental & Safety Compliance

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Subject: Demonstrating compliance with marine SI not-to-exceed (NTE) standards

The certification requirements of 40 CFR Part 1045 become effective beginning with the 2010 model year. As part of this new regulation, compliance with not-to-exceed (NTE) emission standards may be required. This requirement represents an effort to address emissions from running conditions that may be encountered beyond the designated points on the theoretical propeller curve, where most emission testing has been focused. Several questions have been raised by marine engine manufacturers regarding how to demonstrate compliance with this requirement at the time of certification. The intent of this document is to clarify how compliance with NTE requirements for certification might be demonstrated.

It is important to note that the protocol described in this document is intended to clarify how to make this demonstration for certification. This in no way limits the applicability of the NTE standards for testing with in-use engines. Engines are expected to meet all applicable in-use testing requirements (including NTE compliance) under applicable operating conditions regardless of what demonstration has been made for certification. For example, if an in-use engine exceeds the NTE standards based on any type of valid operation (as specified in the regulation) at any time during its useful life, that event will be considered an emission failure regardless of any testing or analysis presented for certification.

To review the emissions testing requirements of Part 1045 Subpart B, all marine SI engines must demonstrate compliance in two ways. First, the engine must be tested over the prescribed duty cycle and emission data is collected at five discrete torque/speed points (see Appendix II of Part 1045). This testing requirement is carried forward largely unaltered from previous marine SI standards (40 CFR Part 91). The second requirement is that the engine meets NTE emission limits at points beyond the normal five test points, but within a prescribed zone ("NTE zone"). Different NTE zones are specified for 2-stroke engines, non-catalyzed 4-stroke engines, and engines with catalysts.

As stated in the regulation, the NTE emission standard is determined by the product of the normal emission standard and a weighting factor (M) (§1045.107(b)). The emission standard is determined by the engine type and/or power rating of the engine (per §1045.103/105) and the weighting factor is dependent on the type of engine per §1045.107(c), (d), and (e). The value of "M" may also vary depending on where in the torque/speed map the engine is being tested (for any 4-stroke engines and 2-stroke engines with catalysts), per §1045.515(c)(4) and (6).

NTE testing requirements are significantly different between 2-stroke engines without catalysts and all other engines regulated under Part 1045. For 2-stroke engines without catalysts, NTE testing is similar to the normal modal testing in that three test speeds are specified, plus a point at full throttle, and a point at idle. Results from these points are weighted using the same factors used for modal testing to determine a single brake-specific emission result (in g/kW-hr). This overall result must meet NTE standards. The key difference between the NTE and modal tests for 2-stroke non-catalyst engines is that for NTE tests, the torque levels at all but the idle speed points may be any value within the bounds of the NTE zone; whereas in modal testing both speed and torque are prescribed. In contrast, 2-stroke engines with catalysts and all 4-stroke engines must be designed to meet NTE requirements at any given point over the entire NTE zone.

Methods for demonstrating compliance with NTE standards for certification vary by the type of engine being tested, but three main elements are recommended for all NTE compliance demonstrations. First, a thorough understanding of the emissions behavior of the engine over the applicable NTE zone must be demonstrated. Second, the manufacturer should select test points within the NTE zone that include the highest emissions of $HC+NO_x$ and CO. Third, emission test data should be presented from these highest emitting points and their emissions levels must be below the NTE standards.

The first element should be a normal byproduct of the engine calibration process. It is anticipated that during development of fuel and/or spark advance maps, emission data is simultaneously being collected. The resulting data produce a map of $HC+NO_x$ and CO emissions over the usable range of the engine. In the case of non-electronically controlled engines, where this testing may not be done as part of normal development cycles, please see the example test sequences in Attachment I for suggestions of how to determine emissions behavior over the NTE zone. This preliminary testing need not be done on certification test fuel, as the primary goal is to determine emission trends rather than establish absolute emission levels. It is expected that the emission maps resulting from this step will be included as part of the application for certification.

For the second element, it is expected that the manufacturer will select the highest emitting points within the NTE zone for further testing. The emissions trend maps discussed in the previous paragraph should be used to identify the highest-emitting points. In addition, the local NTE standard must be taken into account as there are multiple NTE standards across the NTE zone for all 4-stroke engines and 2-stroke engines with catalysts (§1045.515(c)(4) and (6)). It is recommended that testing be conducted at points where the emissions are at the highest in relation to the local NTE standard (lowest compliance margin). It is also worth noting that the highest-emitting points may not necessarily coincide with the boundaries of the NTE zone or the torque/speed points specified for modal testing. Therefore, testing only on the boundaries of the NTE zone and at the modal test points may not be sufficient for demonstrating compliance.

Emissions of HC+NO_x and CO may not have maxima at the same locations and, additionally, the emission trends may not be monotonic across the NTE zone. For these reasons, we do not specify the number of data points required for demonstrating compliance on 4-stroke engines or 2-stroke engines with catalysts. However, 2-stroke engines without catalysts require at least one data point at each of the designated speeds to allow for calculating a single weighted value (§1045.515(c)(5)). Generally speaking, for all other engines, most NTE compliance demonstrations can be completed with data from between two and five additional test points. In either case, results from all test points within the NTE zone (including modal data from duty cycle testing) must be included with the application for certification.

The third element involves emission testing at the previously identified highest-emitting points. This is considered official emission testing and therefore must be completed in accordance with the requirements outlined in Part 1045 Subpart F. For 2-stroke engines without catalysts, the weighted test result must be below the NTE emission standard (§1045.515(c)(5)). For engines subject to NTE testing across the full zone, the emission level must be at or below the NTE emission standard at each measured test point (§1045.515(c)).

In summary, demonstrating compliance with applicable NTE standards at the time of certification involves showing knowledge of the emissions behavior of the engine, using this knowledge to select the highest-emitting points, and presenting evidence that engines meet NTE standards when tested at these points. Applications for certification must include any relevant testing, engineering analysis, or other information in sufficient detail to support a conclusion that all the engines in an engine family comply with the NTE standards.

In Attachment II, you will find examples of methods for demonstrating NTE compliance for both 2-stroke engines without catalysts and 4-stroke engines/2-stroke engines with catalysts. In addition, if you would like further clarification or have questions about your test plans, please contact your certification representative.

Attachment I – Examples of Methods for Determining Emissions Behavior

Two methods are suggested below for determining the emissions behavior over the applicable NTE zone. In the first example, shown in Figure 1, speed/torque sweeps are carried out to determine emissions behavior. In this case four sweeps are conducted in addition to the E4 propeller curve. Each of these curves roughly follows the "speed$^{1.5}$" power relation that the E4 propeller curve is based on. The spacing of the test points should primarily depend on how sharply or gradually emissions change over the NTE zone.
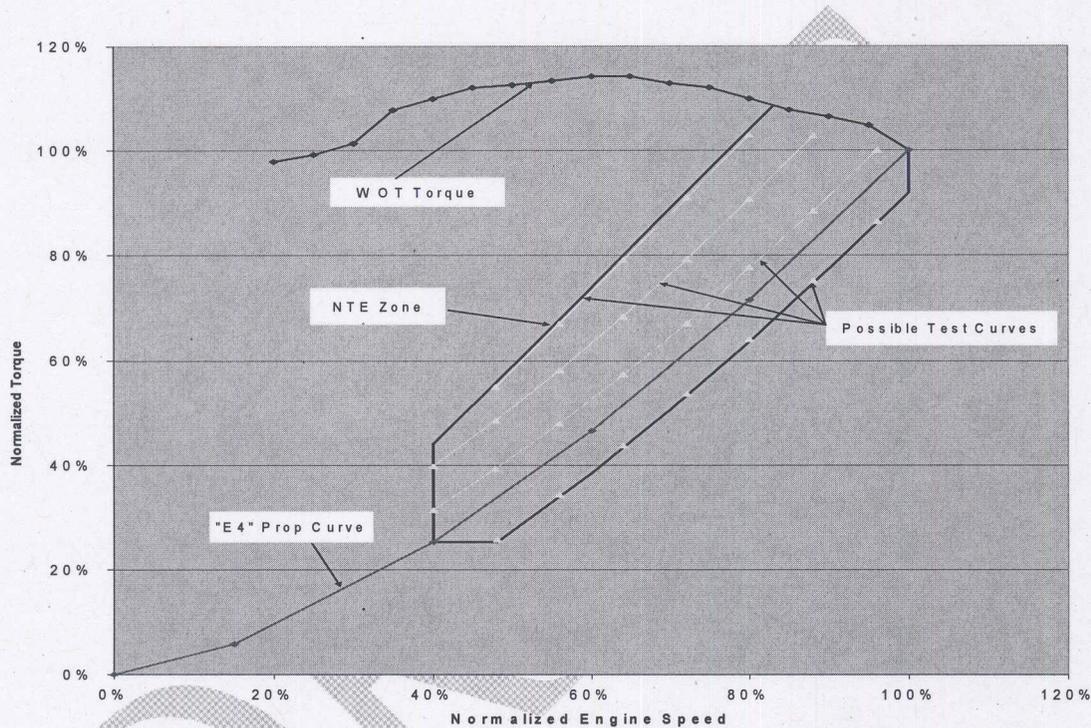
Figure 1 – Example of test curves following the propeller curve for preliminary testing to determine emission behavior over the NTE zone.

The example presented in Figure 2 is more consistent with normal engine mapping and calibration exercises. In this case, a grid of test points is formulated from speed and torque points at discrete intervals. Again, the spacing of the points is dependant on how sharply emission levels change across the area of interest. If this testing was being conducted solely for demonstrating compliance with NTE standards, test points outside of the NTE zone could be omitted.
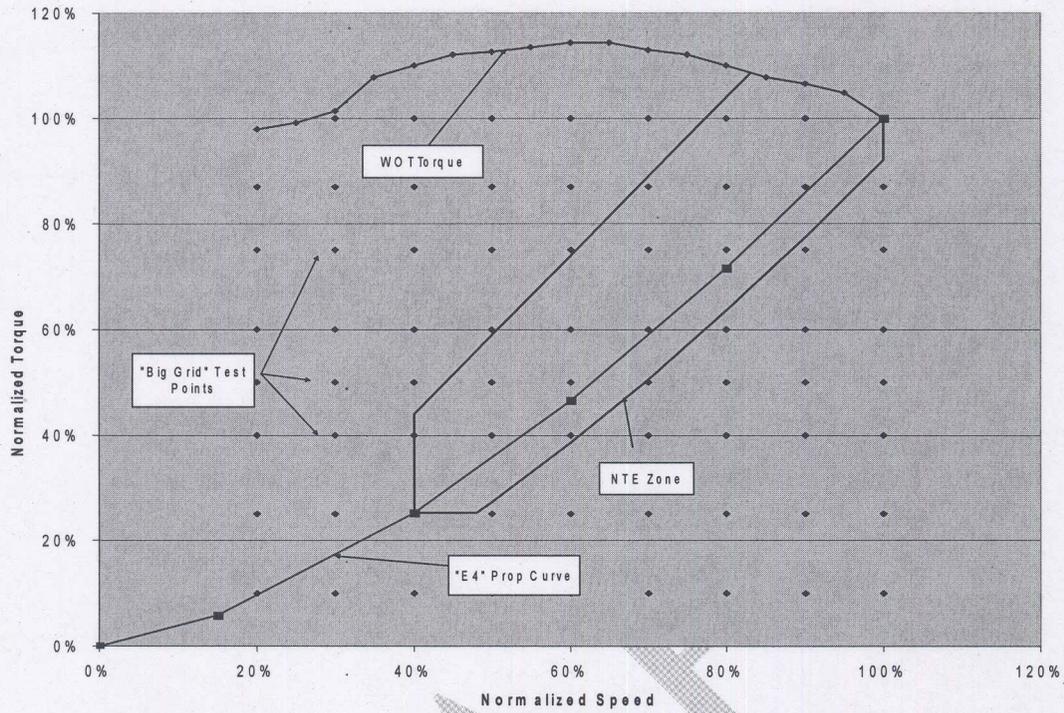
Figure 2 – Example of using a grid of torque/speed points for preliminary testing to determine emission behavior over the NTE zone.

Attachment II – Example of Compliance Demonstration for NTE Standards

2-Stroke Engine without Catalyst

One example for satisfying the NTE requirement would be to conduct torque sweeps at 40%, 60%, 80% normalized speed and WOT. For each of the four cases, determine the torque level which produces the worst emissions of both $HC+NO_x$ and CO (within the boundaries of the NTE). Conduct emission testing at the prescribed speeds and at the torque level that was determined to produce the highest emissions for each speed point. Weight each point according to the table in part 1045 Appendix II. The idle point can be carried over from the modal testing part of your certification testing. The weighted composite of this test must not exceed the NTE emission standard (1.2 x the normal emission standard).

4-Stroke Engine (or 2-stroke with catalyst)

From data collected during calibration, construct emission maps over the applicable NTE zone for both $HC+NO_x$ and CO. An example of what such a map may look like is provided below (shown for a non-catalyst engine).
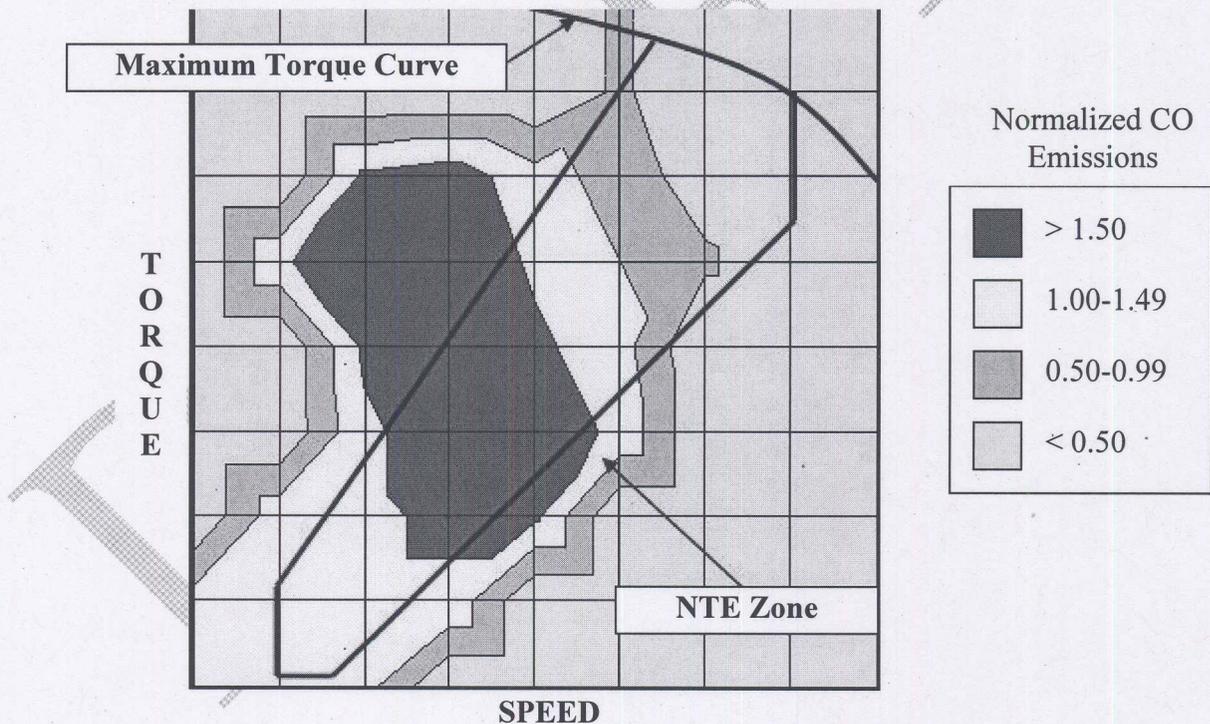

Figure 3 – Example CO Emission Map

Since the engine under consideration is 4-stroke and non-catalyzed, Figure 3 of §1045.515 (shown below) applies. From this figure, and the associated description, the NTE multiplier for CO is 1.5; meaning that at any point within the NTE zone, the emission level must be at or below 1.5 times the normal emission standard (or Family Emission Limit, if applicable). For $HC+NO_x$, the NTE zone is divided into two subzones

with different multipliers. In this instance the multiplier of 1.6 for Subzone 2 allows slightly higher emissions than the multiplier of 1.4 for Subzone 1.
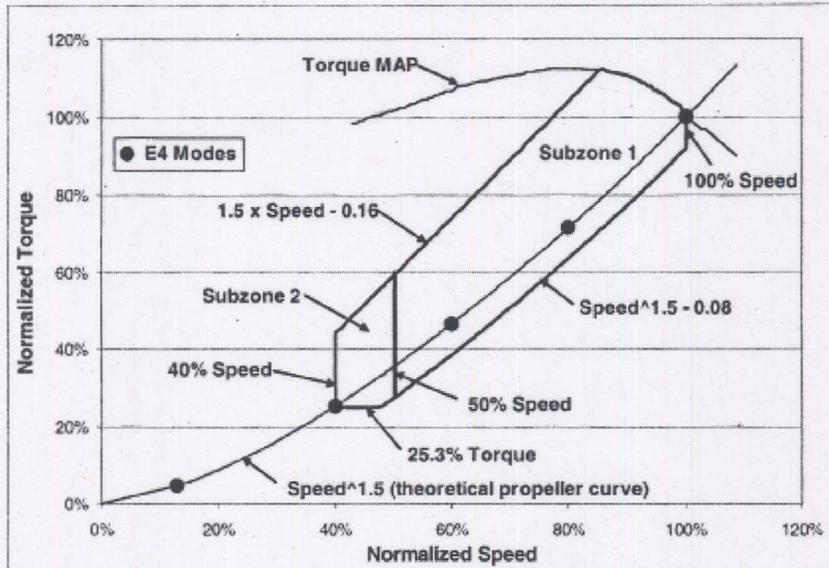
Figure 4 – NTE subzone for 4-stroke, non-catalyzed engines (from 40 CFR 1045.515)

Based on the prescribed NTE zone and the emission map, testing for CO NTE compliance would be most prudent in the middle region of Figure 3 where emissions are highest. Since the variation in CO emissions are fairly gradual, testing at one or two points in this region would be sufficient. When testing for HC+NO_x compliance, the emission map may be very different from the CO case. Combined with consideration of the two separate NTE multipliers for HC+NO_x, additional test points are likely to be needed to demonstrate compliance.

Once testing is complete, each point is evaluated against the NTE standard. As a reminder, the NTE standard will vary by the location within the NTE zone and exhaust gas specie(s) being considered. If all points are properly selected and the measured emission levels fall within the standards for CO and HC+NO_x, the engine can be considered to be in compliance with NTE requirements.