Response to Comments for the Final Regulations for Revisions to the Federal Test Procedure for Emissions from Motor Vehicles

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U.S. Environmental Protection Agency
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I. **Legal**

A. Impact on Stringency of Tier 1 Emission Standard and Consistency with Section 202(b)(1)(C)

Summary of Proposal

In the NPRM, EPA noted that the proposed regulations were authorized by sections 202, 206, 208, and 301 of the Act. The proposal specifically referred to the language of section 206(h), which requires EPA to:

> review and revise as necessary the regulations under subsection (a) and (b) of this section regarding the testing of motor vehicles and motor vehicle engines to insure that vehicles are tested under circumstances which reflect the actual current driving conditions under which motor vehicles are used, including conditions relating to fuel, temperature, acceleration, and altitude.

The proposal referred to the Support Document to the Proposed Regulations (Support Document) for a more detailed analysis.

In the Support Document, EPA noted that section 206(h) is silent on the impact that test procedure changes should have on emission standards. The text of section 206(h) does not limit or restrict EPA's authority to establish emission standards. The Agency therefore believes that it may propose emission standards along with test procedure changes to the full extent authorized under the Act, including the broad authority of section 202.

The Support Document also noted that the proposed emission standards for the supplemental portion of the FTP do not violate the section 202(b)(1)(C) prohibition on modification of the numerical emission standards specified in 202(g) and (h) (i.e. the Tier 1 exhaust standards) prior to model year 2004. EPA noted that the standards proposed were new standards that were in addition to, not alternative to, the existing Tier 1 standards.

Finally, the Support Document noted that section 202(b)(1)(C) restricts EPA's ability to relax the Tier 1 numerical emission standards in order to account for changes in test procedure. EPA is required to revise the test procedures used to measure compliance with Tier 1 without revising the Tier 1 numerical standards prior to model year 2004. The Support Document states that "Congress clearly envisioned that the test procedure used to measure compliance with Tier 1 standards could change. Congress did address the issue of changes to the Tier 1 standards, and instead of directing EPA to adjust the standards to account for any test procedure changes, Congress prohibited EPA from changing the numerical emission standards prior to MY 2004." The Support Document also noted that any impact on the stringency of Tier 1 standards is properly addressed through consideration of the appropriate effective date for the test procedure changes.

Summary of Comments

AAMA/AIAM provided lengthy comments arguing that the EPA's proposal to revise the Federal Test Procedure (FTP) and establish a Supplemental FTP (SFTP) with new emission standards would effectively increase the stringency of the existing emissions standards. According to AAMA/AIAM, the 1990 amendments to the CAAA do not give the EPA such authority. In their comments, AAMA/AIAM acknowledged the EPA's authority to establish test procedures and emissions standards under section 202(a) of the act; however, it is their contention that the authority is expressly limited by 202(b) and (g). Section 202(b)(1)(C) states "it is the intent of Congress that the numerical emission standards" provided in 202(g) "shall not be modified by the Administrator...for any model year before the model year 2004." AAMA/AIAM stated that the plain language of the statue "leaves no room for indirect modifications effected by manipulating the tests by which the standards are measured."

AAMA/AIAM also acknowledged the EPA's authority to prescribe test procedures under 206 and recognized that 202(b)(1)(C) and 202(g) do not prevent minimal changes to the vehicle. Thus, it was reasoned that the Agency may propose an SFTP and supplemental standards that may require recalibration or adjustments, but the Agency cannot require such standards or procedures which require the installation of additional equipment or substantial alterations to existing vehicles.

AAMA/AIAM claim that the authority granted in section 206(h) must be consistent with other provisions in the Act, i.e., EPA may not increase the stringency of the Tier I standards. AAMA/AIAM comments reviewed the legislative history of section 206(h) to aver that it did not provide the Agency with any new authority to revise the emissions standards either directly or indirectly through revisions to the FTP. AAMA/AIAM pointed out that while much of Title II of the act is derived from HR3030, section 206(h) was added by the Senate. However, in the House Committee Report, the issues of test procedures and standards were addressed specifically, "it is the Committee's intent that if EPA subsequently revise such procedures under the title, the measured emission results under such revised procedures shall be adjusted as necessary to reflect the result that would be achieved under current procedures." AAMA/AIAM also cited remarks from a conferee, Representative Luken, made during a post-conference debate.

AAMA/AIAM comments presented a related argument that section 206(h) does not provide the agency additional discretion to revise the Tier I standards. While not specifying how the Agency should revise the test procedures, the AAMA/AIAM suggested that Congress expected the Agency to exercise its 206(a) authority, as directed in 206(h), within the limits of 202(a) and 202(b)(1)(C). It was AAMA/AIAM's position that the requirement in section 206(h) must conform to the express limitations and to the overall framework of the Act. Therefore, the Agency cannot disregard the prohibitions provided in section 202(b)(1)(C) and its legislative history.

The AAMA/AIAM comments suggested that the EPA's review of 206(a) was cursory and ignored the express limitations of authority. The court case of <u>Chevron U.S.A. Inc. v. Natural Resources Defense Council Inc.</u> was cited to argue that the Agency has no authority to interpret the language differently from plain wording of the statute. Further, it was argued that to interpret otherwise would render 202(b)(1)(C) meaningless. In citing the case of Boise Cascade Corp. v. EPA, AAMA/AIAM made the case that the Agency can not interpret one provision in such a way which renders another provision meaningless. Thus, EPA cannot interpret section 206(h) in such way that the test procedure revisions make attainment of Tier I standards more difficult, and by implication render meaningless section 202(b)(1)(C).

Finally, AAMA/AIAM claimed that the Agency was disregarding its long held recognition of the relationship between test procedures and standards, and stated that such unexplained departure from precedent was arbitrary and capricious. AAMA/AIAM's interpretation of the proposal led them to believe that the Agency considered the restriction of 202(b)(1)(C) only to restrain the Agency from "relaxing" the Tier I standards. AAMA/AIAM concluded that such an interpretation resulted in standards which are entirely malleable and do not provide the stability prescribed by Congress.

Two other comments, submitted by Volvo and MECA, also stated that the revised test procedures should not effectively increase the stringency of the current Tier I standards or future standards.

By contrast, both NRDC and NESCAUM quoted section 206(h) and interpreted the section as indicating that Congress was concerned with a large gap between the real world emissions and emissions measured during the existing test procedure. NRDC and NESCAUM believe that Congress wanted the EPA to revise the test procedure to be representative of actual driving conditions. The comments note that Congress explicitly prohibits EPA from revising the Tier 1 standards prior to 2004.

The comments state, in the context of EPA's supplemental standards, that Congress did not indicate that the EPA was to develop any new emission standards. Both comments went on to cite section 202(b)(1)(c) as evidence that Congress "unequivocally prohibited EPA from modifying those numerical standards."

Both NRDC and NESCAUM express their dismay that the EPA is proposing supplemental procedures while leaving essentially unchanged the current FTP. Both comments believe that the emission standards associated with the supplemental tests are more lenient than existing standards for the FTP, and thus, the EPA's proposal was inconsistent with Congressional intent. NRDC added that the EPA's proposal is also inconsistent with section 202(b)(1)(C), which requires that any revised standard should result in emission reductions. NRDC and NESCAUM urged the EPA to apply the specific numerical standards specified in the Clean Air Act to the revised test procedures, not to manipulate the test procedure in order to "fit" the numerical standards.

Response to Comments

The EPA reaffirms that its actions under section 206(h) to strengthen the test procedure are not prohibited by section 202(b)(1)(C). Section 202(b)(1)(C) is specifically limited in scope and clearly allows EPA to revise the test procedures by which standards are measured. Moreover, section 202(b)(1)(C) merely prevents EPA from changing the specific standards of sections 202(g) and (h). It does not prevent EPA from promulgating supplementary standards relevant to procedures that were not in existence and emissions that were not regulated prior to the promulgation of these regulations.

EPA disagrees with the comments of AAMA/AIAM regarding their claims that section 202(b)(1)(C) limits EPA actions under section 206(h). On the contrary, as noted in the Support Document, the requirements of section 206(h) and 202(b)(1)(C) are separate requirements that create two different duties for EPA. Strengthening the test procedure is not prohibited by section 202(b)(1)(C). Section 202(b)(1)(C) is specifically limited in scope and clearly allows EPA to revise the test procedures by which standards are measured, even if such procedures provide more strict requirements upon vehicle manufacturers.

The provisions of section 206(h) and sections 202(g) and (b)(1)(C) are designed to address two different concerns of Congress. As discussed in the Proposal and the Support Document, the Congressional history shows that Congress' intent in adding section 206(h) was for EPA to increase the scope of the test to make it more representative, as well as to increase the overall in-use emissions control resulting from the test. Congress was also concerned with changing the actual numerical exhaust emission standards from vehicles, and thus revised section 202 to require certain more stringent standards. It also added section 202(b)(1)(C) to keep such "numerical emission standards" stable.

Congress specifically restricted the language of section 202(b)(1)(C) to refer only to "numerical emission standards." Thus, it is clear on the face of the statute that the language of section 202(b)(1)(C) does not apply to revisions of the test procedure. Congress could have easily included language that prevented EPA from revising its regulations in any way to make the Tier 1 standards more stringent. Congress also could have limited the scope of section 206(h) by stating that any actions making the test procedure more stringent would have to be accompanied by a revision of the numerical emission standards to account for such test revisions. Congress, however, instead made absolutely clear that EPA was to revise its test procedure to make it more representative AND EPA was not to revise the numerical Tier 1 exhaust standards prior to model year 2004. Thus, a reasonable reading of sections 202 and 206 and the Legislative History (see 1 Leg. Hist. 890, Chafee-Baucus Statement of Managers, 136 Rec. S16936(Oct. 27, 1990)) is that Congress intended the specific exhaust emission standards mandated in section 202(g), (h) and (b)(1)(C) be mutually consistent with the test procedures promulgated under section 206(h). The regulations promulgated today do just that.

Regarding AAMA/AIAM's comments that EPA cannot use its authority under section 202(a) to increase the stringency of Tier 1 standards, EPA is not increasing the stringency of the Tier 1 standards in this rulemaking. The standards EPA promulgates today are not Tier 1 standards but are supplemental standards intended to implement section 206(h).

Regarding AAMA/AIAM's claim that section 206(h) is limited to test revisions that require only "minimal" changes to vehicles ("minimal changes" could include recalibration of existing emission control equipment, but could not require installation of additional equipment or substantial alteration of existing vehicles), absolutely nothing in section 206 or 202 indicates any such limitation on EPA's authority under section 206.

Regarding AAMA/AIAM's discussion of the legislative history, the comments admit that the final language of section 206(h) came from the Senate bill and that no comparable language appeared in the House bill. The comments point to language in the House Committee report indicating that if test procedures are adjusted, the measured emission results shall be adjusted to reflect the results that would have occurred under current procedures. However, this language never became part of the House bill was not added to the final bill, despite the clear language of the final bill requiring EPA to revise the test procedures. Moreover, the final bill contains a specific requirement that EPA NOT adjust the numerical Tier 1 standards for any reason.

Regarding the comments that EPA's revisions pursuant to section 206(h) must be consistent with the rest of section 206 and the Act, as explained above, these regulations are completely consistent with the express limitation and the overall framework of the Act. The _Chevron_ case cited by AAMA/AIAM affirms EPA's authority to interpret ambiguous language in statutes. More importantly, EPA's regulations are fully consistent with the doctrine in _Chevron_ that the Agency must give effect to the clear intent of Congress. EPA's regulations revise the federal test procedure "to insure that vehicles are tested under circumstances which reflect the actual current driving conditions under which motor vehicles are used," as required under section 206(h), and EPA does not change the numerical Tier 1 emission standards, which section 202(b)(1)(C) forbids. Therefore, EPA has fully effectuated the clear intent of Congress. It is AAMA/AIAM who wish to avoid the clear intent of Congress by requesting that EPA either not revise its test procedures as Congress required or that EPA revise the Tier 1 standards prior to MY 2004, which Congress clearly forbid.

This interpretation does not render section 202(b)(1)(C) meaningless, as EPA's interpretation clearly provides that it cannot change the numerical standards of Tier 1. Clearly, a direct change in the numerical Tier 1 standards would have a direct effect on the stringency of the program. EPA's inability to change such standards, whatever its authority to change the test procedure, still provides considerable constraint on EPA's freedom to increase the stringency of its motor vehicle program.

Finally, EPA has not failed to recognize that there is an interconnection between numerical emission standards and the procedures that test for compliance with such standards. EPA is merely noting that the prohibitions on section 202(b)(1)(C) are directed specifically towards the former, not the latter, and that section 206(h)'s mandate specifically requires that EPA revise the latter to ensure that the test for compliance with such standards, including the Tier 1 standards, are consistent with the actual conditions under which the vehicles are used.

AAMA/AIAM's interpretation of the proposal led them to believe that EPA considers the restriction of 202(b)(1)(C) only to restrain EPA from relaxing the Tier 1 standards, the comments have misinterpreted EPA's intent, which is that the numerical Tier 1 standards may not be revised either to make them more stringent or less stringent.

Regarding the comments of NRDC and NESCAUM, EPA agrees that Congress specifically intended that the Tier 1 standards not be revised prior to 2004. Moreover, EPA agrees that Congress was worried about the gap between emissions as measured by the FTP and real world emissions and that Congress intended EPA to revise the test procedure to eliminate that gap.

However, EPA does not agree that Congress intended to prevent EPA from promulgating supplemental standards in order to effectuate the requirements of section 206(h). Such language is neither explicit nor implicit in the language of the Clean Air Act Amendments. As discussed in the Support Document, Congress provided no prohibition on EPA promulgating supplemental standards under section 202(a). In fact, EPA has clear authority to promulgate such standards and was given broad authority by

Congress to revise appropriate regulations under section 206(h). Moreover, section 202(b)(1)(C) merely prevents EPA from changing the specific standards of sections 202(g) and (h). It does not prevent EPA from promulgating supplementary standards relevant to procedures that were not in existence and emissions that were not regulated prior to the promulgation of these regulations. The standards promulgated today are in addition to, not instead of, Tier 1 standards.

B. Failure to Consider Leadtime and Technology

Summary of Proposal

EPA proposed additions and revisions to the tailpipe emission portions of the Federal Test Procedure (FTP) for light-duty vehicles (LDVs) and light-duty trucks (LDTs). The primary new elements of the proposal were the representation of aggressive (high speed and/or high acceleration) driving behavior, air conditioning, and intermediate-duration periods where the engine is turned off. An element of the proposal that also affected the conventional FTP was a new set of requirements designed to more accurately reflect real road forces on the test dynamometer. The Agency also proposed new emission standards for the new control areas and estimated the per vehicle cost of complying to be in the range of $11.63 to $14.81.

The Agency proposed to phase in the proposed requirements for aggressive driving and air conditioning control prior to implementing the intermediate soak requirements. It was proposed that the standards apply to 40 percent of each manufacturer's combined production of LDVs and LDTs for the 1998 model year, 80 percent in 1999, and 100 percent in 2000. Small volume manufacturers would not have to comply until the 2000 model year. All the proposed requirements would apply during this phase-in period, except that air conditioning requirement could be conducted with a 10-minute soak instead of the proposed 60-minute soak for control of intermediate soak emissions. The 60-minute soak would be required for all vehicles starting with model year 2001, including small volume manufacturers.

Summary of Comments

AAMA/AIAM commented that the EPA failed to adequately consider cost, leadtime, and the technology needed to comply with the proposed SFTP as is required by the cost and leadtime requirements of section 202(a)(2), and under section 307(d)(9).

AAMA/AIAM presented two explanations showing that it is not technically feasible to meet the EPA's leadtime proposal. First, AAMA/AIAM stated that the Agency's determination of leadtime was based on the incorrect assumption that the proposed SFTP standards would require only calibration changes to vehicles, as discussed in detail in section VII of their comments. AAMA/AIAM suggested that the Agency has inadequate data supporting only recalibration changes, and data provided by AAMA/AIAM to the Agency indicated that recalibration changes alone would not be adequate to meet the proposed standards.

On this issue, AAMA/AIAM concluded that to assume that the proposed standards can be met with only calibration changes is a "clear error of judgement and inconsistent with the data before the Agency...Promulgation of the rule in the face of clear, credible and certain data which contradicts the Agency's findings would also be arbitrary and capricious."

AAMA/AIAM also commented on the leadtime proposed for the dynamometer requirement. AAMA/AIAM stated that the proposal contained no discussion on how the Agency determined the leadtime for implementation. AAMA/AIAM claimed the Agency also failed to discuss how the industry could modify facilities while maintaining normal activity and still meet the proposed implementation date. The AAMA/AIAM comments cited evidence submitted to the EPA show significantly more time is required. Finally, AAMA/AIAM felt that there was inadequate data to proceed with the proposed schedule and to do so would be arbitrary and capricious.

Response to Comments

EPA acknowledges that it must provide an explanation for its decisions and must consider leadtime in promulgating standards. EPA has done so, as well as providing appropriate consideration of costs and adequate data on which it has based its decision. Given EPA's careful review and consideration of the issues raised, EPA has clearly not acted in an arbitrary and capricious manner and is entitled to considerable deference regarding its weighing of the data before it. The cases cited by AAMA/AIAM are inapposite.

Specific issues related to leadtime are discussed in section V.G. Vehicle hardware and technology issues are addressed separately for each control requirement (see sections II, III, and IV) and costs issues are discussed in Section IX.A.

C. <u>Cost Estimates</u>

Summary of Proposal

The EPA in its Regulatory Impact Analysis evaluated the economic and environmental impacts of the SFTP. The economic impacts (costs) imposed on the equipment manufacturers included hardware for improved emission control and associated development and redesign costs, improved engine control calibrations, increased costs associated with the certification process including durability data vehicle testing and reporting, and facility costs.

The environmental impact (benefits) of the SFTP was evaluated by estimating the emission reductions associated with the proposed federal test procedure revisions. This was accomplished by determining the expected lifetime emission reductions per vehicle sold after implementation of the proposed regulations nationally.

Summary of Comments

In commenting on costs of the proposal, AIAM/AIAM stated that the EPA underestimated the cost for the individual requirements and overestimated the benefits of the testing changes and new standards. AAMA/AIAM felt that the EPA failed to consider the technological impact of the new requirements. Their comments went on to cite three examples where they felt the EPA did not properly account for all costs: the cost of vehicle redesign for complying with the intermediate soak requirement, engine and exhaust system changes need for complying with the air conditioning requirement, and the impact of the 48" dynamometer requirement.

It was AAMA/AIAM's contention that in calculating emission benefits, the EPA included areas of the country which are already in compliance with NAAQS or areas where NOx waivers are being granted. EPA also used worse case conditions in calculating the benefits from the air conditioning requirement. The comments stated that these assumptions led to an overestimation of emission benefits.

Based on AAMA/AIAM's cost and benefits calculations provided in Appendices 1-3, elements of EPA's proposal were far in excess of the range of the cost effectiveness of recent rules. The comments suggest the appropriate range was $1600 to $5000 per ton for VOC and NOx control. The comments claim that EPA violated its cost-effectiveness policies.

Response to Comments

In the revised RIA the EPA responds to many of the cost and benefit comments made by the manufacturers. In many cases we accepted AAMA/AIAM numbers for facilities and testing (for a more detailed explanation of the revised cost-effectiveness see the RIA section of the response to comments). Based on manufacturer comments and EPA re-analysis, the intermediate soak component of the SFTP was dropped from the final rule. The EPA does not agree with and, therefore did not incorporate, all of the comments of AAMA/AIAM into the RIA. Specifically, the EPA considers the SFTP a national rule which incorporates all areas, including NOx waiver, OTR, and attainment areas, into the analysis (see response to comment section on benefits).

Based on the revised RIA, the EPA believes that the SFTP and its components (A/C and Aggressive Driving) are cost-effective and consistent with EPA policy. The cost-effectiveness ($1,000-$2,000 per ton) is well within the range cited by AAMA/AIAM in its comments. Furthermore, the EPA believes that the range is broader than $1,600-$5,000, as suggested by AAMA/AIAM, and should extend to at least $6,100 which was the cost-effectiveness of the Tier I standard.

D. High Altitude

Summary of Proposal

The Agency did not propose to supplement by further regulation the altitude testing flexibility in current law. EPA stated that it believed any emission controls required for aggressive driving would also be effective during high altitude driving. However, the EPA reaffirmed its authority to perform vehicle testing at any altitude.

Summary of Comments

AAMA/AIAM stated that EPA did not consider the issue of high altitude compliance in the NPRM and that EPA had no basis or technical support for requiring an SFTP standard at all altitudes. The AAMA/AIAM comments went on to discuss the technical problems with meeting SFTP standards and indicated that the only test data at high altitude was provided by AAMA/AIAM. These data illustrated the thermodynamic effects of operating an internal combustion engine at high altitude and projected vehicle performance over US06 at both low and high altitude. AAMA/AIAM concluded that significant redesign to all vehicles would be necessary to comply at high altitude. Separately, Ford commented on the lack of EPA data and recommended that the application of the SFTP requirements to high altitude vehicles was not necessary at this time. Suzuki stated that, due to lower vehicle performance at high altitude, US06 testing at high altitude would require load adjustments to the entire cycle. AAMA/AIAM suggested that the EPA had failed to analyze cost, leadtime and necessary technology and must do so to justify such standards at high altitude within the context of section 202(a)(1) and (2).

Given the lack technical or legal rationale on high altitude requirements in the Preamble, the AAMA/AIAM conjectured that the Agency was apparently compelled by Section 206(f) to require SFTP standards at all altitudes. AIAM/AAMA provided two comments on this issue. AAMA/AIAM believed that the EPA was not compelled to require SFTP at high altitude and argued that the clause in section 206(h) required EPA to review and revise only "as necessary". Thus, EPA did not have to proceed with an all altitude requirement, since it was AAMA/AIAM's contention that such a requirement was not necessary.

AAMA/AIAM also commented that a second interpretation of sections 206(f) and (h) suggested that imposing SFTP standards at all altitudes would imply that the Agency could not set standards for any vehicles until it complied with section 202(a)(1) and (2). AAMA/AIAM responded that this is not possible given the absence of data for high altitude. Thus, AAMA/AIAM concluded that if the SFTP standards apply at all altitudes, then the EPA must withdraw the entire proposal until it can comply with section 202(a)(1) and (2).

Response to Comments

The Agency acknowledges AAMA/AIAM comment that EPA did not have any data on the SFTP requirements at high altitude. The EPA reviewed the data submitted by AAMA/AIAM and member companies on vehicles tested at high altitude The data clearly show the dramatic impact high altitude has on wide-open throttle (WOT) time during the aggressive driving cycle. As discussed in the context of the CO standard (section 3a), EPA concluded that control of WOT emissions should be limited to 2 to 3 seconds due to the durability impact of elevated engine and catalyst temperatures. Testing at high altitude goes well beyond the WOT control which EPA feels is appropriate. In addition, the lower performance levels at high altitude may affect driving behavior.

As the Agency does not have any data on driving behavior at high-altitude, it is not known whether or not the US06 cycle is representative of high-altitude driving.

For all elements of the SFTP, the emission control attained by compliance at low altitude would also be achieved at high altitudes. Thus, given that low altitude emission control will also be effective at high altitude and the lack of data on driving and emissions at high altitude, EPA will not extend the SFTP requirements to high altitude testing.

EPA agrees with AAMA/AIAM that section 206(f) does not compel that all standards promulgated under section 202(a) be "all-altitude" standards. Section 206(f) merely states that the requirements of section 202 standards shall apply to vehicles at all altitudes. However, it does not prevent EPA from explicitly distinguishing between high altitudes and other altitudes in determining the standards that are required under section 202(a); nor does it prevent EPA from excluding high altitude driving from the requirements of particular standards under section 202. In this case, EPA finds that the SFTP standards promulgated under section 202 should not apply to high altitude testing.

E. Executive Order 12866

Summary of Proposal

The EPA, in its Regulatory Impact Analysis (RIA), evaluated the environmental and economic impact of the SFTP. In accordance with EPA policy, an extensive analysis of the costs and benefits of the rule were made. Based on the information available to the EPA, the Agency concluded that the SFTP components --Intermediate Soak, Aggressive Driving, and Air Conditioning-- were cost effective compared to similar rules under the Clean Air Act Amendments and posed the least burden on society while gaining the greatest environmental benefits (see the NPRM RIA for more information on the costs and benefits of the proposed SFTP). The EPA did not explicitly discuss Executive Order 12866 in the NPRM.

Summary of Comments

In their comments, AAMA/AIAM stated that the EPA's cost/benefit analysis did not comply with Executive Order 12866 and that the proposal failed to comply with the three key principles of regulations set forth in the Executive Order: EPA must evaluate a rule’s costs and benefits in order to show that the benefits justify the costs; EPA must avoid inconsistent, incompatible or duplicative regulations; and EPA must tailor the regulation so that it imposes the least burden on society.

AAMA/AIAM supported this contention by citing previous AAMA/AIAM comments regarding EPA's overestimation of benefits and underestimation of costs. The AAMA/AIAM also argued that EPA's proposal rejected options that the industry and EPA jointly developed which would have achieved the objective of the regulation at a reasonable cost. In doing so, AAMA/AIAM stated that EPA actions were inconsistent with the Executive Order 12886 principle of "tailoring its regulation to impose the least burden on society, including...business."

Response to Comments

The EPA, as stated in the response to comments for the RIA and in the legal section concerning costs and benefits, has shown that the benefits do justify the costs. The cost-effectiveness values ($1,000-$2,000 per ton reduced) are well within the range of similar CAAA regulations. AAMA/AIAM argued that the EPA rejected options proposed by industry but failed to cite those proposals or to show how they are more justifiable than EPA's SFTP components. Based on the revised cost-effectiveness of the SFTP, the EPA believes that this regulation is justifiable and imposes the least burden on society while gaining the most benefit.

The EPA is following the requirements of Executive Order 12886. The Agency has performed an extensive cost-effectiveness analysis in its RIA that justifies the costs of the rule, has evaluated the SFTP in relation to other NOx CAAA rules and found the SFTP to be consistent and compatible with the integrated NOx strategy of the EPA, and, as demonstrated by the cost-effectiveness analysis, the SFTP imposes the least burden on society for the benefit achieved.

F. Motor Vehicle Information and Cost Savings Act

Summary of Proposal

The EPA did not explicitly discuss fuel economy impacts in the NPRM.

Summary of Comments

AAMA/AIAM comments noted that the EPA did not address the issue of fuel economy decreases in the proposal. The comments requested that EPA issue fuel economy test procedure adjustments as soon as possible. The adjustments should be coordinated with NHTSA to assure similar adjustments for light-duty trucks. AAMA/AIAM argued that the Motor Vehicle and Information Cost Savings Act required the EPA to give adjustments for measure fuel economy whenever it modified the test procedures for measuring fuel economy.

AAMA/AIAM comments proceeded to review the Cost Savings Act and its legislative history, as well as the CAFE adjustment Factors Rule of July 1, 1985 (see 50 Fed. Reg. 27183(1985); 40 C.F.R. § 600.510-86) to lay out the criteria for determining fuel economy adjustments: 1) directional change can be predicted from revision; 2) magnitude of the change is quantifiable; 3) impact of the change is not due to eliminating the ability of manufacturers to take advantages of flexibilities in the existing test procedures; 4) impact of the change is not solely due to greater ability of manufacturers to reflect in measured fuel economy those design changes expected to have a comparable effect on in-use fuel economy; and 5) test procedure is a change required by EPA or initiated by EPA and is not a change implemented solely by a manufacturer in its own laboratory. AAMA/AIAM stated that the proposed changes to the FTP satisfied the criteria for justifying adjustments.

Specifically, AAMA/AIAM stated that EPA/industry testing has already shown a negative impact on fuel economy and this difference could be measured once sufficient testing is carried out. Regarding the third criteria, AAMA/AIAM said that the proposed changes to the FTP did not fall under the parameters of 40 C.F.R. § 600.510- 86(f)(3) and thus, were eligible for adjustments. The proposed revisions also were not the type referenced in 40 C.F.R. § 600.510-86(f)(4). Finally, the proposed FTP changes were being initiated by the EPA, not solely implemented by a manufacturer, so the EPA was required to provide adjustments.

AAMA/AIAM also commented that the EPA was required to make fuel economy adjustments for any changes to the FTP, even if the changes in test procedure were not performed concurrently with the fuel economy tests. AAMA/AIAM argued that the proposed FTP revisions would result in the addition of bags 4-6 which, while not being part of the fuel economy test, might have an impact on the measured fuel economy, and thus, the EPA must make CAFE test procedure adjustments for the new requirements.

AAMA/AIAM also commented on the timing of the test procedure adjustments. Citing the Preamble to the rule published as 50 Fed. Reg. 27183 (1985), they stated that the EPA must make test procedure adjustments at the same time that it promulgates the final regulations on the FTP changes. AAMA/AIAM also commented that the test procedure adjustments should be based on a comprehensive test program which should be run before the test procedures are in their final form. In concluding their comments on test procedure adjustments, AAMA/AIAM suggested that to comply with its legal obligations, the EPA should do the following: delay finalizing the proposed rule until fuel economy test procedure adjustments are developed, issue a notice of proposed rulemaking on the final test procedures with sufficient information so the EPA and industry can carry out a comprehensive test program, and issue final changes to the test procedures at the same time as the fuel economy test procedure adjustments.

Response to Comments

EPA agrees that, to the extent that changes in the FTP have an effect on the fuel economy test that is run in conjunction with the FTP, then EPA must issue adjustment factors to ensure comparability with the fuel economy test procedures used in 1975. EPA will promulgate any adjustments to the fuel economy calculations through notice and comment rulemaking. EPA shall publish in the near future a proposal regarding this issue. EPA will also be conducting a test program with AAMA/AIAM to review this issue. EPA will address the substantive issues raised by AAMA in that rulemaking.

Regarding the timing of promulgation of the FTP revisions and the rulemaking for CAFE calculation adjustments, EPA disagrees with AAMA/AIAM's suggestion that EPA should delay promulgating final regulations revising the FTP until it makes a determination regarding CAFE calculations. EPA was required by Congress to promulgate its FTP revisions by March 15, 1992. These regulations are well overdue. EPA is under court order to promulgate these regulations by August 15, 1996. Therefore, EPA cannot fail to promulgate these regulations by that date.

EPA does not believe that either the Motor Vehicle and Information Cost Savings Act or its rules require that EPA delay its FTP revisions until the rulemaking regarding CAFE calculations is complete. AAMA/AIAM points to no language in the regulations that requires such a restriction. AAMA/AIAM does note that in its preamble to the July 1, 1985 rulemaking related to earlier CAFE adjustments, EPA stated that it planned to make specific changes to CAFE calculations at the same time as it revised the regulations. However, these stated plans, written eleven years ago, are not in the promulgated regulations and, in any case, cannot control the timing of rulemaking that is mandated by more recent statutory obligations and court orders. Moreover, as AAMA/AIAM admit, EPA regulations do require that any changes in the CAFE calculations occur after notice and comment. EPA has not yet begun the notice and comment process on CAFE adjustments. Given the changes that have occurred between proposal and completion of the FTP rule, the calculations and procedures necessary to begin a rulemaking to determine CAFE adjustments resulting from the FTP rule could not easily have been initiated until final FTP regulations were relatively certain. Given the length of time the rulemaking on CAFE adjustment may need, especially if EPA accepts AAMA/AIAM's request that such rulemaking not be completed until a comprehensive test program is completed, EPA can not delay the completion of the FTP rulemaking until the CAFE rulemaking is completed.

EPA does, however, recognize the manufacturers' need for sufficient leadtime once the Agency makes a final determination of CAFE calculation adjustments, if any. Thus, for <u>only</u> Part 600 fuel economy testing for phase-in years 2000 and 2001, the manufacturers may use the pre-existing dynamometer requirements for their entire fleet. EPA also notes that the July 1, 1985 rulemaking cited to by AAMA/AIAM instituted retroactive changes to the CAFE calculations for all manufacturers.

II. **Standard Setting: Overall Approach**

A. <u>General Standard Setting Criteria</u>

Summary of Proposal

As stated in the NPRM, EPA sought parity between the types and extent of emission controls that manufacturers currently employ to comply with the existing FTP standards and those they would implement to comply across all driving behavior. While EPA, CARB, and the manufacturers initially anticipated that a primary cause of higher emissions during aggressive operation would be "commanded enrichment," data generated in the course of this rulemaking indicated that NOx emissions also substantially increase during aggressive driving. The NPRM sought to control both elevated HC and CO emissions caused by commanded enrichment and elevated NOx emissions caused by erratic air/fuel control and lean events.

The NPRM also stated that the issue of whether this proposed level of CO control would significantly interfere with the ability for vehicles to comply with the proposed level of NOx control was identified too late for EPA to properly evaluate it in the NPRM. Should further data and analyses substantiate that tradeoffs between CO and NOx control would preclude meeting the proposed level of NOx control, the NPRM stated that EPA would consider reducing the stringency of the CO standards for the new control areas in the final rule.

Summary of Comments

AAMA/AIAM stated that the primary goal of aggressive driving ("US06") standards should be to reduce NMHC & CO without exacerbating NOx and without sacrificing engine and catalyst durability. They also stated that the NOx standard proposed in the NPRM seeks to eliminate the NOx problem caused by the NPRM's "extreme" elimination of commanded enrichment, that NOx was never shown to be an "off-cycle" problem, and that EPA's technical feasibility analysis was flawed, leading to a proposal which focused more on NOx control than on off-cycle emissions.

AAMA/AIAM also felt that EPA attempted to eliminate problems one at a time in isolation, rather than considering emissions, performance, and fuel economy as a single system. In addition, they stated that the feasibility of NMHC, CO, and NOx standards must be addressed simultaneously and that EPA ignored the emission trade-offs, thus invalidating their entire analysis. In support of this contention, they pointed out that EPA ignored the fact that the 5-6 vehicles used to justify the proposed NMHC and CO standards had NOx levels approximately a factor of two higher than the proposed NOx standard.

Response to Comments

EPA agrees with AAMA/AIAM's comment that the NPRM considered NMHC, CO, and NOx in isolation, which resulted in flaws in the analysis. In fact, EPA acknowledged in the NPRM that the proposed standards did not fully reflect tradeoffs between CO and NOx emissions. To correct this, for the Final Rule EPA summarized and analyzed comments on setting CO standards separately from NMHC and NOx standards. The CO standard analysis occurs first and the NMHC and NOx standards are analyzed in light of the resultant CO standards. The CO analysis also fully considers impacts on engine and catalyst durability.

EPA does not agree that the primary goal of US06 standards should be to reduce NMHC and CO without exacerbating NOx. The 1990 CAAA clearly set out a generic requirement to ensure test procedures are representative of actual driving behavior. Just because the initial concern identified with actual driving behavior was commanded enrichment, which primarily affects HC and CO, does not mean that EPA should turn a blind eye to other emission impacts of actual driving behavior. In particular, the NPRM documented very large NOx increases on many vehicles during high speed and/or high load operation. Due to the serious ozone problems experienced by many areas of the country and the contribution of NOx emissions to these ozone problems, investigation of the causes and potential mitigation of these NOx increases is a high priority for the Agency. EPA sees no justification for treating NMHC and CO reductions as a higher priority than NOx reductions on US06.

B. Margin for Variability (Headroom)

Summary of Proposal

To account for various sources of vehicle and test variability, the vehicle manufacturers design their vehicles to meet design targets below the emission standard. As acknowledged in the NPRM, the Agency encountered difficultly in determining the appropriate amount of in-use compliance margin to allow when establishing SFTP emission standards. One of the reasons EPA proposed the composite standard approach in the NPRM is that, by preserving the FTP cold start/hot stabilized driving mix and assessing SFTP standard levels relative to FTP standard levels, the current FTP compliance headroom, although unquantified, is implicitly preserved. The NPRM also stated that if data were submitted that could help establish appropriate in-use margins, EPA would reevaluate the most appropriate compliance structure and, if appropriate, may select one of the alternatives in the final rule.

Summary of Comments

In their official comments, AAMA/AIAM simply stated that EPA should "Establish technologically feasible emission design targets based on emission data from vehicles with properly aged hardware and applying the appropriate margin of compliance (headroom) factor of two..." Suzuki stated that "EPA should set standard to provide adequate amount of margin for variability", but did not make any specific suggestions for what this margin should be.

In a subsequent memo from AAMA/AIAM, the manufacturers presented substantial amounts of in-use data on FTP emissions.[1] The data supported the manufacturers claim that their design target for emissions is half the standard.

Mercedes-Benz commented that if the EPA were to promulgate SFTP standards for diesel vehicles, that they be diesel-only NMHC+NOx standards with sufficient headroom. They did not elaborate as to what they considered sufficient headroom.

Response to Comments

No comments were received that disagreed with the NPRM proposal to use the same headroom factor for off-cycle standards as has been used historically for the FTP. In addition, the in-use data submitted by the manufacturers supports a historical headroom factor of two for gasoline vehicles. The data also indicate that hot, stabilized emissions from bags two and three of the FTP are more variable than bag one. As the new cycles being promulgated are also hot, stabilized tests, EPA concurs with AAMA/AIAM's assessment that a headroom factor of two is appropriate for the SFTP.

In examining the most recent diesel LDV certification data, it became apparent that the historical headroom factor of two for gasoline vehicles did not apply to diesel LDV for NOx. For the

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[1] "Compliance Margin/Headroom, Compliance Standards vs. In-Use Emissions", Attachment V to a letter from Gerald A. Esper, AAMA, and Gregory J. Dana, AIAM, to U.S. EPA, January 30, 1995. Available in the public docket for review.

diesel LDV's, the Tier I NOx standard is 1.0 g/mi. Certification emission data suggests that diesel LDV's NOx emissions average 0.82 g/mi. This results in a headroom factor of 1.22. Therefore, a headroom factor of 1.22 will be used for setting SFTP standards for diesel LDV. Further discussion of how the diesel headroom factor is used in setting SFTP standards is found in the following section d.

C. Determination of LDT2/LDT3/LDT4 and Full-Useful Life Standards

Summary of Proposal

The composite standard proposed in the NPRM implicitly tied the new off- cycle standards for each class of vehicles and light trucks to the existing FTP standards for each class. It also implicitly tied off-cycle full-useful life standards to the FTP full-useful life standards.

Summary of Comments

AAMA/AIAM proposed using current FTP ratios to determine SFTP standards for LDT2, LDT3, and LDT4 truck emission classes. As no data was gathered at 100,000/120,000 mile levels, AAMA/AIAM also recommended using the ratio between current FTP standards to set these standards.

Response to Comments

AAMA/AIAM's suggestion to tie LDT2, LDT3, and LDT4 standards and full-useful life standards to LDV/LDT1 half-life standards by the ratio of the applicable Tier I standards is consistent with the standard setting methodology proposed in the NPRM. As no comments were received to the contrary and EPA believes this procedure is appropriate, the standards for full-useful life and LDT2, LDT3, and LDT4 vehicles in the Final Rule are set using the ratio of the applicable Tier I standards. For example, the 50k Tier I CO standard for LDT2s is 4.4 g/mi, compared to 3.4 g/mi for LDVs. Thus, the 50k US06 standard for LDT2s is set by multiplying the US06 CO standard for LDVs (9.0 g/mi) by 4.4/3.4, or 1.294, which equals 11.6 g/mi.

D. NMHC+NOX Standards

Summary of Proposal

The NPRM proposed separate NOx and NMHC standards for the supplemental test requirements. The NPRM stated that the Agency was also considering the alternative of establishing a single standard for NMHC+NOX, instead of separate standards, and invited comment on the cost and emission impacts of this alternative.

Summary of comments

CARB supported setting a combined NMHC+NOX standard for high speed/acceleration compliance on US06, stating that they had committed to proposing the setting of an NMHC+NOX standard for US06 in response to an October 1994 proposal by the automotive industry. However, CARB does not believe it would be appropriate to employ an NMHC+NOX standard for air conditioning standards. CARB recommended setting separate standards for NMHC, CO, and NOx emissions for A/C-on operation, because the range of engine loads encountered with the A/C on is similar to the standard FTP and the evidence suggests that little or no increment to current NMHC or CO standards is necessary for A/C-on operation.

AAMA/AIAM recommended the use of NMHC+NOX standards for all of the supplemental test requirements. All of AAMA/AIAM's standard setting analyses were presented in terms of NMHC+NOX. AAMA/AIAM also stated as a general rule that there are tradeoffs in catalyst efficiency between NMHC/CO and NOx.

NRDC stated that a combined HC + NOx standard would be in direct contradiction of the Congressionally established standards, which set separate limits for specific pollutants, and for the same reasons that EPA can't relax the standards, it can't combine them.

Response to Comments

EPA's analyses of the second-by-second emission data from the US06 testing program clearly indicate that catalyst conversion efficiency is very sensitive to air/fuel ratio. Air/fuel shifts less than 1 percent lean of stoichiometry can cause dramatic reductions in NOx conversion efficiency. While NMHC conversion efficiency is not as sensitive to short air/fuel shifts as NOx conversion efficiency, consistent operation about 1 percent rich of stoichiometry can cause dramatic reductions in NMHC conversion efficiency. Thus, there is only a very narrow range of air/fuel ratio in which the catalyst will convert both NMHC and NOx at the levels required to meet the individual design targets in this rule for NMHC and NOx.

Control of air/fuel ratio in the vehicle is done by feedback from downstream oxygen sensors in the exhaust. Unfortunately, these oxygen sensors are not 100 percent accurate and normal variation occurs in production. Thus, some production vehicles will run slightly richer than designed and some slightly leaner due to the normal variation. This is not a huge problem for compliance with the current FTP emission standards, as about 70 percent of the NMHC emissions over the entire cycle are generated during the cold start, as well as about 30 percent of the NOx emissions, and cold start emissions are largely unaffected by minor changes in air/fuel ratio. However, the variation in air/fuel ratio is a much larger problem for both the US06 and air conditioning standards, which are both conducted in hot, stabilized conditions. During such hot, stabilized tests, oxygen sensor variation could cause some production vehicles to have increased NMHC and decreased NOx emissions, or vise versa, potentially causing individual vehicles to fail one of individual NMHC and NOx standards.

An NMHC+NOX standard minimizes the risk of failing the supplemental requirements in this rulemaking simply due to production variation in oxygen sensor output. This, in turn, allows the standards to be set slightly lower than they could have been otherwise and/or allows the manufacturers to comply with reduced cost. In addition, the NMHC+NOX standard should have no negative impact on overall in-use ozone precursor emissions, as any substantial increase in either NMHC or NOx must be offset by a decrease in the other to avoid failing the standards. As there should be no negative emission impact and it allows the manufacturers increased flexibility in meeting the standards, the Agency is adopting NMHC+NOX standards in the Final Rule. This is consistent with AAMA/AIAM's comment about the tradeoffs between NMHC/CO and NOx and their recommendations to use NMHC+NOX standards. It is also consistent with CARB's position on US06 standards. It is not consistent with CARB's position on air conditioning standards. While EPA agrees with CARB's comments on the similarity of air conditioning loads to FTP loads and that there is little increase in NMHC emissions with air conditioning operation, these factors do not negate the flexibility allowed by NMHC+NOX standards with minimal, if any, emission impact. In addition, CARB's position would make any composite of US06 and air conditioning standards impossible, which is inconsistent with EPA's position on composite standards.

Regarding the comments of NRDC against a combined NMHC+NOx standard, NRDC's comments were based upon the same legal basis as their arguments than EPA can't relax the standards by setting emission levels different from the Tier I standards. As discussed in section I.A., EPA does not agree that Congress intended to prevent EPA from promulgating supplemental standards in order to effectuate the requirements of section 206(h). Section 202(b)(1)(C) merely prevents EPA from changing the specific standards of sections 202(g) and (h). It does not prevent EPA from promulgating supplementary standards relevant to procedures that were not in existence and emissions that were not regulated prior to the promulgation of these regulations. As the standards promulgated today are in addition to, not instead of, Tier 1 standards, there is no prohibition against a combined NMHC+NOX.

III. **Aggressive Driving (USO6)**

A. Aggressive Driving Cycle

1. General

Summary of Proposal

The EPA proposed the US06 driving cycle and corresponding emission standards for the control of emissions resulting from aggressive driving. The proposed US06 driving cycle is ten minutes in duration and has a maximum speed of 80.3 mph.

Summary of Comments

NESCAUM indicated general support for the US06 cycle and MECA also recognized the need for the addition of the US06 cycle to account for the aggressive driving behavior of today's drivers. NESCAUM also pointed out in support of US06's testing of vehicles above legal speed limits, that Congress specifically requested EPA to consider accelerations as a characteristic of "actual [*note: not merely legal]* current driving conditions." NESCAUM did, however, express concern that the data EPA used may not be representative of regional-scale driving which they felt was more heavily influenced by high speed driving and hard, high-speed acceleration.

The EPA also received comments from AAMA/AIAM and SEMA; both commenters raised a number of concerns. In a discussion on the feasibility of meeting proposed standards for US06, AAMA/AIAM stated that the US06 is a very poor compliance cycle for achieving significant NOx reductions. It was AAMA/AIAM's contention that because there are significant changes in US06's relationship with the inventory cycle, REP05, with and without enrichment, and thus, the in-use NOx reduction might be very different from the reduction shown on US06. AAMA/AIAM also stated that they felt this problem arose from EPA designing a cycle concentrating on controlling enrichment.

In their comments AAMA/AIAM also stated that the EPA incorrectly claimed US06 represents driving done by all vehicles. The comments go on to say that each segment of the US06 represents only one vehicle, most vehicle classes aren't represented, and that the cycle is clearly not representative for those vehicles which can not follow it.

SEMA provided extensive comments on the US06 cycle which they contend contains non-representative conditions. SEMA stated that the US06 cycle should be revised to include realistic and representative speed and accelerations. They elaborated on what they thought were a number of significant flaws in EPA's analysis of the driving behavior data:

- The maximum speed on US06 was 15 mph over the legal speed limit, only 0.6 percent of all observed driving was above 65 mph, and only 0.011 percent of all driving was above the 80 mph maximum. SEMA argued that it was inappropriate to include such data since it only represents infrequent and illegal activity. They went on to state that the such data should be treated as outlier and it is more appropriate to use median than mean in making comparisons, as confirmed by the data's high standard deviation.

- SEMA felt that EPA implied the fraction of vehicle time spent outside the envelope of the LA4 speed and accelerations (13 percent) was only the higher speed and accelerations. In contrast, SEMA cited Baltimore data which showed speed and accelerations exceeding the LA4 6.3 percent and 1.3 percent of the time, respectively.

- In analyzing power statistics, SEMA stated that it was more appropriate to use median than mean due to the inclusion of outlier data for power values above 300.

- SEMA disagreed with the EPA's assertion that "the greater variation around the mean demonstrated by the in-use data suggest that the LA4 does not adequately represent the microtransient nature of in-use driving behavior." SEMA argued that the greater variation was due the extreme scatter of the data caused by the inclusion of outlying data points.

- SEMA questioned the validity of using the mean of the absolute value of the jerk statistic because it included decelerations which have little emission impact.

Response to Comments

Today, the EPA will finalize the US06 driving cycle as proposed. The agency appreciates MECA's and NESCAUM's support for the US06 driving cycle. While EPA recognizes NESCAUM's comment that there may be regional differences in driving behavior, EPA believes that as a control cycle, the US06 adequately represents the range of in-use operation and provides for the necessary emission control of such operation.

In developing the US06, the EPA sought to create a cycle which was comprised of segments of in-use driving and which would control emissions under driving currently not represented by the FTP. The US06 cycle is made up of portions of EPA's inventory cycle (REP05) and the California Air Resources, ARB02. This being the case, EPA believes the US06 is representative of driving behavior outside of the FTP for most vehicles. EPA agrees with AAMA/AIAM that the US06 cycle, unadjusted, is not appropriate for all vehicles classes; EPA proposed cycle adjustments for HLDTs and based on vehicle performance (see discussion below). The Agency disagrees with AAMA/AIAM's assertion that a cycle segment can only represent the single vehicle which generated the segment in use. The underlying cycle generation methodology used by the EPA selected representative segments of actual in-use driving data, from a very large database, to match the distribution of in-use speeds and accelerations.

EPA also disagrees with AAMA/AIAM's contention that the US06 is a poor NOx control cycle. The cycle was not designed for control of enrichment, but rather to control emissions during high load and high speed operation. It is under these conditions that high NOx emissions can be generated, as is discussed in the standard-setting section (II). It should also be noted that the US06-REP05 relationship, with and without enrichment, is more stable for NOx than either NMHC or CO. In their comments, AAMA/AIAM showed the NOx US06-REP05 ratio to be 1.047 with enrichment and 1.279 without enrichment, while the CO and NMHC ratios were 2.229 and 2.68 with enrichment and 1.608 and 3.259 without it, respectively. Since the REP05 cycle is representative of real world off-cycle driving, the stable US06-REP05 indicates that NOx reductions on the US06 cycle will result in real world NOx reductions.

Much of SEMA comments focused on EPA's inclusion of what SEMA characterized as outliers in the in-use driving behavior database. EPA disagrees with this characterization. First, the raw driving behavior data went through a quality control process to remove any suspect data before inclusion into the final database. Secondly, the Baltimore/Spokane database contains nearly 7 million seconds of driving behavior data, and thus one-tenth of one percent represents nearly 7000 seconds of real in-use driving behavior. As with any data set, the data will be distributed across a range of values. It is not appropriate to assume, as SEMA did, that data in the tails of the distribution should be treated as outliers, especially when working with a data set as large as the in-use driving behavior data set. In this light, EPA believes it is valid to use the mean or average as a measure of central tendency. Further, using median values does not paint a fundamentally different portrait of driving behavior, but rather the median simply reflects the skewed nature of in-use speed distribution.[2] SEMA's comments are also inappropriate regarding outliers with respect to EPA's analysis of the power measure and EPA's discussion of speed and acceleration variation. Both analyses are based on vehicle speed which, as discussed above, has been subject to a rigorous quality control process.

In their comments, SEMA incorrectly identified the fraction of Baltimore driving above 65 mph as 0.6%. Speeds above 65 mph accounted for 2.61%, or excluding idle operation, 3.30% of Baltimore driving.[3] While SEMA correctly represented the fraction of Baltimore driving at speeds above 80 mph as 0.011%, EPA's finds this point to be irrelevant since the entire US06

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[2] See EPA Report, "Federal Test Procedure Review Project: Preliminary Technical Report," EPA 420-R-93-007, May 1993, p.88. This report is available from the public docket #A-92-64.

[3] ibid.

cycle is at speeds below 80 mph, except for a single second at 80.3 mph.

SEMA also suggested that the inclusion of speeds above 65 mph was inappropriate since, at least at the time of SEMA's submission, these speeds were illegal. EPA believes it was Congress' intent for EPA to characterize actual current driving conditions, without constraining the characterization to behavior within the legal speed limits. The legislative history is clear that Congress intended EPA to design the test to account for "real-world" conditions, covering as wide a range of conditions as is reasonable, including accounting for quick accelerations. See "Clean Air Act Conference Report," Statement of Sen. Baucus, 136 Cong Rec S16977, Legislative History of Clean Air Act Amendments of 1990 (Legislative History) at 1024; Statement of Rep Waxman, Legislative History, at 2475-6; Report of the Senate Committee on Environment and Public Works, Rep. No. 101-228, at 106, Legislative History at 8446. This interpretation was also supported in comments by NESCAUM. Moreover, since that time the federal 55-65 MPH speed limit has been eliminated, and at least one state, Montana, has no specific speed limit.

SEMA correctly identified the 13 percent cited by the EPA as representing all speeds and accelerations outside the envelope of the FTP; this figure does include decelerations outside of the FTP envelope. EPA did not intend to mislead any reader with this often cited figure, but rather made the statement to illustrate the difference between in-use driving and driving represented by the current FTP.

EPA disagrees with SEMA's assertion that it was inappropriate to use the absolute value of the jerk variable - the change in acceleration, both positive and negative (deceleration). As EPA indicated in the proposed rule, the mean value of jerk is zero and has little meaning, while using the mean of the absolute value allows for an analysis of variation in jerk. Also, this analysis focused specifically on representation of real-world driving. Thus, for this analysis all driving including decelerations is relevant, even if, as SEMA argued, the emission impact is small.

In conclusion, EPA does not believe SEMA comments warrant revisions to the US06 cycle.

2. Adjustments for low performance LDVs and LDTs

Summary of Proposal

The Agency proposed adjustments to the aggressive driving cycle for some low-performance LDVs and LDTs. For low performance vehicles, the inertia weight is adjusted by multiplying the original inertia weight by the adjustment factor which is equal to the ratio of the applicable performance cutoff and the ratio of the vehicle weight to rated horsepower (W/P). The performance cutoff for automatic transmission vehicles was a W/P of 31, while manual transmission vehicles had a performance cutoff point of 34 W/P. For eligible vehicles, the adjustment is applied dynamically by the dynamometer only during specified portions of the US06 Cycle, which were identified as the most aggressive.

Summary of Comments

SEMA contends that proposed cycle adjustments for low performance vehicles serves as evidence that EPA sought to develop a severe cycle to force high performance vehicles into enrichment. Further, such adjustments are a way of "handicapping" these vehicles and SEMA felt that such adjustments do not reflect real-world driving.

SEMA requested that the proposed rule be revised to eliminate test conditions which do not reflect real-world conditions with respect to both high performance and low performance vehicles.

In their comments, AAMA/AIAM stated that the EPA's proposed load adjustments were directionally correct but EPA was being arbitrary by limiting adjustments to certain vehicles. They also commented that the use of a vehicle's weight to power ratio was a poor surrogate for vehicle performance. AAMA/AIAM argued that all vehicles should be allowed to go into enrichment after two seconds of wide-open-throttle operation (see USO6 Control of CO in section III) and AAMA/AIAM requested EPA to incorporate this into the US06 testing requirement by setting an appropriate CO standard and allowing load adjustment for all vehicles after two seconds at wide-open-throttle. AAMA/AIAM indicated that they felt the two second criteria would result in 3-5 seconds of WOT stoichiometric control.

Suzuki presented data on a 1.0L Geo Metro showing that the 5 segments of the US06 driving cycle identified by EPA for load adjustment account for all WOT events of 4 seconds or greater duration. Test data using Suzuki's proposed negative road grade method indicated a 6 percent negative road grade adjustment was necessary to eliminate enrichment events on the US06 cycle for the Geo Metro tested with both a 4-second and 6-second stoichiometric timer.

Suzuki also commented on EPA's proposal to adjust dynamometer inertia weight for low performance vehicles. Suzuki stated that instantaneous reductions in inertia weight are not technically feasible, but similar results can be achieved through the use of negative road grades to

In their comments, Horiba recommended that EPA not use dynamic inertia reduction. Horiba's position was that inertia reduction violates the basic philosophy of dynamometer simulation by reducing the load the vehicle would experience in normal operation. Further, Horiba felt that implementation of EPA's proposal would require fundamental changes to the dynamometer controls. Horiba stated that it is more accurate to have low powered vehicles use full throttle and accelerate at the vehicle's capability.

Response to Comments

Based on comments and data provided by AAMA/AIAM, the EPA has modified the proposed adjustment methodology for low performance LDVs and LDTs. Load adjustments will be made for any vehicle after it has been at wide open throttle for 8 seconds during any of the five EPA-specified acceleration events. The dynamometer load will be adjusted dynamically to allow the vehicle to maintain the driving trace but at less than full throttle.

EPA disagrees with SEMA's contention that the proposed cycle adjustments were a way of handicapping lower performance vehicles. Rather, as discussed above, the cycle was intended to represent the full range of in-use operation. For a small minority of vehicles, the US06 cycle results in extended WOT operation which are not representative of in-use operation.[4] In order to create a single cycle which can be used by all light duty vehicles, EPA believes the adjustments are appropriate and necessary for a small number of low performance vehicles.

Responding to AAMA/AIAM's comment on the use of W/P as a performance measure, the EPA recognizes that the W/P is not a perfect measure, particularly for trucks. In light of the modifications to the CO standard, EPA believes it is now possible to use actual time at wide-open throttle as a direct performance measure, thus, a W/P criteria is not necessary. As detailed in the CO standards response (section III.B.) the EPA believes that engine and catalyst durability concerns are best addressed by setting an appropriate CO standard which would require no more than 4 seconds of WOT stoichiometric control for low performance vehicles, while at the same time limiting WOT events to 8 seconds during the US06 cycle. Thus, load adjustments will be made for any vehicle after it has been at wide open throttle for 8 seconds during any of the five EPA-specified acceleration events. The dynamometer load will be adjusted dynamically to allow the vehicle to maintain the driving trace but at less than full throttle.

On the issue of the adjustment method, the EPA disagrees with Horiba's assertion that the use of a load adjustment is inconsistent with trying to simulate in-use operation. As

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[4] See "Final Technical Report on Aggressive Driving Behavior for the Revised Federal Test Procedure Notice of Proposed Rulemaking," Section 4. This document is available from public docket No. A-92-64 for review.

discussed above, without adjustments to the load to limit the duration of WOT events the US06 driving cycle is not representative of in-use operation for low performance vehicles. On the practical issue of implementing a dynamic load adjustment, information Ford has provided to EPA on their experience suggests that a only a software modification is necessary to incorporate dynamic load adjustment, leaving the dynamometer controls fundamentally unchanged. EPA also believes the test data provided by Ford on dynamic load adjustments disproves Suzuki's claim that instantaneous load adjustments are not technically feasible[5]. Suzuki's use of negative grade is directionally correct; however, it is a much more crude method than the dynamic load adjustment and requires an iterative process to determine the appropriate load adjustment.

3. Adjustments for Heavy Light-Duty Trucks

Summary of Proposal

The Agency proposed adjustments to the aggressive driving cycle for all heavy light-duty trucks (HLDTs). The proposal called for US06 cycle testing of HLDTs with the truck ballasted to curb weight plus 300 lbs and the dynamometer inertia weight determined from this same basis, while FTP testing remains at Adjusted Loaded Vehicle Weight.

Summary of Comments

SEMA contends that proposed cycle adjustments for heavy, light-duty trucks serves as evidence that EPA sought to develop a severe cycle to force high performance vehicles into enrichment. Further, such adjustments are a way of "handicapping" these vehicles and SEMA feels the adjustments do not reflect real-world driving. SEMA requested that the proposed rule be revised to eliminate test conditions which do no reflect real-world

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[5] Ford's presentation and data on dynamic load adjustment are available in the public docket, No. A-92-64

conditions with respect to both high performance and low performance vehicles.

ARB commented on EPA's proposed adjustments for light-duty trucks tested over US06. EPA proposed to test vehicles at curb weight by 300 pounds for the US06 cycle, instead of the adjusted load vehicle weight as required for the current FTP. ARB believes that for trucks of 6001-8500 pounds Gross Vehicle Rated Weight additional adjustments may be necessary, and ARB requested EPA to consider a method for such adjustments.

Response to Comments

EPA believes that comments received do not warrant revisions to the EPA proposed adjustments for HLDTs. This class of vehicle will be tested at curb weight plus 300 pounds and receive the same load adjustments to all LDVs and LDTs , when appropriate.

EPA disagrees with SEMA's contention that the proposed cycle adjustments were a way of handicapping heavy, light-duty trucks (HLDTs). Rather, as discussed above, the cycle was intended to represent the full range of in-use operation. For a small minority of vehicles, the US06 cycle results in extended WOT operation which are not representative of in-use operation.[6] In order to create a single cycle which can be used by all light duty vehicles, EPA believes the adjustments are appropriate and necessary for small number of low performance vehicles, including some HLDTs.

CARB's comments showed agreement with EPA on the use of a vehicle test weight based on curb weight plus 300 pounds. CARB also requested that the EPA explore additional adjustments for these vehicles. In the NPRM, the EPA proposed that HLDTs are also eligible for a load adjustment. EPA believes this proposal is still appropriate and HLDTs will be eligible for dynamic load adjustments using the same performance-based criteria as is

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[6] See "Final Technical Report on Aggressive Driving Behavior for the Revised Federal Test Procedure Notice of Proposed Rulemaking," Section 4. This document is available from public docket No. A-92-64 for review.

available for LDVs. EPA has also accommodated HLDTs in setting standards. The US06 standard for HLDTs is based on the standard for LDVs multiplied by the ratio of the HLDT to LDV Tier I standards. This ratioing can be considered an adjustment in that the Tier I ratio is based on HLDTs tested at adjusted load vehicle weight while the US06 vehicles will be tested at curb weight plus 300 pounds. Finally, EPA believes data on 3 HLDTs from AAMA/AIAM 's US06 test program also supports these adjustments. Employing the methodology used in setting the CO standards, emissions for vehicles 207 and 208 were well below the 7.35 g/mi design target (1/2 the standard). Vehicle 209, at 9.8 g/mi exceeded the design target; however, as tested, this vehicle would have received a dynamic load adjustment which the EPA believes would have allowed it to meet the design target.

B. Control of CO

1. Durability Impacts

Summary of Proposal

The implicit US06 CO standard proposed by EPA for Tier I LDV and LDT1 vehicles was 3.4 g/mile. This was set to implicitly eliminate commanded enrichment on the US06 cycle, including wide open throttle (WOT) events up to 8 seconds in duration. Comments were specifically requested on the need to allow some commanded enrichment events during the US06 cycle to avoid elevated catalyst temperature levels from in-use operation which would lead to catalyst deterioration.

Summary of Comments

AAMA/AIAM had the following comments on the potential impacts of the proposed rules on catalyst durability:

- EPA's proposed standards seek to eliminate all enrichment without regard for impact on durability.

- EPA glossed over the impact of completely eliminating commanded enrichment on increasing catalyst temperature.

In-use catalyst temperatures can easily exceed those experienced over the US06 cycle if in-use wide open throttle (WOT) events are proceeded by higher loads or the WOT events occur at higher speeds.

- Catalyst deterioration is not on-off. A long period of time at 850°C can produce the same deterioration as a short period of time at 900° C.

- The catalyst temperature data used in the analysis were from tier 0 vehicles without close-coupled catalysts.

- EPA states that extended WOT in-use driving situations will be infrequent and not much of a consequence on catalyst temperature. If this is true, then the same can be said about the need to control emissions during these situations. As about 2/3rds of WOT occurs within 2 seconds of the start of a WOT event, CO emissions from WOT events over 2 seconds have an extremely small impact on fleet-average CO emissions and air quality.

- All vehicles should be allowed to use enrichment after two seconds of WOT.

- A two second limit will keep NOx increases down and the increase in catalyst temperature to manageable limits for Tier I vehicles.

A number of comments from individual manufacturers and from SEMA echoing AAMA/AIAM's catalyst durability concerns. Honda stated that the maximum catalyst temperature they could tolerate was 900°C and that the CO standard would need to be less stringent to protect catalyst from overheating on US06. SEMA stated that EPA's imposition of a timer and/or elimination of commanded enrichment will further aggravate the tendency for vehicles, particularly high performance vehicles, to experience excess catalyst and engine/component temperatures. Both GM and Suzuki stated that extended stoichiometric control results in excess temperature in warm-up catalysts.

GM supported AAMA/AIAM's recommendation to limit WOT stoichiometric control to two seconds, after which enrichment would be allowed. Ford stated that, if longer WOT times are dictated, then the CO standard should be raised commensurately to allow commanded enrichment to cool the catalysts.

MECA did not support concerns about catalyst durability, stating that catalyst formations exist which are capable of withstanding temperatures in excess of 900° C.

CARB, in an April 10, 1996 memo, submitted additional comments relating to WOT enrichment delay criterion.[7] CARB stated that they no longer supported the use of the two-second stoichiometric WOT requirement due to concerns that this could possibly cause an increase in the likelihood of aftermarket modifications and, worst case, tampering. CARB was concerned that this could potentially undermine the effectiveness of the California On-Board Diagnostic II systems and future inspection and maintenance program. Thus, CARB recommended establishing a US06 CO standard, without a WOT enrichment delay criterion, based on both stoichiometric non-WOT operation and four seconds of WOT enrichment delay on lower performance vehicles.

Response to Comments

The comments and data received from CARB and AAMA/AIAM on the proposed CO standard's potential impact on catalyst temperatures and deterioration convinced EPA to revise the proposed SFTP CO standard. Using the "times two" headroom previous determined to be appropriate for off-cycle standards, the EPA believes the appropriate 50,000 mile US06 CO standard is 9 g/mile for LDV and LDT1 vehicles, with the appropriate ratio applied to the other trucks classes (see table III-6).

EPA shares the concerns expressed by most commentators about impacts of stoichiometric control during WOT on catalyst

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[7] Memorandum from Robert H. Cross, Assistant Chief, Mobile Source division, CARB, to Margo Oge, Director, Office of Mobile Sources, EPA, "Reference No. TF-96-008", April 10, 1996.

deterioration. In fact, the Agency specifically asked for comments on the potential impact of the rule on catalyst temperatures and deterioration in the NPRM. It is clear that stoichiometric control during WOT operation will increase catalyst temperatures. It is also clear that high catalyst temperatures can decrease the durability of the catalyst. What is not clear is the magnitude of the impact in the temperature regions seen over the US06 cycle.

The catalyst temperatures on most, if not all, of the vehicles tested appear to be safely under 900°C, the point at which rapid catalyst deterioration begins to occur. Figures III-1 through III-4 present the maximum catalyst temperature recorded on the US06 cycle for each vehicle in the US06 phase II test program. Figures III-1 and III-2 present the LDV data for production and stoichiometric calibrations, respectively, and Figures III-3 and III-4 present the same data for LDTs. None of the vehicles ever exceeded 900°C with production calibrations and only three of the 31 vehicles exceed 900°C with the stoichiometric calibrations. In addition, based upon comments received from MECA and a review of recent SAE papers on catalyst development, it is clear that new catalyst formations will be more thermally resistant than existing catalysts. On the other hand, most of the catalyst temperature data available to EPA on the US06 is for underfloor catalysts. Not only do close-coupled catalysts run considerably hotter than underfloor catalysts, but manufacturers are moving the catalysts even closer to shorten catalyst light-off in response to tighter tailpipe emission standards. Finally, as noted by AAMA/AIAM in their comments, low-level catalyst deterioration can begin to occur at temperatures below the point where deterioration occurs quickly.

While manufacturers submitted data on the impact of extreme temperatures (i.e. > 900° C) on catalyst deterioration, no data was submitted that would allow EPA to quantify how frequently such operation actually occurs or the catalyst deterioration that occurs at temperatures in the 800-900 C° range. To further address this issue, EPA contracted with Energy and Environmental Analysis, Inc. (EEA) to assess the impact of stoichiometric control on engines and catalyst. EEA assessed the impact of eight seconds (or more) of continuous stoichiometric control at WOT on engine and catalyst temperatures.[8] Given the comments received in response to the NPRM, EEA's conclusions were somewhat surprising. While EEA concluded that catalyst deterioration is not a substantial issue, in part because they expect the industry to move exclusively to more thermally resistant catalyst formations in the future, they did raise the issue of engine over-temperature problems. To withstand the higher combustion temperatures at stoichiometry for eight or more seconds, EEA concluded that many vehicles would need more thermally resistant engine components, at an average costs of $35.70 per vehicle.

On the basis of the available information, EPA has not been able to conclude whether or not catalyst deterioration would be significantly affected by extended stoichiometric control at WOT. EPA believes the manufacturers have overstated the potential catalyst deterioration problem by focusing only on extreme temperature events which rarely occur and by ignoring the increased thermal resistance of new catalyst formations. On the other hand, EPA believes that MECA and EEA did not address the proper question. Both MECA and EEA concluded that catalyst deterioration during stoichiometric operation using the newer catalyst formations would be no worse than current catalyst deterioration with commanded enrichment. While EPA agrees with this conclusion, the proper question is, given new catalyst formations, will elimination of commanded enrichment cause higher deterioration than would occur if commanded enrichment were allowed at WOT. This is especially important given the fact that manufacturers must improve the durability of their catalysts in order to meet future, more stringent, emission standards.

To assess the potential emission impact of WOT stoichiometric control, EPA conducted an analysis of the proportion of emissions that occur at WOT. Tables III-1 and III-2 present the results from two different evaluations of WOT durations. Table III-1 is based upon data generated by GM for CO

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[8] See the report, "Assessment of Technology Costs to Comply with Proposed FTP Revisions," prepared for EPA by Energy and Environmental Analysis, Inc. This document is available from public docket No. A-92-64 for review.

emissions during air/fuel events less than 14.2:1 on the REP05 cycle (14.2:1 was chosen because it is the point at which enrichment exceeds the normal air/fuel variation seen during closed-loop operation). These data were used to calculate the emissions for throttle < 85 percent (i.e. less than WOT), 1-2 seconds from the start of a WOT event, 3 seconds from the start of a WOT event, and more than 3 seconds from the start of a WOT event. These results were calculated for six different subsets of the data and are listed in Table III-1. The most appropriate, from a sensitivity analysis point of view, is the third, highlighted, line, which excludes heavy light-trucks and lower performance vehicles. These exclusions are appropriate because the heavy light-trucks were tested at half-payload, which is not being used for high speed and acceleration emission control, and load adjustments will be applied to lower-performance vehicles.

Table III-1: REP05 Test Results -- Phase I testing CO emissions during seconds where A/F < 14.2

		Average CO gram/mi emissions during a/f<14.2					**% of Total CO during a/f<14.2**			
Vehicle set	**% WOT time**	**All**	**TP<85 %**	**1-2 sec WOT**	**3 sec WOT**	**>3 sec WOT**	**TP<85%**	**1-2 sec WOT**	**3 sec WOT**	**>3 sec WOT**
All	0.15%	6.43	3.49	1.31	0.41	1.22	54%	20%	6%	19%
w/o HLDT	0.13%	4.56	2.64	1.06	0.3	0.56	58%	23%	7%	12%
w/o HLDT, <30 wgt/pwr	0.09%	3.59	2.34	0.81	0.19	0.25	65%	23%	5%	7%
LDV only, <30 wgt/pwr	0.08%	2.72	1.85	0.63	0.12	0.12	68%	23%	4%	4%
also w/o Taurus, Civic	0.04%	2.29	1.85	0.29	0.05	0.00	81%	17%	2%	0%

		Average CO gram/mi emissions during a/f<14.2					**% of Total CO during a/f<14.2**			
also w/o Mustang, Seville, 420SE	0.05%	2.27	1.72	0.46	0.07	0.01	76%	20%	3%	0%

The CO results (from the third line of table III-1) indicate that almost 2/3 (65 percent) of the total enrichment CO occurred during part-throttle (i.e. < 85 percent) enrichment. About 2/3 of the remaining CO (23 percent of the remaining 35 percent) occurred during the first two seconds of WOT events. CO generated during the third second of WOT operation only adds 5 percent of total enrichment CO, or 0.19 g/mi. Note that the longer WOT events added significant amounts of CO for the heavy light-trucks and for low-performance vehicles (to a maximum of 19 percent instead of 7 percent), but that the emissions during the third second after start of WOT events increased much less (to a maximum of 7 percent from 5 percent).

Table III-2: 6-Parameter Data Set

Event Duration	**From start of WOT event (>85% TP)** **% All**	**% 1-2 Seconds**	**% = 3 Seconds**	**% > 3 Seconds**
1	0.0044	0.0044	0.0000	0.0000
2	0.0054	0.0054	0.0000	0.0000
3	0.0042	0.0028	0.0014	0.0000
4	0.0016	0.0008	0.0004	0.0004
5	0.0018	0.0007	0.0004	0.00072
6	0.0009	0.0003	0.0002	0.00045
8	0.0004	0.0001	0.0001	0.00025
25	0.0013	0.0001	0.0001	0.001144
Total (seconds)	0.02	0.0146	.0024	0.0030
% of total		73%	12%	15%

	REP05 **CO from WOT only--w/o HLDT, <30 wgt/pwr** **From start of WOT event** **All**	**1-2 seconds**	**3 seconds**	**>3 seconds**
Total (g/mi)	1.25	0.81	0.19	0.25
% of total		65%	15%	20%

Table III-2 lists the results from the 6-parameter data set from the instrumented vehicle study[9]. One of the parameters directly measured in the six-parameter data was throttle position. WOT events only occur 0.02 percent of the time in this data set, compared to 0.09 percent of the time calculated from WOT events during the REP05 cycle (from Table III-1). However, there are likely to be significant biases in the six-parameter data, as data was collected primarily on mid-range performance vehicles and only one vehicle had a driver under 25 years of age. Despite the differences in total WOT time, one interesting observation is that the relative portion of the third second since the start of a WOT event to the total amount of WOT events is remarkably consistent (14 percent and 12 percent, respectively, for the REP05 and the 6-parameter data). This indicates that the REP05 results are likely to be representative of the additional CO generated during the third second after the start of a WOT event.

Another factor to be considered is the impact of stoichiometric operation at WOT on NMHC and NOx emissions, not just CO. Figure III-5 compares the NMHC+NOx emissions between the no-commanded enrichment calibration and the production calibration for each vehicle at WOT. The comparison indicates that, on the median vehicle, the NMHC decrease without enrichment was largely offset by higher NOx emissions. While the better calibrated vehicles are likely to have a decrease in overall NMHC+NOx emissions at WOT of about 0.5-1.0 g/mile when commanded enrichment is eliminated, WOT events comprise less than 0.1 percent of all in-use driving. When the potential emission impact at WOT is weighted by this factor, the overall impact drops to no more than 0.001 g/mile. Thus, while stoichiometric operation at WOT directionally reduces NMHC+NOx on the better calibrated vehicles, it's overall impact is negligible.

Some sensitivity analyses of the incremental emission benefits from longer WOT control can be done based upon the REP05 cycle CO data in Table III-1. For example, for the light-trucks

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[9] See the public docket for "Light-duty Vehicle Driving behavior: Private Vehicles Instrumentation - Draft Final Report," prepared by the Radian Corp. for EPA

and cars less than 30 ETW/HP run over REP05 (the third line on Table III-1), extending WOT control from 2 seconds to 3 seconds would capture an additional 0.19 g/mi of CO (from the "3 sec WOT" column), averaged over the entire REP05 cycle. As REP05 represents 28 percent of all driving[10], this would decrease overall CO emissions by about 0.05 g/mi. Extending WOT control beyond 3 seconds would only capture an additional 0.07 g/mi on these vehicles when averaged over all driving (calculated from the "> 3 sec WOT" column multiplied by the 28 percent REP05 weight).

One other important factor is the influence of lower-performance vehicles. Line 2 from the REP05 table (Table III-1) includes the lower performance vehicles; the much higher CO emissions at WOT when low-performance vehicles are included indicates that these vehicles spend a much higher proportion of time at WOT than higher-performance vehicles. This finding is consistent with previous analyses in support of the NPRM.[11]

Based upon the limited emission benefits associated with stoichiometric control of extended duration WOT events, EPA has concluded that these limited emission benefits do not justify the potential cost associated with more thermally resistant engine components, which was estimated by EEA to possibly exceed $35 per vehicle and the risk of increased catalyst deterioration due to higher temperatures. Thus, in support of the Final Rule, EPA analyzed ways of maintaining the large majority of the CO emission benefits without the risk of significantly higher temperatures from stoichiometric operation.

In their comments, both AAMA/AIAM and GM stated that elimination of commanded enrichment during the first two seconds

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[10] See "Final Technical Report on Aggressive Driving Behavior for the Revised Federal Test Procedure Notice of Proposed Rulemaking," Section 3. This document is available from public docket No. A-92-64 for review.

[11] See "Final Technical Report on Aggressive Driving Behavior for the Revised Federal Test Procedure Notice of Proposed Rulemaking," Section 4. This document is available from public docket No. A-92-64 for review.

of WOT operation on the US06 cycle is not a significant problem, so long as commanded enrichment is allowed after a few seconds (manufacturers did comment that certain types of in-use operating conditions could cause elevated temperatures and virtually immediate catalyst deterioration at WOT without enrichment). The manufacturers' relative lack of concern about short duration stoichiometric operation is supported by analyses done by EPA for the NPRM, where it was demonstrated that catalyst temperatures climb approximately 20°C per second during WOT operation at stoichiometry. As the chance of high catalyst temperatures and deterioration increases with increasing duration of stoichiometric operation during WOT events; there should be relatively little concern at short durations.

EPA and CARB spent considerable time evaluating three options to limit the duration of WOT stoichiometric control to periods that would not be likely to cause catalyst deterioration (i.e. 2-4 seconds, based upon the above analyses and manufacturer comments):

- *Option 1.* The vehicle manufacturers proposed a method of dynamically adjusting the load during the test whenever a vehicle had stayed at WOT for two seconds. The concept is to adjust the load so that the vehicle can continue to follow the test cycle trace without having to stay at WOT. As the vehicle would need to catch back up to the driving trace and driver cannot react instantaneously to the load reduction, the manufacturers presented data indicating that they would need to delay commencement of commanded enrichment at WOT for an additional second or two, or 3-4 seconds total, to avoid triggering commanded enrichment during the test. While EPA believes this concept has merit from the viewpoint of establishing CO requirements, it was ultimately rejected because the reduced load introduced by the dynamic load adjustment has the potential to significantly reduce tested NOx emissions under the US06 cycle, impacting the effectiveness of NOx control. As part of testing the manufacturers conducted on Tier I vehicles over the US06 cycle, three vehicles were retested by the manufacturers with lower dynamometer loads, to compensate for excessive WOT times (i.e. WOT durations over 8 seconds in duration). Tables III-3 and III-4 compare the NOx emissions with the load adjustments to the unadjusted results. Table III-3 summarizes the NOx emissions during seconds 46-66 of the US06 cycle, which covers an acceleration from zero to over 60 mph. Table III-4 summarizes the results from seconds 310-340 of the US06 cycle, which covers a high speed passing maneuver. The most significant data are the "Tailpipe Emissions: 20 sec NOx" column in Table III-3 and the "Tailpipe Emissions: 30 sec NOx" column in Table III-4. While the results were very erratic, all the reduced load tests on the Escort and the Ranger in Table III-3 resulted in significantly lower NOx than the NOx emissions using standard load. Similarly, all the reduced load tests on the Metro and the Escort in Table III-4 had significantly lower NOx emissions than the similar tests using standard load. The other two cases, the Metro in Table III-3 and the Ranger in Table III-4, were inconclusive. Despite the variability in the results, load adjustments clearly have a substantial impact on tested NOx emissions, overall.

Table III-3: NOx Sensitivity to Load Adjustment over US06, first 20 seconds of hill 2 (46-66)

					Engine-Out Emissions			Tailpipe Emissions		
Vehicle	Test	Event	Load	WOT Time	20 sec NOx	Total NOx	20 Sec/Total	20 sec NOx	Total NOx	20 Sec/Total
Metro	u801ss01	2	Prod	10	1.548	25.990	0.060	0.055	0.638	0.086
	u801ss02	2	Prod	13	1.596	26.457	0.060	0.074	0.678	0.108
	Average				**1.572**	**26.223**	**0.060**	**0.064**	**0.658**	**0.097**
	u801ss03	2	Prod	1	1.581	25.016	0.063	0.055	0.746	0.074
	u801ss04	2	Prod	0	1.748	28.269	0.062	0.080	0.746	0.107
	Average				**1.664**	**26.643**	**0.062**	**0.068**	**0.746**	**0.091**
	u801as01	2	-3%	2	1.355	23.855	0.057	0.069	0.404	0.172
	u801as02	2	-3%	2	1.385	24.063	0.058	0.019	0.437	0.043
	Average				**1.370**	**23.959**	**0.057**	**0.044**	**0.421**	**0.108**
	u801as03	2	-4%	0	1.486	24.595	0.060	0.054	0.504	0.107
	u801as04	2	-4%	1	1.460	24.133	0.061	0.037	0.488	0.075
	u801as05	2	-4%	0	1.429	23.456	0.061	0.054	0.505	0.108
	u801as06	2	-4%	0	1.574	26.790	0.059	0.041	0.482	0.086
	Average				**1.487**	**24.744**	**0.060**	**0.047**	**0.495**	**0.094**
	u801as07	2	-5%	0	1.500	23.749	0.063	0.075	0.625	0.121
	u801as08	2	-5%	2	1.617	26.504	0.061	0.063	0.537	0.116

	Average				**1.558**	**25.126**	**0.062**	**0.069**	**0.581**	**0.119**
Escort	u201ss01	2	Prod	2	2.521	29.817	0.085	0.514	4.705	0.109
	u201ss02	2	Prod	3	2.786	33.854	0.082	0.442	5.204	0.085
	Average				**2.654**	**31.836**	**0.083**	**0.478**	**4.955**	**0.097**
	u201as01	2	-1%	7	2.821	33.294	0.085	0.416	4.762	0.087
	u201as02	2	-1%	0	2.417	32.914	0.073	0.330	4.537	0.073
	Average				**2.619**	**33.104**	**0.079**	**0.373**	**4.650**	**0.087**
	u201as01	2	-2%	0	2.122	29.285	0.072	0.347	4.283	0.081
	u201as01	2	-2%	2	2.563	32.985	0.078	0.512	5.346	0.096
	Average				**2.343**	**31.135**	**0.075**	**0.429**	**4.814**	**0.081**

Table III-3, cont'. NOx Sensitivity to Load Adjustment over US06,
First 20 seconds of hill 2 (46-66 sec)

					Engine-Out Emissions			Tailpipe Emissions		
Vehicle	Test	Event	Load	WOT Time	20 sec NOx	Total NOx	20 Sec/Total	20 sec NOx	Total NOx	20 Sec/Total
Ranger	u204ss01	2	Prod	6	2.992	35.244	0.085	0.522	3.004	0.174
	u204ss02	2	Prod	5	2.618	34.576	0.076	0.434	3.827	0.113
	u204ss03	2	Prod	7	2.706	35.773	0.076	0.585	3.257	0.180
	u204ss04	2	Prod	6	2.949	40.051	0.074	0.623	3.607	0.173
	Average				**2.816**	**36.411**	**0.077**	**0.541**	**3.424**	**0.158**
	u204as01	2	-3%	4	2.607	34.662	0.075	0.428	3.548	0.121
	u204as01	2	-3%	6	2.864	38.119	0.075	0.411	4.087	0.101
	u204as01	2	-3%	5	2.415	32.341	0.075	0.348	3.325	0.105
	u204as01	2	-3%	2	2.754	36.551	0.075	0.292	3.436	0.085
	Average				**2.660**	**35.418**	**0.075**	**0.370**	**3.599**	**0.103**
	u204as01	2	-4%	6	1.547	31.205	0.050	0.028	2.986	0.009
	u204as01	2	-4%	3	2.803	36.387	0.077	0.563	3.603	0.156
	Average				**2.175**	**33.796**	**0.064**	**0.296**	**3.294**	**0.090**
	u204as01	2	-5%	2	2.313	32.078	0.072	0.315	4.164	0.076
	u204as01	2	-5%	4	2.570	35.546	0.072	0.418	3.640	0.115
	Average				**2.442**	**33.812**	**0.072**	**0.367**	**3.902**	**0.094**

u204as01	2	Down shift	3	2.384	32.368	0.074	0.374	3.675	0.102
u204as01	2	Down shift	2	2.631	36.056	0.073	0.552	4.747	0.116
Average				**2.507**	**34.212**	**0.073**	**0.463**	**4.211**	**0.110**

Table III-4. NOx Sensitivity to Load Adjustment during US06, High Speed Passing Maneuver (310-340 sec)

					Engine-Out Emissions			Tailpipe Emissions		
Vehicle	Test	Event	Load	WOT Time	30 sec NOx	Total NOx	30 Sec/Total	30 sec NOx	Total NOx	30 Sec/Total
Metro	u801ss01	7	Prod	16	3.494	25.990	0.134	0.078	0.638	0.122
	u801ss02	7	Prod	16	3.534	26.457	0.134	0.075	0.678	0.111
	u801ss03	7	Prod	15	3.450	25.016	0.138	0.116	0.746	0.155
	u801ss04	7	Prod	17	3.865	28.269	0.137	0.054	0.746	0.072
	Average				**3.585**	**26.433**	**0.136**	**0.081**	**0.702**	**0.115**
	u801as01	7	-3%	8	2.748	23.855	0.115	0.032	0.404	0.080
	u801as02	7	-3%	9	2.885	24.063	0.120	0.028	0.437	0.065
	Average				**2.816**	**23.959**	**0.118**	**0.030**	**0.421**	**0.072**
	u801as03	7	-4%	5	2.737	24.595	0.111	0.041	0.504	0.081
	u801as04	7	-4%	5	2.700	24.133	0.112	0.035	0.488	0.072
	u801as05	7	-4%	6	2.490	23.456	0.106	0.028	0.505	0.055
	u801as06	7	-4%	8	2.824	26.790	0.105	0.031	0.482	0.065
	Average				**2.688**	**24.744**	**0.109**	**0.034**	**0.495**	**0.068**
	u801as07	7	-5%	7	2.405	23.749	0.101	0.048	0.625	0.077
	u801as08	7	-5%	6	2.610	26.504	0.098	0.037	0.537	0.069
	Average				**2.507**	**25.126**	**0.100**	**0.043**	**0.581**	**0.073**

Escort	u201ss01	7	Prod	8	4.159	29.817	0.139	0.971	4.705	0.206
	u201ss02	7	Prod	8	4.351	33.854	0.129	0.788	5.204	0.151
	Average				**4.255**	**31.836**	**0.134**	**0.880**	**4.955**	**0.179**
	u201as01	7	-1%	2	3.836	33.294	0.115	0.472	4.762	0.099
	u201as02	7	-1%	4	3.935	32.914	0.120	0.565	4.537	0.125
	Average				**3.886**	**33.104**	**0.117**	**0.519**	**4.650**	**0.099**
	u201as01	7	-2%	4	3.297	29.285	0.113	0.694	4.283	0.162
	u201as01	7	-2%	3	3.901	32.985	0.118	0.651	5.346	0.122
	Average				**3.599**	**31.135**	**0.115**	**0.673**	**4.814**	**0.162**

Table III-4, cont'. NOx Sensitivity to Load Adjustment during US06, High Speed Passing Maneuver (310-340 sec)

					Engine-Out Emissions			Tailpipe Emissions		
Vehicle	Test	Event	Load	WOT Time	30 sec NOx	Total NOx	30 Sec/Total	30 sec NOx	Total NOx	30 Sec/Total
Ranger	u204ss01	7	Prod	18	3.596	35.244	0.102	0.177	3.004	0.059
	u204ss02	7	Prod	19	3.659	34.576	0.106	0.309	3.827	0.081
	u204ss03	7	Prod	19	3.757	35.773	0.105	0.269	3.257	0.083
	u204ss04	7	Prod	18	4.235	40.051	0.106	0.506	3.607	0.140
	Average				**3.812**	**36.411**	**0.105**	**0.315**	**3.424**	**0.092**
	u204as01	7	-3%	9	3.534	34.662	0.102	0.316	3.548	0.089
	u204as01	7	-3%	8	3.482	38.119	0.091	0.420	4.087	0.103
	u204as01	7	-3%	9	2.803	32.341	0.087	0.308	3.325	0.092
	u204as01	7	-3%	9	3.293	36.551	0.090	0.242	3.436	0.070
	Average				**3.278**	**35.418**	**0.093**	**0.321**	**3.599**	**0.089**
	u204as01	7	-4%	7	2.938	31.205	0.094	0.411	2.986	0.137
	u204as01	7	-4%	5	2.894	36.387	0.080	0.275	3.603	0.076
	Average				**2.916**	**33.796**	**0.086**	**0.343**	**3.294**	**0.104**
	u204as01	7	-5%	5	2.685	32.078	0.084	0.373	4.164	0.090
	u204as01	7	-5%	3	2.629	35.546	0.074	0.224	3.640	0.061
	Average				**2.657**	**33.812**	**0.079**	**0.298**	**3.902**	**0.076**

u204as01	7	Down shift	6	2.527	32.368	0.078	0.305	3.675	0.083
u204as01	7	Down shift	7	3.024	36.056	0.084	0.415	4.747	0.087
Average				**2.776**	**34.212**	**0.081**	**0.360**	**4.211**	**0.086**

- *Option 2.* Raise the CO standard and extend the two-second timer criteria (requiring no commanded enrichment at WOT, i.e. stoichiometric operation) proposed in the NPRM for high-performance vehicles to all vehicles. Raising the CO standard implicitly reduces the duration of stoichiometric control required during WOT operation, as it allows a certain amount of enrichment to be introduced during US06 operation while still meeting the CO standard. A potential problem with this approach is the need to accommodate the amount of CO generated on lower performance, heavy vehicles, due to the much longer amount of time such vehicles spend at WOT. As higher performance and lighter vehicles do not spend as much time at WOT, they could go into enrichment at lower throttle positions and/or after shorter WOT durations and still meet a CO standard set to accommodate the WOT time of lower-performance, heavier vehicles. This gives high performance vehicles a relaxation in the test conditions. One way to correct for this advantage to high performance vehicles would be to set a secondary engineering requirement for two seconds of stoichiometric operation during WOT and for all part-throttle operation. However, while the two-second timer approach has some appeal from a theoretical point of view, EPA ultimately rejected this approach because of four practical problems with implementation. First, this would impose a double requirement on manufacturers (i.e. to meet both an emission standard and a secondary design criteria), which is inconsistent with EPA's recent efforts to streamline the certification process and would increase the enforcement burden on EPA. Second, it is a design criteria, which is not consistent with EPA's general policy of setting performance standards. Third, it does not work for engine technologies that do not run at stoichiometry, such as diesel engines, and could pose a problem for future technology engines and/or alternative fuels. Fourth, and most importantly, while a two-second WOT criteria works fine for the US06 cycle, it may cause unacceptably high temperatures under other driving conditions, such as on road grades or while pulling a trailer. EPA investigated concepts that would allow exceptions from the two-second criteria for conditions that could cause high temperatures, but abandoned them due to the complexities of designing acceptable criteria and monitoring manufacturer implementation.

- *Option 3.* Raise the CO standard to a level that would allow enrichment on most vehicles after, at most, two seconds of WOT operation and no more than four seconds of operation on any vehicle. This would allow manufacturers to use enrichment as needed to protect the catalyst under extreme in-use driving conditions that go beyond the requirements of the US06 cycle. The drawback to this approach, as discussed in the last paragraph, is that it would allow high performance vehicles to use enrichment immediately at WOT, as these vehicles spend little or no time at WOT on the US06 cycle and, thus, can use enrichment immediately at WOT without failing the CO standard.

Despite the small loss of CO control on higher performance vehicles, EPA has concluded that option 3, raising the CO standard without a two-second design criteria, is the most appropriate choice. Option 3 avoids the potential NOx increase of Option 1 and the complexity and potential catalyst degradation of Option 2, and the approach was also recommended by CARB. In addition, the CO loss is very small, as:

- 65 percent of in-use enrichment CO is generated at part-throttle (as discussed, above), which will still be eliminated by this approach;

- the instrumented vehicle surveys indicate that medium and high performance vehicles, for which this approach would lose some CO control, spend relatively little time at WOT and, thus, have relatively little impact on in-use CO emissions, and;

- low performance vehicles, which spend a much higher proportion of time at WOT just to keep up with traffic and, thus, generate much more commanded enrichment CO, would still need to eliminate enrichment for up to 4 seconds at WOT to meet the CO standard.

The CO standards on US06 have been deliberately set high to allow limited amounts of commanded enrichment, which is needed to ensure excessive engine and catalyst temperatures do not occur. To ensure that excessive amounts of enrichment and, hence, CO emissions do not occur during commanded enrichment, this Final Rule includes a minimum air/fuel ratio requirement. The air/fuel ratio shall not be richer than the leanest air/fuel mixture required to obtain maximum torque at a given speed and load, termed the lean best torque, plus a tolerance of 6 percent of the lean best torque fuel consumption. The 6 percent tolerance is included to allow for normal variance in production torque characteristics, as well as the impact of engine deposits on knock in use. If additional enrichment beyond the LDT plus 6 percent fuel rate point is required for protection of the engine or the emission control hardware, the manufacturer shall describe the conditions and the leanest air to fuel mixture necessary to ensure sufficient protection of the hardware. EPA may request data demonstrating the need for additional enrichment to project the engine or emissions control hardware.

In setting the level of the CO standard for the US06 cycle, EPA's primary criteria was to select a CO standard that most vehicles could meet while eliminating enrichment for no more than two seconds at WOT. However, as discussed earlier, setting the standard at a level that would allow the lowest performance vehicles to meet with no more than two seconds of stoichiometric control would allow higher performance vehicles to use enrichment at part throttle. To prevent this and to reflect the much higher proportion of time low performance vehicles spend at WOT in use, a secondary criteria was to set the CO standard at a level that would require no more than four seconds of stoichiometric control at WOT on lower performance vehicles.

Based upon this criteria, total CO emissions over the US06 cycle were calculated from a combination of the production and stoichiometric calibration data. To simulate a two-second timer, CO data from the stoichiometric calibration data was used except when the vehicle spent more than two consecutive seconds at WOT. For any point on the US06 cycle where the vehicle had spent more than two consecutive seconds at WOT, production calibration data for the same points were substituted. This method simulated the CO levels that would occur if the vehicle were allowed to use enrichment after two seconds. This method was then repeated using a four second continuous WOT criteria. The results are presented in Table III-5.

Table III-5a. CO Emissions Resulting From 2 and 4 Second Stoichiometric Timers Over Entire US06, LDVs and LDT1s

TWO SECOND STOICHIOMETRIC EVENTS						**FOUR SECOND STOICHIOMETRIC EVENTS**					
Veh. No.	**Model**	**CO (g/mi)**	**Headroom**	**Full Stoich**	**Remarks**	**Veh. No.**	**Model**	**CO (g/mi)**	**Headroom**	**Full Stoich**	**Remarks**
102	Cherokee	7.14	14.28	0.89		102	Cherokee	5.57	11.14	0.89	
201	Escort	6.43	12.86	0.40	Adjusted	201	Escort	2.44	4.88	0.40	Adjusted
202	Mustang	2.61	5.22	1.84		202	Mustang	1.84	3.68	1.84	
203	Town Car	2.18	4.36	2.03		203	Town Car	2.03	4.06	2.03	
204	Ranger	10.66	21.32	1.82	Adjusted	204	Ranger	4.68	9.36	1.82	Adjusted
301	Saturn A4	1.99	3.98	0.45		301	Saturn A4	0.97	1.94	0.45	
302	Saturn M5	3.75	7.50	0.18		302	Saturn M5	2.29	4.58	0.18	
303	Cavalier	6.32	12.64	3.64		303	Cavalier	4.28	8.56	3.64	
304	Beretta	4.72	9.44	1.86		304	Beretta	2.63	5.26	1.86	
305	Grand-Am	1.66	3.32	0.98		305	Grand-Am	1.03	2.06	0.98	
307	Monte Carlo	0.09	0.18	0.09		307	Monte Carlo	0.09	0.18	0.09	
310	Aurora	3.09	6.18	2.73		310	Aurora	2.73	5.46	2.73	
311	Seville	2.22	4.44	2.22		311	Seville	2.22	4.44	2.22	
312	STS	2.80	5.60	2.80		312	STS	2.80	5.60	2.80	
314	Camaro	0.60	1.20	0.55		314	Camaro	0.55	1.10	0.55	

316	S-Truck M5	9.76	19.52	1.22	
501	Mazda	7.59	15.18	3.47	
601	Galant	1.25	2.50	0.44	
701	Altima	1.00	2.00	0.48	
801	Metro	6.04	12.08	3.37	Adjusted
Average		**4.10**	**8.19**	**1.57**	

316	S-Truck M5	6.35	12.70	1.22	
501	Mazda	4.55	9.10	3.47	
601	Galant	0.63	1.26	0.44	
701	Altima	0.51	1.02	0.48	
801	Metro	4.22	8.44	3.37	Adjusted
Average		**2.62**	**5.24**	**1.57**	

Table III-5b. CO Emissions Resulting From 2 and 4 Second Stoichiometric Timers Over Entire US06, LDT2s, LDT3s, LDT4s

TWO SECOND STOICHIOMETRIC EVENTS

Veh. No.	Model	CO (g/mi)	Headroom	Full Stoich	Remarks
101	B150 Van	6.98	13.96	3.19	LDT2
205	Windstar	8.50	17.00	4.64	LDT2
322	GMC	2.85	5.70	2.57	LDT2
324	GMC	1.78	3.56	1.75	LDT2
208	Bronco	7.04	14.08	0.13	LDT3
206	Econoline	14.84	29.68	2.18	LDT4
702	Quest	12.47	24.94	1.06	LDT4
207	Econoline	0.79	1.58	0.07	LDT4
Average		**5.03**	**10.06**	**3.04**	

FOUR SECOND STOICHIOMETRIC EVENTS

Veh. No.	Model	CO (g/mi)	Headroom	Full Stoich	Remarks
101	B150 Van	4.83	9.66	3.19	LDT2
205	Windstar	5.05	10.10	4.64	LDT2
322	GMC	2.57	5.14	2.57	LDT2
324	GMC	1.75	3.50	1.75	LDT2
208	Bronco	3.59	7.18	0.13	LDT3
206	Econoline	9.81	19.62	2.18	LDT4
702	Quest	5.90	11.80	1.06	LDT4
207	Econoline	0.07	0.14	0.07	LDT4
Average		**3.55**	**7.10**	**3.04**	

With the four second criteria, the highest calculated CO level for any LDV was 4.55 g/mile (vehicle 501). Considering LDV and LDT1 vehicles together, there were four vehicles with calculated CO levels between 4 and 4.68 g/mile, but only two vehicles with higher calculated CO levels (vehicle 102, the Cherokee, at 5.6 g/mile and 316, the S10 pickup, at 6.3 g/mile). Both of the vehicles above 5 g/mile are LDT1s, which frequently have a problem with the high speed passing maneuver on US06 because of their higher aerodynamic losses at high speeds. Rather than set the CO standard of the level of these two vehicles, a better strategy is to allow dynamic load adjustments to reduce maximum WOT times on the cycle to eight seconds. While this will cause some reduction in NOx emissions, as discussed previously, the NOx impact is greatly reduced because the adjustment would only apply to a small number of vehicles and, even then, only for brief periods of the US06 cycle (which, in turn, overstates the actual frequency of high loads by a factor of about three). With this strategy, a CO design target of 4.5 g/mile should allow all vehicles to use enrichment at WOT after a delay of no more than four seconds.

Applying the 4.5 g/mile CO standard to the two second criteria data, 13 of the 20 LDV and LDT1 vehicles could meet the 4.5 g/mile design target with a two second delay (or less) before using enrichment at WOT. Thus, the 4.5 g/mile CO target also meets the primary criteria that most vehicles meet the standard with no more than two seconds of stoichiometric control at WOT.

Using the "times two" headroom previously determined to be appropriate for off-cycle standards, the result is a 50,000 mile US06 CO standard of 9 g/mile for LDV and LDT1 vehicles. While this almost triples the CO standard proposed in the NPRM, the impact on in-use CO emissions is proportionally far less. This is because the US06 cycle only represents 28 percent of all in-use operation and, even within this window, overstates the amount of extended WOT operation, compared to in-use operation, by a factor of about three. As indicated in Tables III-1 and III-2 and discussed, above, most enrichment CO emissions are generated during part-throttle and most in-use WOT throttle operation does not last more than two seconds in duration. Thus, even at 9 g/mile, well over 80 percent of CO from commanded enrichment will be controlled.

This is illustrated by the average CO emissions generated on US06 by the Tier 1 vehicles in the US06 phase II test program. LDV and LDT1 vehicles averaged 17.6 grams/mile with production calibrations. Compared to this baseline level, raising the CO design target from the implicit level of 1.7 grams/mile in the NPRM to the Final Rule level of 4.5 grams/mile reduces the CO benefit on the US06 cycle from 15.9 g/mile to 13.1 g/mile, a reduction of only 18 percent. The in-use emission impact will be less yet, as the US06 cycle overstates the amount of WOT operation. While it may seem as if raising the standard from 3.4 to 9.0 g/mile should have a major impact on the stringency of the standard, given the severity of the US06 cycle and the extremely high baseline emission levels, analyses support that a standard of 9.0 g/mile will still achieve the large majority of the potential CO emission benefits.

The CO standard needs to be at this level because of the extreme sensitivity of CO emissions to commanded enrichment. Each second of commanded enrichment generates about 2-4 grams of CO, enough to add about 0.3-0.5 grams/mile to the overall weighted US06 test results. Thus, raising the standard from 3.4 to 9.0 grams/mile, which raises the design target level from 1.7 to 4.5 grams/mile, is an allowance of only about 6-10 seconds of enrichment on a cycle which greatly overrepresents extended WOT operation.

Ratioing the 9.0 gram/mile half-life standard for LDV/LDT1 to the other truck classes and to full-useful life yields:

Table III-6: Light Duty CO Full Life and Intermediate Life Standards

Type	**GVWR**	**LVW**	**ALVW**	**Intermediate Life CO Standards (g/mi)**	**Full Life CO Standards (g/mi)**
LDV	all	all	all	9.0	11.2
LDT1	0-6000	0-3750	all	9.0	11.2
LDT2	0-6000	3751-5750	all	11.6	14.6
LDT3	>6000	all	3751-5750	11.6	16.9
LDT4	>6000	all	>5750	13.2	19.3

2. Performance Impacts

Summary of Comments

AAMA/AIAM had the following comments on the potential impacts of the proposed rules on vehicle performance:

- EPA's proposed standards seek to eliminate all enrichment without regard for impact on performance. EPA glossed over the impact of completely eliminating commanded enrichment on reducing engine power.

- EPA cannot ignore the value consumers place on vehicle performance. EPA must either factor the lost value of performance to consumers or factor in engine or drivetrain modifications into it's analysis of emissions and fuel economy.

- Larger engines or modified drivetrains will entail additional costs in complying with CAFE standards.

- EPA did not use proper statistical techniques to distinguish variability from consistent trends in the WOT time analysis used to claim minimal effects on performance.

- A two second limit on WOT control will keep the loss of power to manageable limits for Tier I vehicles.

Both GM and Suzuki stated that extended stoichiometric control at WOT would result in elimination of small displacement engines.

SEMA expressed their belief that stoichiometric control at WOT would create a safety concern for low-powered vehicles, as they could be underpowered and thus less safe when merging onto highways or climbing hills. SEMA also stated that the use of timers on high performance vehicles will cause an in-use safety problem when enrichment is invoked and extra power is suddenly introduced.

Response to Comments

EPA believes the revisions to the CO standards render the comments on performance impact, for practical purposes, moot. With the 9.0 g/mi CO standard, some vehicles will be able to use enrichment immediately at WOT, most vehicles will need to delay enrichment for no more than two seconds, and no vehicle should need to delay enrichment for more than 4 seconds. The manufacturers method proposed in their comments would inherently require a 3-4 second timer, for which they indicated that there should not be a significant performance impact.

In the support documents to the NPRM, EPA discussed in some detail the potential impact of elimination of commanded enrichment on vehicle performance and concluded that the impact was likely to be small. The loss of power on most vehicles should be only 3-5 percent and there was no statistically significant change in WOT times when enrichment was eliminated. Nothing in the comments or data submitted to EPA provide compelling evidence to revise this conclusion.

EPA also disagrees with SEMA's statements about potential safety concerns on low-powered vehicles and the use of timers on high-performance vehicles. While there would be a small reduction in performance on low-powered vehicles if enrichment were eliminated for extended periods of time, the performance reduction is very small (3-5 percent) compared to the range of performance levels that already exist in the vehicle fleet (which differ by a factor of 2-3). If low-powered vehicles can manage to merge onto highways or climb hills with less than half the performance level of many high-performance vehicles, an additional power loss of 3-5 percent would be relatively insignificant. Similar logic applies to the use of timers on high performance vehicles. The introduction of enrichment after a period of stoichiometric operation will cause a sudden increase in the power output of the engine. However, this increase is likely to be no more than 5 percent. Under hard accelerations, engine output will increase many times this amount from second to second as the engine increases RPM. In addition, turbochargers frequently have a delay before they begin delivering additional power. The sudden increase in power delivered by the turbocharger, which can be in the range of a 50 percent power boost, has not been reported to be a safety concern in any vehicle. Thus, it is extremely unlikely that a 5 percent power boost when enrichment is eliminated would be a safety concern.

While EPA disagrees with most of the comments on the impact of enrichment on vehicle performance, the issue is rendered largely insignificant due to the change in the CO standards from the NPRM to the Final Rule. With the 9.0 g/mi CO standard, some vehicles will be able to use enrichment immediately at WOT, most vehicles will need to delay enrichment for no more than two seconds, and no vehicle should need to delay enrichment for more than 4 seconds. As the manufacturers stated in their comments that a two second limit on WOT control will keep the loss of power to manageable limits for Tier I vehicles and proposed a method for such control that would inherently require a 3-4 second timer, there should not be a significant performance impact even on the vehicles that would need a short period of WOT enrichment control. The change in the CO standard also alleviates any need to assess the value consumers place on vehicle performance, as many vehicles will not experience any performance loss and the impact even on the lower-performance vehicles will be quite small.

3. Two-second timer requirement on high performance vehicles

Summary of Proposal

For high performance vehicles, the manufacturer must demonstrate stoichiometric control for wide-open throttle events of two seconds or less in order to ensure that these vehicles have aggressive driving emission control over similar vehicle operation as the rest of the fleet.

Summary of Comments

Ford commented that it is inappropriate to force vehicles to two seconds of stoichiometric control at WOT if they did not go into WOT on the US06. SEMA stated that the proposed requirements burden high performance vehicles with unnecessary requirements while low performance vehicles have been accorded artificial relief; requiring a two-second stoichiometric timer only in high performance vehicles is particularly biased and inappropriate since the total contribution to the emission inventory is de minimis.

Response to Comments

EPA disagrees with SEMA's comment that the two-second timer requirement in the NPRM accorded artificial relief to low performance vehicles. The timer requirement was limited to high-performance vehicles simply because lower-performance vehicles would be required to have two seconds of enrichment control at

WOT by the CO standard on the US06 cycle. A separate timer requirement for the lower performance vehicles would have been a duplicative, unnecessary requirement.

EPA does agree with SEMA's comment (and Ford's indirect comment to the same effect) that the total contribution of WOT operation on high performance vehicles to the emission inventory is small. As discussed above, EPA has concluded that the emission benefit is so small as to not be worth the potential degradation in catalyst performance and the potential need for more thermally resistant engine components. Thus, EPA will not finalize the two-second stoichiometric timer for high performance vehicles.

C. Control of NMHC and NOx

Summary of Proposal

The NPRM proposed to hold US06 NOx emissions to overall FTP emission levels and NMHC emissions to FTP bag 2 emission levels. For Tier I LDV and LDT1 vehicles, the FTP NOx standard is 0.4 g/mile. While no standards exist for FTP bag 2 emissions, the average FTP bag 2 emissions for Tier I LDV and LDT1 vehicles would correspond to an NMHC standard of roughly 0.05 g/mile. Thus, the NPRM implicitly proposed an US06 NMHC+NOx standard of about 0.45 g/mile for LDV and LDT1 vehicles.

Summary of Comments

AAMA/AIAM submitted a proposal to set US06 standards by averaging all the Tier I LDV and LDT1 US06 stoichiometric test results from the US06 phase II test program, multiplied by a factor of two to provide necessary headroom. Based upon this methodology, they proposed US06 standards of 1.1 g/mile NMHC+NOx. AAMA/AIAM also stated that this emission level, with appropriate load adjustments, should be feasible with only recalibration for most vehicles.

AAMA/AIAM also submitted a number of comments on the standards proposed by EPA. They stated that EPA presented no emission data showing that US06 NOx levels could be reduced to full FTP NOx levels and that EPA performed no analyses to assess the reason why US06 catalyst NOx efficiencies were lower than over bag 2 of the FTP. AAMA/AIAM also expressed their belief that EPA concluded that the proposed NOx standard was feasible based on two vehicles having bag 2 efficiency levels at the same level of theoretical US06 levels required to meet the US06 NOx standard even though the actual US06 efficiencies were below the actual bag 2 efficiency levels. They also stated that EPA assumed that not only could all vehicle's improve their NOx efficiency levels to bag 2 levels, but that all vehicles could achieve the bag 2 efficiency levels of the two best vehicles in the database. Finally, they stated that, because increased breakthrough occurs in the catalyst over the US06 cycle at high exhaust flows, recalibration alone would be insufficient to meet EPA's proposed standards and larger catalyst would be required.

Ford also commented that EPA's proposed standards cannot be met with only calibration changes and stated that catalyst systems will have to be redesigned, including catalyst volume, precious metal loading, and catalyst placement. Ford also submitted information on EGR calibration strategy, expressing concern that increasing EGR flow to reduce NOx over the US06 cycle could have negative impacts on driveability, HC emissions, and fuel economy. Ford also stated that using EGR at WOT, even at only 5-6 percent flow rates, leads to a 10-20 percent reduction in torque.

Response to Comments

Comments and new data provided by AAMA/AIAM convinced EPA to revise the US06 standards based on new data for Tier 1 vehicles. EPA believes this data, which was not available for incorporation into the NPRM, is a more appropriate database for setting US06 standards. After considering several alternative methodologies, the EPA established Tier I US06 design targets based on the simple average of the vehicles identified as having reasonable air/fuel calibrations (i.e. without a significant lean or rich bias during US06 operation). The half-life NMHC+NOx design target is 0.29 g/mi for LDV and LDT1, 0.455 for LDT2 and LDT3, and 0.665 for LDT4.

As EPA acknowledged in the NPRM, there was wide variation in the test results used to establish the proposed standard. Composite NOx on the simulated US06[12] differed by a factor of 6:1 from the highest LDV to the lowest. As most of these vehicles were calibrated to the less stringent Tier 0 emission standards, EPA's proposed standards were based upon the premise that Tier 1 vehicles properly calibrated for US06-type driving should be able to meet the level of the best Tier 0 data.

In their comments, manufacturers contended that the proposed standards were based upon unfounded assumptions and that EPA should simply take the average of all the data. Rather than contest the assumptions used to set US06 emission standards for Tier 1 vehicles from Tier 0 vehicle data, EPA has analyzed the new US06 data from the phase II test program on Tier I vehicles. As this data, which was not available for the NPRM, is a more appropriate database for setting US06 standards, EPA has reviewed the analyses for US06 standard stringency for the Final Rule using this new data.

The manufacturers tested 18 LDV, 6 LDT1, 5 LDT2 and 3 LDT3/4 Tier 1 vehicles in this second phase of testing. A baseline FTP was conducted for each vehicle and two tests were run on US06, both with the production calibration and with a "stoichiometric" calibration designed to eliminate commanded enrichment. The average of the US06 tailpipe emissions with each calibration are plotted for NMHC, CO, and NOx, respectively, on figures III-6 through III-8 (LDV/LDT1) and figures III-9 through III-11 (LDT2/3/4).

Unfortunately, as seen on figures III-8 and III-11, wide variation still exists from vehicle to vehicle in the NOx emission levels on US06. While NMHC levels on US06 are also

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[12] The US06 cycle was not run on the initial test program so US06 emissions were estimated by adding together modal emission data from the segments of the REP05 and ARB02 cycles that comprise the US06 cycle.

quite variable, they are almost a factor of 10 lower in magnitude than NOx emission levels. Thus, it is important to focus on the NOx emission variability in order to set appropriate US06 emission standards. Understanding the causes of this variation can help establish the appropriate emission level and estimate the type and cost of technology needed for vehicles to comply with different emission levels.

EPA approached the issue of appropriate emission standards using three different methods. The first approach, which was also the most ambitious, attempted to identify the calibration strategies, vehicle parameters, and emission control technology and hardware associated with lower NOx emission levels. As this approach was largely inconclusive, EPA evaluated two additional approaches to setting standards. The second approach was modified for Tier 1 vehicles from a method proposed to CARB by the vehicle manufacturers for setting LEV emission standards, based upon relationships between US06 and FTP hot, stabilized engine out emission levels and catalyst conversion efficiency. The third approach was a simple average of the vehicles identified as having reasonable air/fuel calibrations (i.e. without a significant lean or rich bias during US06 operation).

1. Parameter Identification

A wide variety of parameters were developed and tested for correlation with the variation in NOx emission levels, including vehicle weight, engine size, performance, exhaust flow, type of fuel injection, space velocity of the catalyst, catalyst loading, and nine measures of air/fuel control. A complete list of the parameters assessed appears in Table III-13.

One important factor was quickly identified: significant bias in the air/fuel ratio. A significant lean bias (i.e. air/fuel ratio mid-point about 14.7:1 or higher) caused a consistent loss in NOx conversion efficiency throughout the US06 cycle. A significant rich bias (i.e. air/fuel ratio mid-point about 14.3:1 or less) caused a consistent loss in CO conversion efficiency, with highly variable results on NOx conversion efficiency (i.e. some vehicles had extremely high NOx conversion efficiencies with the rich bias, others had relatively poor NOx conversion efficiency).

These impacts on catalyst conversion efficiencies are completely consistent with catalyst operation theory. Excess oxygen inhibits the reduction of NOx in the catalyst, while CO conversion requires free oxygen (CO conversion efficiency was chosen for this analysis instead of HC conversion efficiency because CO conversion is more sensitive to the loss of free oxygen than HC). Only in a very narrow range around stoichiometric can both conversions occur simultaneously in the catalyst. Evaluation of tailpipe CO emissions and/or catalyst conversion efficiency is also a reliable way to determine the point at which the air/fuel ratio shifts rich of stoichiometric; thus, it is a good double-check on the air/fuel ratio measurements made during the test, which are not completely reliable.

Most of the rich- and lean-bias vehicles can be readily identified from a cross-plot of overall CO conversion efficiency vs. overall NOx conversion efficiency, as shown in Figure III-12. Every vehicle with less than 80 percent overall CO conversion efficiency (these vehicles are circled on Figure III-12 and labeled "rich bias") also showed significant rich air/fuel bias. (Appendix I contains second-by-second plots of the air/fuel ratio and tailpipe CO emissions, which were generated and evaluated for every vehicle. Tailpipe CO was included as a check on the air/fuel ratio measurement, as the measurement of air/fuel ratio is less accurate than tailpipe CO and CO is extremely sensitive to rich operation.) Every vehicle with more than 90 percent CO conversion efficiency and less than 90 percent NOx conversion efficiency had a significant lean air/fuel bias, as defined by having virtually no CO emissions during high-speed cruise operation (these vehicles are labeled "lean bias" in Figure III-12).

The remaining vehicles on Figure III-12 appear, at first glance, to be relatively balanced between NOx and CO conversion efficiency, indicating that they have air/fuel calibrations centered at or near stoichiometric operation. For each of these vehicles, new plots were made which added second-by-second exhaust flow and tailpipe NOx emissions to the parameters plotted in Appendix I, in order to assess air/fuel biases and tailpipe CO and NOx emissions with respect to the load on the engine. These plots are presented in Appendix II. Evaluation of the second-by-second air/fuel ratio and tailpipe CO and NOx emissions during normal operation (as indicated by moderate exhaust flow) substantiate the relative lack of lean or rich bias on most of these vehicles. However, there were a number of vehicles in this group that, upon closer examination, appear to be biased or poorly calibrated, as discussed below.

Vehicles 310, 311, 312 all exhibited very similar calibrations. As clearly indicated in their plots in Appendix II, during normal high speed driving (as indicated by periods with moderate exhaust flow), these calibrations were actually biased a little lean of stoichiometric, which can be seen by the air/fuel ratio centered above 14.5:1, frequent small tailpipe NOx spikes, and very low tailpipe CO. The reason why the overall CO conversion efficiency was only 80-85 percent on these vehicles is because they did not completely eliminate enrichment during high power events. Almost all the CO on these vehicles occurred during 4-6 very high CO spikes, which correspond to the highest exhaust flows and air/fuel ratios consistently at or below 14.0:1. If these periods of commanded enrichment were eliminated, as was done for the other vehicles tested, these vehicles would clearly move into the "lean-bias" area on Figure III-10.

The graphs of vehicles 101 and 203 do not disclose a clear air/fuel pattern. While both vehicles have the frequent low levels of tailpipe NOx associated with lean-bias calibrations (vehicles with good stoichiometric control, such as 102, 702, 314, 316, and 318, tend to have extremely low tailpipe NOx emissions except during the highest load points), they also have the frequent periods of moderate tailpipe CO levels associated with rich-bias. One possible explanation was the fairly erratic air/fuel control exhibited by these vehicles (i.e. lots of both rich and lean spikes), another was that the calibration was fine and this was as good as these vehicles could do without improving hardware. To test these hypotheses, the stoichiometric calibrations were compared to the production calibrations on both vehicles (the second-by-second plots of the production calibrations are contained in Appendix III). For both vehicles, the air/fuel ratio for the production calibration was more tightly controlled, reducing the amount and size of the lean excursions and greatly reducing tailpipe NOx emissions. This indicates that the stoichiometric calibrations on these vehicles were slightly compromised and that the test results with the stoichiometric calibrations are not representative of what can be achieved with proper calibrations. The case for vehicle 203 is especially strong, as the vehicle generated only about 5.5 g/mi CO with the production calibration, indicating that the changes made for the stoichiometric calibration would not be needed (or desired) for the vehicle to comply with the proposed US06 emission standards.

The stoichiometric calibration for vehicle 304 appears to be unstable. The second-by-second plot of air/fuel ratio indicates that the vehicle began the test biased a little lean, drifted slightly rich during the middle of the test, and drifted back a little lean toward the end of the test. Comparison with the production calibration indicates that the stoichiometric calibration was also biased leaner than the production calibration. Due to the apparent change in the bias and the apparent instability in the air/fuel control, this vehicle is not considered to be a good representation of proper calibration.

Vehicle 305 was unusual in that the second-by-second air/fuel ratio plot indicated a rich bias, while having the frequent low levels of tailpipe NOx generally associated with lean bias and without the substantial CO levels generally found with rich bias. The only other vehicle which behaved this way was 207. To try to shed some light on what was going on, the production calibration for vehicle 305 was also examined. As can be seen on the plots, the second-by-second air/fuel ratio with the production calibration appeared to have the same amount of rich bias as the stoichiometric calibration. However, the air/fuel appeared to be more tightly controlled with the production calibration and, except during the highest load periods, tailpipe NOx and CO were both lower than for the stoichiometric calibration.

In summary, the vehicles were grouped as follows:

Table III-7: Calibration Classification

Type	**Good**	**Rich-bias**	**Lean-bias**	**Erratic/ Suspect**
LDV	202 203 (P) 307 314 701	303 401 501 801	201,301, 302,310, 311,320, 000	203 (S) 304 305
LDT1	102 204 315 316 318			
LDT2	103 322 324 702	205		101
LDT3/LDT4	206		207 208	

Three items to note:

- While the stoichiometric calibration of vehicle 203 is considered to be erratic, as explained above, the production calibration appears to be fine and the vehicle almost meets the CO design target of 5 g/mi even with the production calibration. Thus, vehicle 203 with the production calibration can be considered to be representative of "good" calibrations.

- There are four vehicles which are below the CO design target for their vehicle class: 315, 318, 324, and 701. Note that all four vehicles are considered to have "good" calibrations. As all four vehicles met the proposed CO design level with the production calibration, the production calibration is considered by EPA to be more representative for these vehicles than the stoichiometric calibration. All analyses of appropriate NMHC+NOx emission levels and standards conducted in the rest of this section use the production calibration data for these four vehicles, as well as for vehicle 203.

- The great majority of the biased or suspect calibrations were LDVs. While only 4 of 18 LDVs were considered to be properly calibrated at stoichiometric (plus one more with the production calibration), all 5 LDT1s and 4 of the 6 LDT2s appear to be properly calibrated.

As can be seen on Figure III-12, removing the vehicles with biased or erratic air/fuel calibrations greatly reduces the range of catalyst efficiency variation seen from vehicle to vehicle. However, there are still substantial differences between the best vehicles, such as 702 and 102, and some of the other remaining vehicles, such as 204, 206, and 307. In order to evaluate potential causes of these differences, EPA regressed both overall NOx catalyst efficiency and total tailpipe NOx emissions against a wide variety of vehicle parameters. These parameters are listed in Table III-13.

The purpose of the regressions was to establish parameters correlated with the best NOx catalyst conversion efficiency, such as exhibited by vehicles 702, 102, 314, 316, and 318. If the parameters associated with the best catalyst performance were to be identified, this information could be used to determine the cost and feasibility associated with different emission standard levels.

Unfortunately, once the obviously lean and rich biased vehicles were removed, the regressions did not identify the causes of most of the variability in the NOx conversion efficiency. The best R-squared value obtained using parameters whose coefficients did not violate standard combustion theory was only about 0.4. The results of this regression are presented in Table III-8. Of the four parameters, two (# sec > 16.8 and auto/manual transmission) are not significant at the 90 percent confidence level (i.e. their P-values are greater than 0.1). Only A/F fraction 1 and A/F fraction 2 are significant at high confidence levels. The coefficient of A/F Fraction 2 suggests that tight air/fuel ratio control during stoichiometric operation (i.e. between 14.0-15.2 air/fuel ratio) is desirable. However, the coefficient of A/F Fraction 1 suggests that excursions outside the 14.0-15.2 air/fuel range (both rich and lean) are also desirable. Given the low R-squared value, the strongest conclusion that can be drawn is that there are factors affecting overall catalyst conversion efficiency that are not captured in the summary statistics.

Table III-8: Best Regression of NOx Catalyst Efficiency

Regression Statistics						
Multiple R	0.725					
R Square	0.526					
Adjusted R Square	0.400					
Standard Error	4.541					
Observations	20					
ANOVA	***df***	***SS***	***MS***	***F***	***Significance F***	
Regression	4	343.567	85.892	4.165	0.018	
Residual	15	309.325	20.622			
Total	19	652.892				
	Coefficients	***Standard Error***	***t Stat***	***P-value***	***Lower 95%***	***Upper 95%***
Intercept	113.379	22.335	5.076	0.000	65.774	160.984
#sec >16.8	-0.110	0.066	-1.677	0.114	-0.251	0.030
A/F Fraction 1	-85.183	29.361	-2.901	0.011	-147.764	-22.602
A/F Fraction 2	72.739	18.921	3.844	0.002	32.411	113.067
(1=A/0=M)	-4.114	2.746	-1.498	0.155	-9.967	1.740

Note: Vehicle 206 excluded (LDT4)

An alternative set of regressions were conducted that included the FTP bag2 NOx conversion efficiency as an input variable. The goal was to evaluate whether some of the intangible factors were already incorporated into the hot, stabilized conversion efficiency of the FTP. The results here are also somewhat inconclusive. When overall US06 NOx conversion efficiency was regressed only against the FTP bag2 NOx conversion efficiency, the R-squared was only 0.21, indicating that most of the variation in overall US06 NOx conversion efficiency was not due to baseline hot, stabilized calibration strategies. The entire set of variables in Table III-13 were once again evaluated with the inclusion of the FTP bag2 NOx conversion efficiency as an input variable. The best R-squared value obtained using parameters whose coefficients did not violate standard combustion theory increased to 0.66. The results are presented in Table III-9. Note that both the # sec > 16.8 and the auto/manual transmission variables (which were only mildly significant for the regressions without the FTP bag2 NOx variable) do not appear. While the Platinum loading/Average exhaust volume variable did have some impact on the overall R-squared value, it is not significant at the 90 percent confidence level. Again, in addition to the FTP bag2 NOx conversion efficiency, only A/F fraction 1 and A/F Fraction 2 are significant at high confidence levels. While their coefficients are somewhat reduced from the regression without FTP bag2 NOx efficiency, they have the same sign. Thus, the primary conclusions that can be drawn from this set of regressions are similar to those presented in the last paragraph for the regressions without FTP bag2 NOx efficiency.

Table III-9: Best Regression of US06 NOx Catalyst Efficiency

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.864
R Square	0.746
Adjusted R Square	0.661
Standard Error	2.956
Observations	17

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	308.001	77.000	8.811	0.001
Residual	12	104.865	8.739		
Total	16	412.866			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	10.333	26.707	0.387	0.706	-47.856	68.523
A/F Fraction 1	-36.988	13.890	-2.663	0.021	-67.252	-6.724
A/F Fraction 2	47.997	13.847	3.466	0.005	17.828	78.167
Bag 2 NOx %	0.779	0.242	3.218	0.007	0.252	1.307
Platinum	65833.133	46215.644	1.424	0.180	-34862.103	166528.368

Note: Vehicles 102 and 103 (no Bag 2 NOx data), 305 (lean bias), and 206 (LDT4) excluded

The problems encountered with regressing summary statistics for the entire US06 cycle can perhaps be best illustrated by examining the air/fuel strategy for vehicles 702 and 102, the two vehicles which did the best job of simultaneously converting CO and NOx in the catalyst over US06. Figures III-13 and III-14 present the second-by-second air/fuel ratio, tailpipe NOx, tailpipe CO/10, and exhaust volume with the stoichiometric calibration over the US06 for vehicles 702 and 102, respectively. It is clear that the calibration strategies are completely different, yet each achieves very high NOx conversion efficiency. Vehicle 702 has what is referred to as "tip-in enrichment," meaning that the computer delivers a small amount of additional fuel every time the throttle opening increases, but just for a very brief period of time. The tailpipe NOx levels indicate that this amount is nicely balanced to cancel out any negative effects of previous lean events, while avoiding direct impacts on stoichiometric NOx efficiency.[13] The relative modest increases in tailpipe CO emissions also indicate that the enrichment periods are quite brief. On the other hand, vehicle 102 achieves conversion efficiencies similar to vehicle 702 without enrichment. This vehicle has extremely tight air/fuel control. In comparison with vehicle 702, 102 appears to have more problems with NOx during high load events, while maintaining even lower NOx during more moderate loads. However, the NOx spikes on vehicle 102 may actually be associated with small, but extended, periods of enrichment, such as the ones around 50-60, 130-140, and 560-580 seconds into the cycle. Note that the high load

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[13] NOx conversion efficiency with good stoichiometric control is higher than NOx conversion efficiency with a rich air/fuel ratio. This effect has been observed on vehicles tested as part of the FTP Revision project, as reported in a paper by John German, "Observations Concerning Current Motor Vehicle Emissions", SAE Technical Paper 950812, February, 1995. It was also reported in a 1990 paper by Dr. Kathleen C. Taylor of General Motors Research, "Catalysts in cars", CHEMTECH, September, 1990, p. 554-555.

points between 280 and 330 seconds into the cycle (which correspond to the high speed passing maneuver) on vehicle 102 were run with absolutely no variation in air/fuel ratio and virtually no tailpipe NOx.

The frequent air/fuel excursions on 702 help explain the significance of the variable A/F Fraction 1 in the regressions, discussed above. The extremely tight air/fuel control of 102 helps to explain the significance of tight air/fuel control around stoichiometric also identified in the regressions (A/F Fraction 2). However, other vehicles with frequent air/fuel excursions did not convert NOx nearly as efficiently. It is likely that the duration of the excursions has a significant impact on the catalyst efficiency, a factor that is difficult to capture in regressions. The sequencing of rich and lean excursions is also likely to affect actual catalyst operation, as oxygen storage in the catalyst can delay recovery of NOx conversion efficiency. The effect of these types of interactions are virtually impossible to assess using overall catalyst efficiency. Thus, while vehicles 702 and 102 offer empirical evidence that other vehicles can greatly reduce NOx emissions on US06, the modest R-squared values for the regressions indicate that there are complex interactions in the catalyst which make it difficult to quantify the amount of reductions that can be achieved.

The next step of the analysis was to try to identify some of the catalyst interactions by regressing the second-by-second NOx catalyst efficiency individually for each vehicle. A series of variable were created to examine the carry-over impact of air/fuel ratio on catalyst conversion efficiency. Running averages of the fuel/air ratio were created for three, five, ten, and fifteen seconds (fuel/air was used instead of air/fuel to prevent overestimating the impact of decel fuel shutoff). A separate set of averages were created that weighted the fuel/air at each point by the exhaust flow. In addition to these running averages, the instantaneous fuel/air ratio, the exhaust volume, and the square of the exhaust volume were also used as inputs to the regressions. The exhaust volume and the square of the exhaust volume were used to examine the potential impact of the catalyst space velocity on catalyst efficiency. A series of regressions were run on each vehicle. A summary of the results with the highest R-squared value for each vehicle is presented in Table III-10 (note that the list is sorted by R-squared value).

Table III-10: Best regression of US06 second-by-second NOx catalyst efficiency, by r2 value

		Values at max r2 point			Regression Coefficients			P-value (chance is not significant)		
Vehicle		r2 value	#sec a/f	wgt(1=y)	Exhvol	Exhvol2	A/Fratio	Exhvol	Exhvol2	A/F ratio
202	LDV	0.93	15	1	0.35	-1.39	3879	0.73	0.001	0
318	LDT1	0.83	10	0	0.58	-0.93	2694	0.67	0.08	1.00E-213
315	LDT1	0.75	10	1	0.73	0.09	2705	0.74	0.92	1.00E-161
316	LDT1	0.75	10	0	7.89	-2.14	2568	0.01	0.22	1.00E-137
101	LDT2	0.75	5	1	8.93	-2.91	1911	1.00E-07	1.00E-09	1.00E-147
322	LDT2	0.71	5	1	5.11	-2.09	1915	0.0003	1.00E-07	1.00E-144
702	LDT1	0.69	10	1	15.3	-4.79	2802	1.00E-15	1.00E-13	1.00E-122
204	LDT1	0.67	15	0	13.9	-6.18	3023	1.00E-05	1.00E-07	1.00E-99
314	LDV	0.63	15	0	27.1	-10.2	2092	1.00E-11	1.00E-09	1.00E-79
304	LDV	0.63	15	0	64.4	-28.1	2024	1.00E-19	1.00E-12	1.00E-52
701	LDV	0.61	10	1	0.12	-0.16	1906	0.98	0.95	1.00E-99
324	LDT2	0.61	5	0	4.57	-2.73	2550	0.0007	1.00E-11	1.00E-112
203	LDV	0.45	5	0	1.99	-1.83	2871	0.14	1.00E-05	1.00E-68
305	LDV	0.42	15	0	8.55	-5.56	2750	0.02	0.0001	1.00E-61
102	LDT1	0.34	5	1	3.66	-4.47	682	0.12	1.00E-05	1.00E-45
312	LDV	0.3	10	1	-4.49	0.17	2523	0.08	0.86	1.00E-47
103	LDT2	0.3	15	0	-4.45	-0.29	1549	0.08	0.74	1.00E-45
307	LDV	0.28	5	0	1.63	1.12	1595	0.62	0.47	1.00E-38
206	LDT4	0.1	0		14.5	-4.1		1.00E-15	1.00E-15	0.33
310	LDV	0.09	10	1	8.49	-2.94	2363	0.002	0.002	1.00E-11
311	LDV	0.01	NA	NA	NA	NA	NA	NA	NA	NA

Although not presented in the summary, for every vehicle the instantaneous fuel/air ratio was not a statistically significant factor. Except for two vehicles, 206 and 311, running averages of the fuel/air ratio were a significant factor at extremely high confidence levels (i.e. the air/fuel p-value, or probability that the variable was not significant, was less than 1*E-11). However, the running average which produced the best correlation differed from five to fifteen seconds and was split roughly evenly between the weighted and unweighted average. In addition, even though the p-value for the running air/fuel average was extremely low in almost all cases, the R-squared values were very high for some vehicles but only fair to poor on others. Unfortunately, there does not appear to be a significant correlation between the length and type of the running average which produced the best result and either the better R-squared values or the number and length of excursions outside 14.0-15.2 air/fuel ratio. Thus, although the data clearly indicates that NOx catalyst efficiency is influenced by past air/fuel events, it is not clear how this effect can be quantified or incorporated into standard setting.

Exhaust volume and the square of the exhaust volume were significant at very high confidence levels for about half of the vehicles, but had fair or poor confidence levels on the other half. In most cases, the confidence level for exhaust volume tracked that of the square of the exhaust volume. In every case where the confidence level for both variables was at least 95 percent, the exhaust volume coefficient was positive and the square of the exhaust volume coefficient was negative, indicating that NOx conversion efficiency increases with increasing load at moderate exhaust flows, but decreases with increasing load at high exhaust flows on these vehicles. The NOx conversion efficiency of the other half of the vehicles appears to be relatively insensitive to exhaust flow.

The issue of exhaust flow impacts on NOx catalyst conversion efficiency is an important one, as data submitted by manufacturers and independent analyses show that NOx conversion efficiency decreases dramatically at high exhaust flows, especially with an aged catalyst (the negative effect of catalyst aging on conversion efficiency at high exhaust flows appears to be much more pronounced for NOx than for HC or CO). In fact, in a report prepared under contract to EPA, EEA estimated that the catalyst size would have to be increased by 50 percent in order to maintain normal NOx conversion efficiency during the highest load points on the US06 cycle.

While the vehicle specific regressions demonstrate strong support for a reduction in NOx conversion efficiency at high exhaust flows, at least on about half of the vehicles, they demonstrate that NOx efficiency also increases as exhaust flow increases from low exhaust flows to some midrange point, before starting down at high exhaust flows. Table III-11 lists the results from Table III-10 resorted by the exhaust volume confidence level. While the magnitude of the coefficients for both the exhaust volume and the exhaust volume squared differ greatly from vehicle to vehicle, the relationship between the coefficients is much more consistent. For every vehicle with an exhaust volume confidence level of at least 99 percent (i.e. the p-value is less than 0.01), the exhaust volume coefficient is positive, the exhaust volume squared coefficient is negative, and the magnitude of the exhaust volume coefficient ranges from 1.7 to 3.7 times the magnitude of the exhaust volume squared coefficient.

Table III-11: Best regression of US06 second-by-second NOx catalyst efficiency, sorted by Exhvol P-value

		Values at max r2 point			Regression Coefficients			P-value (chance is not significant)		
Vehicle		r2 value	#sec a/f	wgt(1=y)	Exhvol	Exhvol2	A/Fratio	Exhvol	Exhvol2	A/F ratio
304	LDV	0.63	15	0	64.4	-28.1	2024	1.00E-19	1.00E-12	1.00E-52
206	LDT4	0.1	0		14.5	-4.1		1.00E-15	1.00E-15	0.33
702	LDT1	0.69	10	1	15.3	-4.79	2802	1.00E-15	1.00E-13	1.00E-122
314	LDV	0.63	15	0	27.1	-10.2	2092	1.00E-11	1.00E-09	1.00E-79
101	LDT2	0.75	5	1	8.93	-2.91	1911	1.00E-07	1.00E-09	1.00E-147
204	LDT1	0.67	15	0	13.9	-6.18	3023	1.00E-05	1.00E-07	1.00E-99
322	LDT2	0.71	5	1	5.11	-2.09	1915	0.0003	1.00E-07	1.00E-144
324	LDT2	0.61	5	0	4.57	-2.73	2550	0.0007	1.00E-11	1.00E-112
310	LDV	0.09	10	1	8.49	-2.94	2363	0.002	0.002	1.00E-11
316	LDT1	0.75	10	0	7.89	-2.14	2568	0.01	0.22	1.00E-137
305	LDV	0.42	15	0	8.55	-5.56	2750	0.02	0.0001	1.00E-61
312	LDV	0.3	10	1	-4.49	0.17	2523	0.08	0.86	1.00E-47
103	LDT2	0.3	15	0	-4.45	-0.29	1549	0.08	0.74	1.00E-45
102	LDT1	0.34	5	1	3.66	-4.47	682	0.12	1.00E-05	1.00E-45
203	LDV	0.45	5	0	1.99	-1.83	2871	0.14	1.00E-05	1.00E-68
307	LDV	0.28	5	0	1.63	1.12	1595	0.62	0.47	1.00E-38
318	LDT1	0.83	10	0	0.58	-0.93	2694	0.67	0.08	1.00E-213
202	LDV	0.93	15	1	0.35	-1.39	3879	0.73	0.001	0
315	LDT1	0.75	10	1	0.73	0.09	2705	0.74	0.92	1.00E-161
701	LDV	0.61	10	1	0.12	-0.16	1906	0.98	0.95	1.00E-99
311	LDV	0.01	NA	NA	NA	NA	NA	NA	NA	NA

The point at which the NOx conversion efficiency begins to decrease with increasing exhaust flow is the point at which the change in the exhaust volume times its coefficient equals the change in exhaust volume squared times its coefficient, or:

derivative of ((coeffexh)(exh)) =derivative of ((coeffexh sq)(exh^2))
or coeffexh = 2 (coeffexh sq)(exh)
or exh = coeffexh / (2 * coeffexh sq)

Thus, the point at which NOx conversion efficiency begins to turn down is the ratio of the exhaust volume coefficient to the exhaust volume squared coefficient, divided by two. As the ratio of the of the coefficients ranges from 1.7 to 3.7, the exhaust flow point at which the NOx conversion efficiency begins to turn down ranges from 0.85 to 1.85 cubic feet per second (cfs). This is a very high exhaust flow; most of the US06 is run at lower exhaust flows. In addition, the exhaust flow during the FTP is much lower than on the US06; typical exhaust flows on the FTP are less than 0.25 cfs. Thus, there appear to be two impacts due to increased exhaust flow on US06 compared to the FTP. The first is an increasing NOx conversion efficiency as the exhaust flows increase from typical FTP levels to the maximum efficiency at 0.85-1.85 cfs. This beneficial effect may be due to better mixing in the catalyst at higher flows or to the higher catalyst temperatures generated during the higher loads on the US06. Figures III-15 through III-17 include the second-by-second catalyst temperatures on the US06 for vehicles 202, 203, and 208, respectively. Figures III-18 through III-20 present the same information on the same vehicles for the FTP. These graphs clearly show that the catalyst temperature during most of the FTP runs around 600 degrees Centigrade or a little less, while temperatures on the US06 generally range between 650 and 850 degrees Centigrade. This upward trend in NOx conversion efficiency at lower exhaust flow is offset by the second factor, insufficient space-velocity in the catalyst to convert all the incoming NOx at high flow rates, once the exhaust flow increases to a rate above 0.85-1.85 cfs. Unfortunately, it is very difficult, if not impossible, to quantify the relative impact of these offsetting factors without a working model of catalyst conversion efficiency. Such a model was beyond EPA's ability to create for this rulemaking.

On a qualitative basis, it appears that these two factors affecting NOx conversion efficiency on the US06 may be partially or largely offsetting. The moderate exhaust volume region in which the NOx conversion efficiency increases compared to the FTP constitutes the majority of the US06 cycle. On the other hand, the decrease in NOx conversion efficiency at the highest exhaust volumes correlates to the square of the exhaust volume, instead of being linear, and this is also where the highest engine-out NOx occurs. Thus, even though the highest exhaust volumes occur a minority of the time on the US06, the larger impacts on the proportion of NOx that reaches the tailpipe may more than offset the NOx conversion efficiency improvement at the moderate exhaust flows.

One way to compare the relative impacts is to compare the overall NOx conversion efficiency on US06 to FTP bags 2 and 3. Figure III-21 presents this comparison for LDV, LDT1, and LDT2 vehicles (the three LDT3/4 vehicles were excluded because their baseline emissions are much higher than the other vehicles and because two of the three vehicles had missing FTP modal data). The first group of vehicles is the "good" vehicles identified, above, the second group is the rich bias vehicles, the third group is the lean bias vehicles, the fourth group the erratic/suspect vehicles, and the fifth group contains the average efficiencies for each of the four groups. One striking result is the difference in the relationship of US06 to FTP hot, stabilized NOx conversion efficiency for the good calibrations compared to the rich, lean, and suspect calibrations. With the exception of vehicle 801, the US06 NOx conversion efficiency was significantly lower than the FTP bag2 or bag2+bag3 conversion efficiencies for every rich, lean, or suspect calibration. However, the US06 NOx conversion efficiency for the good calibrations tracked the FTP bag2 and bag2+bag3 conversion efficiency reasonably well. In fact, the average NOx conversion efficiency for the good vehicles was only slightly lower than the FTP bag2 conversion efficiency and significantly better than the FTP bag2+bag3 conversion efficiency. This suggests that, with good stoichiometric control, US06 NOx conversion efficiencies are similar to, or possibly somewhat better, than FTP hot, stabilized conversion efficiencies. This supports the speculation in the previous paragraphs that the two factors influencing US06 NOx conversion efficiency may be largely offsetting.

2. Manufacturer Methodology for LEVs Adapted for Tier I

While the analyses presented in the previous section yielded useful insights on a number of issues, there appear to be subtle interactions between different engine and calibration parameters that affect catalyst conversion efficiency in ways that EPA was unable to quantify. Thus, EPA was not able to directly set standards based upon the above approach.

At a meeting between the vehicle manufacturers and CARB on January 9-10, 1996, the manufacturers presented an approach to set NOx standards for LEV LDV/LDT1 vehicles. The approach was based upon three basic concepts:

- The manufacturers estimated, based upon their test data on Tier I vehicles, that: US06 engine-out emissions = 1.75 * FTP engine-out emissions

- NOx conversion efficiency decreases at high exhaust volumes, which is also the point at which engine-out NOx levels are the highest. The manufacturers did not quantify the overall efficiency reduction, but they did present an "engineering guess" that catalyst breakthrough during US06 hot, stabilized operation would increase by 25 percent, compared to FTP hot, stabilized operation. Thus:

  US06 catalyst breakthrough = 1.25 * FTP catalyst breakthrough

- Baseline hot, stabilized FTP emission levels can be estimated by subtracting the incremental emissions generated from the cold start from half the FTP standard (half the standard is used because manufacturers have historically targeted their vehicles to half the emission standard). The manufacturers also presented cold start emission data from 13 Tier I vehicles. If one vehicle with weighted hill 1 emissions of 0.21 g/mi is ignored as an outlier (0.21 g/mi is already over the 0.2 g/mi FTP target even without the rest of the FTP), the other 12 vehicles averaged about 0.2 g/mi for the whole FTP (almost exactly half the standard) and 0.05 weighted g/mi for hill 1. Thus:

hot, stabilized FTP target = (standard / 2) - (weighted hill 1 emissions)
= (0.4/2) - 0.05
= 0.15 g/mi

While the manufacturers did not present conclusions for Tier I vehicles and have not endorsed this methodology for Tier I vehicles, the methodology has a significant advantage that interested EPA. Specifically, because the methodology uses the FTP hot, stabilized emission levels as the basis for calculating US06 target emissions, many of the interactive factors that EPA was unable to quantify should be implicitly incorporated into the FTP hot, stabilized baseline, for which manufacturers have already optimized emissions. Thus, at the same level of emission optimization:

US06 emission target = Hot, stabilized FTP emission target
* engine-out increase (from concept 1)
* catalyst breakthrough increase (from concept 2)

If the manufacturers' estimate of a 25 percent increase in catalyst breakthrough is used, along with the 75 percent increase in engine-out emissions and the 0.15 g/mi baseline FTP hot, stabilized target levels, this methodology would yield a US06 NOx target level of 0.328 g/mi for Tier I vehicles. Doubling this level for a times two headroom factor yields a US06 NOx standard of 0.65 g/mi.

However, this methodology has a major flaw. As discussed at some length in the last section, the relationship between US06 and FTP NOx catalyst conversion efficiency is uncertain. The manufacturers' estimate of a 25 percent increase in catalyst breakthrough is based only upon the loss in NOx catalyst conversion efficiency that occurs at very high exhaust flows. Not only is this estimate basically an educated guess, but, more importantly, it ignores the increase in NOx conversion efficiency that occurs at the more moderate exhaust flows during the majority of the US06 cycle. The last section concluded that, while the relative impact of these two factors was not quantifiable based upon available information, it was likely that the factors were largely offsetting. If the assumption were made that there is no change in the overall NOx conversion efficiency between US06 and hot, stabilized FTP driving, this methodology would yield an US06 NOx design target of 0.25 g/mi. While the uncertainty in the relationship of the US06 to hot, stabilized FTP NOx conversion efficiency causes EPA to hesitate using this approach to set US06 design targets, it would seem to support a NOx design target somewhere within a range around 0.25 g/mi.

3. Average of Vehicles with Good Calibrations

Despite all the effort expended by EPA investigating the first two methods of setting standards, the only factor identified with a consistent, significant impact on US06 emissions was unbiased air/fuel calibrations (i.e. no significant lean or rich bias during US06 operation). Of the 29 LDV, LDT1, and LDT2 Tier 1 vehicles tested over the US06 cycle, 14 were identified as having no significant air/fuel bias. These vehicles cover a wide range of manufacturers, size, weight, performance, and catalyst loading and space velocity. Substantial work on identifying additional factors causing differences in emissions and catalyst conversion efficiency between these 14 vehicles failed to revealed any other significant influences. Given the lack of additional factors identified and the reasonable representation of the whole fleet by the vehicles having unbiased air/fuel calibrations, EPA has determined that the most appropriate way to set US06 standards is to simply average the data from vehicles with good calibrations, adjusting for the FTP headroom of the vehicles tested.

As noted previously, there were five vehicles which met or almost met the CO design target level with production calibrations; for these vehicles, the production US06 emission results were used when calculating the average emission levels. For all other vehicles, the emission results with the stoichiometric calibration were used. For standard setting purposes, vehicles were grouped according to the FTP emission standard to which they were designed, e.g. LDV and LDT1 vehicles were grouped together while LDT2 vehicles were grouped separately. As there was only one LDT3 or LDT4 vehicle with a good calibration, the Agency judged that it was not appropriate to analyze standards for these vehicles on only one data point.

Table III-12. Average bag emissions for vehicles with good calibrations

Type	**US06**			**FTP**		
	NMHC	**NOx**	**NMHC**	**NMHC**	**NOx**	**NMHC**
LDV/LDT1	0.047	0.253	0.300	0.138	0.199	0.336
LDT2	0.084	0.309	0.393	0.205	0.355	0.560

As discussed in section II.B, the historical headroom factor for the FTP is two. This means that FTP design targets are half the emission standards. The Tier I NMHC standard at 50,000 miles (equivalent to the oxygen sensor and catalyst aging used for the US06 test program) is 0.25 g/mi and the NOx standard is 0.4 g/mi, for a total of 0.65 g/mi. Thus, the average FTP emissions for the Tier I LDV/LDT1 vehicles tested with good calibrations in the US06 test program should have been half this, or 0.325 g/mile. As the average emissions in the US06 test program for these vehicles were a little higher, 0.336 g/mile, the average US06 emissions need to be adjusted by this offset when setting US06 design targets. Multiplying the average US06 LDV/LDT1 NMHC+NOx emissions of 0.300 by 0.325/0.336 yields an US06 design target of 0.29 g/mile. Appropriate NMHC+NOx design targets for other truck classes are determined by the ratio of the respective FTP NMHC+NOx standards, as discussed later in section II.D.

4. Feasibility of Proposed NMHC+NOx Design Targets

Figures III-22 through III-24 compare the US06 NMHC+NOx emissions for each vehicle to both the FTP NMHC+NOx emissions for each vehicle and the US06 design level the manufacturer must target to meet the composite standards discussed in section VI.A. (as indicated earlier, the production calibration test results met the CO design targets and are also used to represent stoichiometric calibrations for five vehicles; vehicle 203 and

701 on figure III-20, vehicle 315 and 318 on figure III-21, and vehicle 324 on figure III-22). Figure III-22 contains LDV data, figure III-23 contains LDT1 data, and Figure III-24 contains LDT2 data. The average for each category of air/fuel calibration is also included. In Figure III-22, the first group of vehicles are the "good" calibrations, the second group the "rich" bias calibrations, the third group the "lean" bias calibrations, and the forth group the "erratic/suspect" calibrations. Note that the LDT1 chart (Figure III-23) does not contain any rich, lean, or suspect calibrations and that the LDT2 chart (Figure III-24) has only one rich-bias vehicle (205), no lean-bias vehicles, and only one erratic/suspect vehicle (101).

On the surface, this design target appears to be very difficult for many of the LDVs to meet. Figure III-22 indicates that only 5 of the 18 LDVs tested had unbiased air/fuel calibrations and most of the rest must significantly reduce their NMHC+NOx emissions to meet the US06 design target of 0.29 g/mi. However, the Agency believes that the great majority of vehicles can meet the standard simply with better attention to proper air/fuel calibration. This conclusion is supported by the following factors:

- Each vehicle identified as having a lean-bias or an erratic stoichiometric calibration had NMHC+NOx levels over twice the design target. The difference between the behavior of these vehicles and vehicles identified as having good calibrations indicates that proper calibration around the stoichiometric point is essential for good US06 emission control. The "good" group contained a representative mix of vehicles, performance, and emission-related parameters. So did the "lean-bias" group. As no highly significant results were found in any case except for unbiased air/fuel control and both groups were relatively unbiased in regards to other parameters, the Agency has every reason to believe that better air/fuel calibration will reduce the emissions from all of the vehicles with lean-bias and erratic calibrations to the level of the vehicles with good calibrations.

- The conclusion from the preceding paragraph is supported by the emissions from the LDT1 and LDT2 trucks. As a group, these trucks had much lower US06 emissions than the LDVs, as well as much better overall air/fuel calibration strategies. All five of the LDT1s tested had good stoichiometric air/fuel control and four of the five meet the design level of 0.29 g/mi, even with the crude, unoptimized stoichiometric calibrations used for the test program. The fifth LDT1, 204, had emissions with the stoichiometric calibration that were significantly above the design target. However, the emissions with the production calibration were substantially lower than with the stoichiometric calibration on this vehicle, which is not typical of the vehicles identified with good air/fuel calibrations. Thus, this vehicle may not be as far from the design target as it appears from the stoichiometric calibration data. For the LDT2s, five of the six vehicles tested meet or come very close to meeting the design target of 0.455 g/mi with the crude, unoptimized stoichiometric calibration used for the test program. This includes all four of the vehicles with good calibrations as well as vehicle 205, which was identified as having a rich air/fuel bias. The only LDT2 with stoichiometric calibration results substantially above the design target was 101, which was identified as having a change in the closed-loop air/fuel calibration from the production to the stoichiometric calibration. As the production calibration on vehicle 101 produced NMHC+NOx emissions right at the design target level, it appears likely that all six of the LDT2s can meet the design target level with little, if any, modification. Thus, of the 11 LDT1 and LDT2 vehicles tested, 10 should be able to meet the standard easily. For the last vehicle, 204, it is not clear if it can meet the standard with only improved air/fuel calibrations or if it would require some increase in catalyst loading or improved EGR. As these trucks constitute an extremely broad range of weight, performance, and engine size, it is difficult for the Agency to believe that LDVs would not be able to duplicate the emission performance of the trucks, given proper air/fuel calibration strategies.

- Of the 14 LDV, LDT1, and LDT2 vehicles with good calibrations, 8 meet the design target levels for their vehicle class (0.29 g/mi NMHC+NOx for LDV and LDT1, 0.455 g/mi for LDT2) and 4 more would need reductions of only 6-26 percent to meet the design target levels. Emission levels a little bit above the design target level should not be a concern, as the stoichiometric calibrations developed by the manufacturers for the test program only eliminated commanded enrichment and lean-on-cruise features. No attempt was made to optimize the control of NOx emissions during the high speeds and loads encountered on US06. Given additional development, manufacturers should be able to fine-tune the calibrations to incrementally lower emissions. In addition, it should be noted that the headroom factor of two used to set the off-cycle emission standards was based upon the average of FTP emissions compared to the standard. Normal variation around this average means that many of the vehicles have FTP emissions somewhat over half the standard level. As this does not create a problem for FTP compliance, similar normal variation above the design target level should also not cause a problem for US06 compliance.

- As discussed in section III.C.3, above, one of the methodologies evaluated was setting US06 NOx standards based upon ratios of US06 engine-out emissions and catalyst conversion efficiency to FTP hot, stabilized levels. The NOx portion of the 0.29 g/mi design target, based upon the NOx emissions in Table III-12 for LDV/LDT1 vehicles, is about 0.25 g/mi. This is exactly the same level that was calculated using the methodology in section III.C.3 with the assumption that the NOx conversion efficiency on US06 was the same as FTP hot, stabilized NOx conversion efficiency. While EPA was not able to quantify the exact relationship between US06 and hot, stabilized FTP NOx conversion efficiency, the analyses conducted by EPA indicate that equivalent NOx conversion efficiency is a plausible mid-range assumption, which is in turn supportive of a 0.29 g/mi US06 NMHC+NOx design target for LDV/LDT1.

- Five of the vehicles tested, 101, 102, 315, 318, and 702, meet the NMHC+NOx design target levels with production calibrations and five others, 202, 205, 307, 324, and 401, are within 15 percent of the NMHC+NOx design target level with production calibrations. Three of these vehicles, 315, 318, and 324, also meet the CO design target levels with production calibrations. The rest of these vehicles should be able to meet both the NMHC+NOx and CO design target levels simply by eliminating part-throttle commanded enrichment.[14] These results indicate that roughly 35 percent of the LDV, LDT1, and LDT2 vehicles should be able meet the US06 design targets simply by eliminating most commanded enrichment. Also, note that three of the vehicles, or about 10 percent of the test fleet, meet the design target levels with current production calibrations.

- Of the nine vehicles with good calibrations that need to reduce commanded enrichment to meet the CO design target level, five had lower NOx emissions with the stoichiometric calibration compared to the production calibration, while only four vehicles increased NOx emissions with the stoichiometric calibration. This indicates that the higher NOx conversion efficiency at stoichiometric, compared to rich conversion efficiency, offsets the engine-out increase in NOx at stoichiometric for vehicles that do not have a lean bias to their stoichiometric calibrations. Thus, eliminating commanded enrichment can reduce both CO and NMHC without increasing tailpipe NOx emissions.

- As discussed later in the air conditioning section, improved EGR systems and better calibration of EGR flow during off-cycle conditions are estimated to reduce NOx emissions during air conditioning operation by about 10 percent most vehicles. Such improvements are not accounted for in the US06 standard, primarily because the Agency is not requiring

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[14] Of the nine vehicles with good calibrations that needed to reduce commanded enrichment to meet the CO design target level, five had lower NOx emissions with the stoichiometric calibration compared to the production calibration, while only four vehicles increased NOx emissions with the stoichiometric calibration. This indicates that the higher NOx conversion efficiency at stoichiometric, compared to rich conversion efficiency, offsets the engine-out increase in NOx at stoichiometric for vehicles that do not have a lean bias to their stoichiometric calibrations. Thus, eliminating commanded enrichment can reduce both CO and NMHC without increasing tailpipe NOx emissions.

any increase in EGR flow at or near WOT.[15] Thus, the emission benefit from the EGR improvements should be substantially lower on US06 than during air conditioning operation. As EPA did not quantify how much lower the emission benefits would be on US06, the impact was not incorporated into the US06 design target. However, this could still have directional reductions in US06 NOx emissions, making it incrementally easier for vehicles to meet the US06 design target.

One of the five LDVs with good calibrations, vehicle 701, and one of the eleven LDT1/LDT2 vehicles, vehicle 204, appear to have a larger problem in meeting the design target level than the other fourteen vehicles. Vehicle 701 would need a 32 percent reduction from its US06 stoichiometric emission results to meet the design target level and vehicle 204 would need a 46 percent reduction (although, as noted previously, the production results on vehicle 204 were much lower; vehicle 204 would only need a 23 percent reduction from the production calibration results to meet the NMHC+NOx design target level). While these are not huge reductions, they may not be achievable simply with better air/fuel control around stoichiometry. This indicates that a small fraction of vehicles may need to improve emission-related hardware to order to meet the design target levels. As only one of five LDVs with good calibration and one of all eleven LDT1/LDT2s appear to have a substantial challenge in meeting the proposed standards, plus more attention to calibration strategy may allow either or both of these vehicles to meet the design target level without improved hardware, EPA believes it is unlikely that more than 10 percent of the fleet will need additional hardware to meet the US06 emission levels being promulgated by this rule. The most likely hardware to be used, due to the relatively small emission decrease needed, would be increased catalyst loading.

Table III-13. Parameters Evaluated for Impact on NOx Emissions

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[15] Note that, as no increases are required in EGR flow at WOT, Ford's comments about the impact of increased EGR flow on WOT performance are moot.

	Variable	Description
Air/fuel summary parameters	Avg A/F	Average of all a/f points between 14.0 and 15.2
	Std. A/F	Std. deviation of all a/f points 14.0-15.2
	A/F frac. 1	Proportion of 14.0-15.2 a/f points to total
	A/F frac. 2	Of 14.0-15.2 a/f points, proportion within 0.2 of mean
	# < 14.0	Number of seconds < 14.0 a/f ratio
	#14.8-15.2	Number of seconds between 14.8-15.2 a/f ratio
	#15.2-16.8	Number of seconds between 15.2-16.8 a/f ratio
	#sec>16.8	Number of seconds > 16.8 a/f ratio
	sum-lean	Exhaust flow weighted sum of fuel/air for a/f>14.6
	sum-all	Exhaust flow weighted sum of fuel/air for all points
Vehicle parameters	Displace	Engine displacement (liters)
	Trans	Transmission (automatic or manual)
	Fuel system1	(1=MPI/0=TBI) Multi-point or throttle-body
	Fuel system2	(1=SFI/0=no) Sequential multi-point fuel injection
	Weight	Inertia Weight class
	Hp	Manufacturers advertised horsepower
	IW/HP	Inertia Weight/horsepower (performance measure)
	N/V	N/V ratio: measure of top gear engine revolutions/mile
	EGR	EGR equipped
	Cat. Volume	Total catalyst volume
	Platinum	Platinum loading (grams)
	Palladium	Palladium loading (grams)
	Rhodium	Rhodium loading (grams)
	Cat. loading	Total catalyst loading (grams)

Other test summaries	Avg. sp. Vel	Average exhaust volume/Total catalyst volume
	Max Sp Vel	Maximum exhaust volume/Total catalyst volume
	Plat/avg exh	Platinum loading/Average exhaust volume
	Pall/avg exh	Palladium loading/Average exhaust volume
	Rhod/avg exh	Rhodium loading/Average exhaust volume

IV. **Intermediate Soak**

Summary of Proposal

The Agency proposed to control tailpipe emissions following soaks of intermediate duration (between 10 minutes and 3 hours) by requiring that emissions on the SC01 cycle following a 60 minute soak not be greater than emissions over Bag 3 of the FTP. The purpose of the requirement was to mitigate significant emission increases following soaks of intermediate duration relative to the 10 minute hot soak seen during testing of Tier 1 vehicles. The Agency stated that the intermediate soak standard would be appropriate if a significant percentage of vehicles is certified to Tier 1 standards for a significant time following implementation of the SFTP. The Agency noted that an intermediate soak requirement may be less appropriate for vehicles certified to lower emission standards Under the assumption that at a minimum Tier 2 standards would be in place by 2004-2006, and that it was likely that a National LEV program would be in place before then, the Agency stated that the decision to finalize the intermediate soak requirement would be contingent on the cost effectiveness and feasibility of the requirement for vehicles complying with LEV and lower standards. The Agency surmised that increased thermal insulation around the catalytic substrate(s) would be used to meet this requirement.

Summary of Comments

All comments received from the auto manufacturers objected to the intermediate soak requirement, citing that the cost of such a requirement would not justify the benefits to be gained. This argument was centered on four major points, elaborated in most detail in the AAMA/AIAM submission: 1) the emission benefit from controlling intermediate soak emissions will be significantly reduced as more advanced cold start technologies are implemented to comply with lower emission standards, 2) the cost of implementing EPA's primary control strategy, catalyst insulation, would be prohibitive from an exhaust system packaging standpoint, 3) the use of catalyst insulation would increase the thermal severity of the catalyst environment, bringing greater risk of catalyst deterioration over the life of the vehicle, and 4) the test facility implications of adding an intermediate soak procedure would be significant. Based on these objections, AIAM/AAMA recommended that the intermediate soak requirement be dropped from the rulemaking.

GM, Honda and Land Rover submitted additional comments which essentially echoed the objections to the proposal from the joint AAMA/AIAM submission. GM argued that the exhaust system and vehicle chassis costs which would result from catalyst insulation would be prohibitive, and provided a supporting cost estimate. Honda stated that quick light-off technology used on LEV's and ULEV's will render the intermediate soak requirement redundant as these vehicles enter the in-use fleet, and provided test data from a prototype ULEV following a 60 minute soak showing emission levels to be equivalent or lower than emissions after a 10 minute soak on a Tier 1 vehicle. Land Rover's comments centered on the primary issues of catalyst temperature, repackaging costs and reduced benefit from the requirement with the advent of LEV/ULEV technology.

Comments which supported the inclusion of the intermediate soak requirement to make the FTP more representative of in-use driving where submitted by the Northeast States for Coordinated Air Use Management (NESCAUM), the National Renewable Energy Laboratory (NREL), and the Manufacturers of Emission Controls Association (MECA). NESCAUM and MECA support the intermediate soak requirement in the context of making the test procedure representative of in-use driving per the intent of the Clean Air Act Amendments of 1990. NESCAUM advocated the use of the air conditioning system during the intermediate soak test procedure to control synergistic effects of the two conditions and that the test procedure should place greater emphasis on short trips as observed in the driving survey data. NREL recommended that the intermediate soak period be extended to at least 2 hours to provide an improved representation of in-use soak periods from the Baltimore survey data set, with a waiver of the procedure when "available thermal-management hardware clearly obviates the need by demonstrating the capability to maintain temperature”.[16]

Comments supplied by NREL and MECA also provided information on technology under development which would mitigate intermediate soak emissions. MECA stated that several technologies have been developed recently which could be used to control intermediate soak emissions, including electrically heated catalysts, low thermal inertia substrates, double-walled exhaust components and hydrocarbon traps. NREL's comments in this area focussed on their work with variable conductance insulation (VCI), an emerging technology which allows heat to be retained in the catalyst for soak periods up to 30 hours, and is able to reject heat during vehicle operation at a rate comparable to a typical uninsulated catalyst to avoid thermal overload. MECA's comments acknowledged this technology in their comments, stating that "in some cases, insulating techniques can maintain catalyst bed temperatures for long periods of time while allowing for heat rejection at a rate approaching that of a conventional catalytic converter if required, thereby allaying the possibility of a catalytic converter being exposed to over-temperature events."

The California Air Resources Board (CARB) commented that based on testing of LEV vehicles, there appears to be potentially significant emissions impact of extended soak time. However, CARB was concerned about long-term durability impacts of catalyst insulation on LEV vehicles. CARB believes that further investigation is necessary regarding the cost and benefits of intermediate soak requirements; thus, CARB indicated it may "opt-out" of intermediate soak requirements for LEV vehicles.

Response to Comments

Controlling intermediate soak emissions would require hardware changes to keep the catalyst warm longer or to heat it up faster. Possible techniques include catalyst insulation and catalyst preheaters, but any technique will likely result in significant redesign and retooling investments. For example, the

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[16] NREL comments are available from public docket No.A-92-64 for review.

most inexpensive technique, as discussed in the NPRM, is likely to be catalyst insulation. Even this option would require redesign of the catalyst can, possibly including new can material, and development of a thicker, insulated, catalyst mounting material. The overall size of the catalyst would increase due to the insulating material, possibly to the point at which it would not fit into current space, which would require redesign of the vehicle floorpan. Finally, the catalyst insulation would increase internal catalyst temperatures, potentially leading to higher catalyst deterioration.

In the analysis conducted by EPA in support of the NPRM, all of the redesign problems were considered manageable and cost effective for Tier 1 vehicles, provided that the high up-front redesign and tooling costs could be amortized over at least five years of production. This differs from US06 and air conditioning control, which can be predominantly accomplished without hardware changes and high retooling costs. Because of the hardware investment to meet intermediate soak requirements and the high potential for intermediate soak requirements to be in effect on Tier 1 vehicles for only a couple years before being replaced by NLEV or Tier 2 requirements, it would likely be a waste of manufacturers' resources to establish intermediate soak requirements only for Tier 1 vehicles. Thus, one of EPA's criteria in promulgating intermediate soak requirements was whether or not they would continue to be cost effective and feasible for LEV-like vehicles.

Unfortunately, the cost effectiveness and feasibility of intermediate soak requirements on Tier 2 or NLEV vehicles is much less certain. While catalyst temperature data indicate that the increased catalyst temperature caused by catalyst insulation is not likely to be a problem for Tier 1 vehicles, Tier 2 or NLEV vehicles are likely to move catalysts closer to the engine, increasing the temperature concerns with catalyst insulation. EPA does not have sufficient information on the impact of catalyst insulation on the durability of Tier 2 or NLEV catalysts, including their higher baseline temperatures and improved catalyst formulations, to quantify the extent of this concern.

Moving the catalysts closer to the engine will also reduce catalyst light-off time, potentially reducing intermediate soak emissions even without intermediate soak standards. To perform this evaluation, the Agency analyzed soak data on prototype LEV vehicles supplied by ARB and three manufacturers (see Appendix IV). These data showed that the benefit from controlling intermediate soak emissions per the NPRM proposal on LEV vehicles would be about 60 percent of that on Tier 1 vehicles, or about 0.04 g/mi NMHC+NOx. Under the Agency's "best-case" cost scenario, this level of benefit would result in a NMHC+NOx cost/ton of approximately $3100. Taking into account some uncertainties about the need to revise floorpans on some vehicles, possible reduced benefit of insulation, and possibly requiring insulation on multiple catalysts, the upper bound estimate is approximately $13,000 per ton NMHC+NOx reduced. Per NESCAUM's comment concerning the synergistic impacts of air conditioning and soaks, these estimates include an estimate of the NOx increase resulting from AC operation over soaks based on data from a LEV prototype vehicle.

Although the analysis of the LEV soak data indicates that there would continue to be some emissions benefits from controlling soak emissions, these data also indicate that intermediate soak emissions are being reduced as a result of the technology to be used for complying with Tier II or LEV standards which target cold start emission reductions. On the control side, there are still many uncertainties concerning the cost of control and the feasibility of the proposed technology which have not been resolved. The control technologies which are mentioned in both the MECA and NREL comments would be effective in reducing intermediate soak emissions, but all of the technologies which would provide comparable or superior performance to conventional catalyst insulation would likely be more costly if the cost is assigned solely to the control of intermediate soak emissions. Some of the technologies mentioned in the MECA comments will already be in place to comply with LEV and ULEV standards, regardless of whether an intermediate soak procedure is in place.

In response to comments from NESCAUM, MECA and NREL supporting the inclusion of an intermediate soak period for the purpose of in-use representivity, the Agency believes that adding a 1 to 2 hour procedure would add little value to the FTP for the purpose of controlling in-use emissions. Although the spectrum of in-use soak times included in the FTP would be broadened, the in-use benefit, as discussed above, would be small relative to the impact of changing the procedure.

As a result of the reduced benefit and uncertainties regarding cost and feasibility of control, the Agency has decided not to finalize the intermediate soak requirement at this time. However, because this action is based on emission levels from a small sample of prototype vehicles as well as current technological restrictions, the Agency is not ruling out the possibility of promulgating this requirement at a later time. Intermediate soak emissions will continue to contribute somewhat to the in-use inventory even as LEV and ULEV technologies penetrate the in-use fleet. The Agency will monitor the performance of production LEV and ULEV vehicles over intermediate soaks to verify the conclusions from the prototype analysis. At the same time, the Agency will encourage the development of technologies which will allow for the control of intermediate soak emissions in a manner which is cost effective and not detrimental to the emission control system. The Agency may decide to go forward with an intermediate soak requirement at a later point if the potential for benefit continues to exists on vehicles certified to lower emission standards, and the uncertainties surrounding cost effective control are resolved.

V. **Air Conditioning**

A. Air Conditioning Test Cycle

Summary of Proposal

The proposed SFTP included three single-bag emission test cycles: a hot stabilized 866 Cycle; a new Start Control Cycle (SC01) simulating driving proceeded by a preconditioning cycle and a soak period; and a new Aggressive Driving Cycle (US06) run in the hot stabilized condition. Air conditioning simulation was proposed to be performed during the hot stabilized 866 cycle and the start control cycle (SC01).

Comments were specifically solicited on the possibility of substituting the 505 component of the LA4 (the LA4 consists of a 505 cycle followed by an 866 cycle) for SC01 and on whether full air conditioning simulation should be added to the US06 cycle. The Agency also stated that it believes it may be appropriate to return to the issue of cold start testing with air conditioning operation with respect to future technologies and future test procedures and emission standards; comments were also solicited on this issue.

Summary of Comments

NESCAUM, MECA, and CARB all supported the need to account for air conditioning load over the cycles proposed in the NPRM (866+SC01). NESCAUM and CARB also supported testing with actual air conditioning load over cold start conditions (bag 1 of the FTP). NESCAUM stated that EPA should assume that air conditioning use occurs in all summertime driving conditions, including air conditioning use during the cold start cycle. MECA and CARB stated that air conditioning load should also be accounted for during aggressive diving (US06). CARB suggested that EPA consider a "demonstration" requirement with specified emission levels over the US06 when air conditioning is used to ensure that the effect of air conditioning usage is minimized over this cycle.

AAMA/AIAM stated that EPA has not demonstrated the feasibility of its proposed standards for operation over SC01. The comments were especially critical of EPA's conclusion that the difference in emissions between SC01 and the 505 were due to microtransient emission response, which could be controlled with sequential multi-point fuel injection and better calibrations. AAMA/AIAM stated that the data did not justify using SC01 and recommended that the air conditioning test procedure consist of the hot LA4 without a soak. AAMA/AIAM also stated that cold start emissions related to air conditioning operation are already addressed through the FTP and can only be improved by increasing the overall stringency of the current Tier 1 standards.

Suzuki stated that SC01 is too aggressive in general and too severe for small engines. They recommended that EPA consider a unique schedule or cycle adjustment for small engines, due to the disproportional load air conditioning places on small engines.

Response to Comments

As discussed in the NPRM, the EPA recognized that the proposed SC01 cycle needed revisions to better reflect the in-use speed/acceleration distribution; the revised cycle is known as SC03. The final A/C test requirement will consist of a 10 minute soak and the SC03 cycle. Except for the revisions to SC01, EPA did not find the arguments presented by the commenters sufficient to make additional modifications. The 866 cycle was dropped because it was determined to be less representative of in use air conditioning operation.

As discussed in the support documents for the NPRM, EPA is concerned about emissions from microtransient driving behavior. There are many vehicles whose emissions are sensitive to driving behavior and the in-use driving survey data indicate that small speed variations occur about 50 percent more frequently in use than on the LA-4 driving cycle. Thus, to ensure that the test procedure properly reflects actual driving behavior and emissions, as required by Congress in the 1990 CAAA, EPA believes it is critical for the test procedures to include representative microtransient driving. Comments received from NESCAUM, NRDC, and CARB were supportive of this position. On the other hand, there is some merit to AAMA/AIAM's arguments that factors other than microtransients likely impact the difference in emissions seen on the SC01 versus the 505 driving cycles. This is likely to be especially true for NOx emissions, which are sensitive to the average acceleration load per mile (a good measure of the average acceleration load per mile is Positive Kinetic Energy (PKE)). Thus, while EPA believes it is critical to include a more representative cycle in the SFTP, the final rule does not require emissions over the new cycle to meet the same level of emissions as over the 505. Instead, the standards have been adjusted for the difference in emissions between the new cycle and the 505. While this lessens the stringency of the standard somewhat from that proposed in the NPRM, EPA considers this a worthwhile tradeoff for the inclusion of the more representative cycle, which will ensure that there is no in-use emission increase compared to the certified emission levels.

As indicated in the NPRM, an error was made in the generation of the SC01 cycle. Proper matching of the in-use driving distribution yielded a revised cycle, called SC03. The first 270 seconds of SC03 incorporates the same start cycle developed from the driving survey data that was used for the start of SC01. The rest of the cycle was developed such that the overall speed/acceleration distribution of SC03 matched the remnant speed/acceleration distribution as closely as possible. Overall, SC03 has a PKE value about halfway between the PKE values of the 505 and the SC01 cycle. Increased manufacturer acceptance of the cycle was demonstrated by the fact that the manufacturers incorporated the cycle into the third phase of air conditioning testing. EPA calculated the likely difference in emissions between the 505 and SC03 cycles by multiplying the difference in emissions between the 505 and the SC01 cycles by the ratio of the differences between the PKE values of SC03 and the 505 to SC01 and the 505 (i.e., the difference in emissions between SC03 and the 505 was calculated to be 48 percent of the difference in emissions observed between SC01 and the 505).

The adjustments made in SC03 address Suzuki's comment that the SC01 was too aggressive in general. However, EPA disagrees with Suzuki's other comments that the SC01 is too severe for small engines and that EPA should consider a unique schedule or cycle adjustment for small engines, due to the disproportional load air conditioning places on small engines. While it is true that air conditioning places a disproportional load on small engines, this is merely a reflection of what actually occurs in use. In addition, while the increase in the overall load due to air conditioning is larger on small engines, the total mass flow through a small engine is still lower than occurs with larger engines and heavier vehicles. Thus, small engines should be able to comply with the standards.

The 866 cycle was dropped from the final rule because inclusion of the 866 cycle would greatly over-represent low speed, low acceleration driving. Emission reductions achieved on the 866 with air conditioning operation may not result in equivalent in-use emission reductions. As the SC03 cycle was specifically developed to match the speed and acceleration distribution of in-use driving, less the high speed and acceleration driving represented by US06, the SC03 offers far more assurance that emission reductions on the cycle will proportionally reduce in-use emissions. While this issue was not specifically addressed by NESCAUM or MECA, the Agency believes that dropping the 866 cycle complies with the spirit of their comments to make the air conditioning test cycle representative of actual vehicle operation.

While EPA agrees in principal with comments from MECA and CARB that air conditioning load should be included in aggressive driving (US06), EPA believes that, in practical terms, adding air conditioning load to the US06 cycle would be largely meaningless. The US06 cycle already pushes virtually all vehicles into WOT; inclusion of air conditioning load would simply expand the amount of time spent at WOT and increase the overall engine-out NOx emissions proportionally to the extra load. This increase would wind up being incorporated into higher emission levels, without any real impact on the control of emissions during air conditioning operation. In addition, data from the first phase of air conditioning testing demonstrates that the emission impact of air conditioning operation diminishes at higher speeds. Finally, adding an air conditioning requirement to the US06 would require additional facilities to be built to accommodate the added testing demands, plus the additional facilities would be more expensive in order to accommodate the 80 mph speeds on US06 (current environmental chambers can only generate representative wind flow up to about 70 mph). Given the testing resources and facilities impact of testing air conditioning operation over the US06 cycle and the dubious emission benefits, EPA believes that such a requirement is not necessary or cost effective.

EPA also agrees in principal with comments from NESCAUM and CARB that air conditioning operation during cold starts should be accounted for. However, as discussed in the support document for the NPRM, the air conditioning impact is an issue of increased engine-out emissions. The primary way to address emission increases on the cold start would be to bring the catalyst to a hot functional condition faster than current technology vehicles are able to. Given the Agency's general goal with these revisions to the FTP of achieving the same level of control in the new control areas that is achieved on the FTP under the currently applicable standards, the Agency believes that the technology-forcing aspect of requiring control of air conditioning related emissions on a cold start test is inappropriate at this time because of the lead time requirements to implement the new catalyst technology. Consequently, a cold start test is not included in the final rule for air conditioning related controls. The Agency believes it is appropriate to return to this issue as part of the Tier 2 standards, when the air conditioning impact can be assessed as part of the standard-setting process.

B. Air Conditioning Simulation

Summary of Proposal

As an alternative to using a full environmental chamber for air conditioning testing, the NPRM proposed a simulation procedure that could be conducted in a standard test cell at 95° F. The proposed simulation included a 95° F ± 5° F test cell ambient temperature, A/C set to "maximum A/C" with interior air recirculation, high interior fan setting, coldest setting on the temperature slide, driver's window down, and front-end supplemental fan cooling. Testing in a full environmental chamber was proposed to also be permitted, at the manufacturers option.

Comments were also requested on two other simulations, bench testing and a dynamometer simulation approach proposed by the vehicle manufacturers, dubbed "Nissan-II."

Summary of Comments

NESCAUM stated that EPA should rely on the actual operation of the air conditioner with an environmental simulation. They also expressly requested that EPA not lower the maximum ambient temperature. Horiba also opposed using the dynamometer to simulate the air conditioning load, stating that it would affect the driveability of the vehicle on the dynamometer differently from how the vehicle drives on the highway. Horiba suggested that the air conditioning be turned on for the test, with the windows open and an auxiliary heat source if necessary.

CARB advocated the use of full environmental chambers for air conditioning testing. In support of this position, CARB submitted an analysis of the incremental cost of full environmental chambers which concluded that they would cost less than $3 per vehicle. CARB requested that EPA do a cost effectiveness analysis of using full environmental chambers. CARB was willing to consider options for "short-cut procedure if sufficient correlation with environmental chamber data can be demonstrated."

AAMA/AIAM stated that EPA's proposed simulation is not acceptable. They were particularly critical that EPA's proposal did not provide adequate cooling at the front of the vehicle and that the "windows down" aspect of EPA's recommended approach did not represent real world driving conditions. AAMA/AIAM also stated that correlation of the proposed simulation with the full environmental chamber results was poor and that EPA's analysis of the correlation was misleading because the EPA simulation used a different Astro Van than the full environmental testing and EPA focused on the absolute emissions difference, not the percent difference.

In addition, AAMA/AIAM stated that, in order to perform the EPA test, facilities must be capable of handling the increased cell temperature, humidity, and increased air flow, which would be very costly.

Honda stated that a full environmental chamber would not be cost effective, considering the cost of the technology needed to comply with the air conditioning requirement. They strongly recommended that EPA not only address air conditioning simulation technology, but also consider facility cost and feasibility so that all manufacturers can conduct SFTP tests without an additional heavy burden.

Response to Comments

Based on EPA's experience and data provided by AAMA/AIAM, the EPA has concluded that while simulations are not yet ready to take the place of the full environmental chamber, there is a strong probability that further development could yield an effective air conditioning simulation. Thus, the EPA will require the use of full environmental chambers, with an option, as suggested by CARB, for a "short-cut procedure if sufficient correlation with environmental chamber data can be demonstrated."

One of the goals in creating off-cycle emission controls is to come up with a common set of test procedures between EPA and CARB. As both CARB and the vehicle manufacturers did not support the air conditioning simulation proposed in the NPRM, much work has been done since the publication of the NPRM on development of other air conditioning simulations.

The test data used in the analyses in the NPRM came from a test program which is named ACR1. The “AC” refers to the fact it is an air conditioning test program, the “R” refers to the site of the testing (Rochester, NY) and the “1” to the first test program. Subsequent to the NPRM a second round of testing called ACR2 was run which, in later analysis, was found to be run at a higher humidity level than desired and consequently is not used in any analyses in this rule. Finally a third round of testing was run at two testing facilities; the Rochester, NY data set is called ACR3 and the Chrysler data set is called ACC3.

The manufacturers' ACR3 program included evaluation of two air conditioning simulations. One was proposed by EPA and used sun lamps to provide additional heat load in an otherwise standard test cell at 75° F. The second, developed by Toyota, turned on the heater at its highest temperature setting simultaneously with the air conditioner to provide the heat load. The ACC3 program was run at Chrysler, in part, to evaluate improvements to the "Nissan-II" approach discussed in the NPRM.

Figure V-1 compares the results of the EPA and Toyota simulation approaches to the full environmental chamber results (A/C on) for the ACR3 data. The air conditioning off results are also shown for comparative purposes. Except for vehicle 210, the EPA procedure consistently under predicted actual air conditioning emissions. The Toyota procedure produced the same average emissions over all six vehicles as the full environmental chamber, but the correlation was highly variable from vehicle to vehicle. Only vehicle 203 actually correlated well; the Toyota procedure substantially understated emissions on four of the other five vehicles, offset by a very large increase in emissions on vehicle 208.

Figure V-2 compares the results of the improved Nissan-II approach to the full environmental chamber for the ACC3 data. The Nissan II approach closely matched the full environmental chamber results on two vehicles, 208 and 801, while understating emissions on vehicle 201 and overstating emissions on vehicle 205 by a roughly equal amount.

It is obvious that none of the simulations, at this time, have demonstrated sufficient correlation with full environmental chambers to be used as a permanent substitute for full environmental chambers. On the other hand, development of simulations is still in the early stages. Both the EPA and Toyota simulations used in the ACR3 program were pilot programs for simulations that had never been tried before. By contrast, the Nissan-II simulation used in the ACC3 program was the second incremental improvement to a dynamometer simulation approach and the results correlated much better with the full environmental chamber than the earlier two dynamometer simulations. The conclusion reached by EPA is that, while simulations are not yet ready to take the place of the full environmental chamber, there is a strong probability that further development could yield an effective air conditioning simulation.

At the same time, as per CARB's request, EPA has spent considerable effort evaluating the cost of using full environmental chambers, as well as the incremental savings associated with an air conditioning simulation. EPA has reached two conclusions based upon these evaluations. First, while using full environmental chambers for all air conditioning testing would cost a little more than estimated by CARB, $3.05 per vehicle, the cost is still low enough to support CARB's conclusion that air conditioning control using full environmental chambers is cost effective. Second, while simulations are not necessary for cost effective control of air conditioning emissions, a workable simulation would allow a cost reduction of about $3 per vehicle.

The long range solution reached by EPA is to mandate the use of full environmental chambers, with an option, as suggested by CARB, for a "short-cut procedure if sufficient correlation with environmental chamber data can be demonstrated." In order to avoid prematurely selecting a simulation, no express simulation procedure is proposed for use in the long run. To encourage proper development and use of simulations, "quality check" criteria have been developed in cooperation with CARB and incorporated into the final regulations.

Manufacturers who choose to use an air conditioning simulation beginning with the 2003 model year must submit a description of the simulation procedure, data supporting the correlation between the simulation and the full environmental chamber, and any vehicle-specific parameters to EPA in advance. In general, EPA will conditionally approve any procedure, provided that the procedure can be run by EPA for SEA and in-use enforcement testing and available data, including past correlation testing, does not indicate a correlation problem. EPA may require the manufacturer to demonstrate emission correlation between the simulation and the full environmental chamber on up to five vehicles per model year (one for small volume manufacturers) of EPA's choice. The vehicles will be selected by EPA and two additional vehicles may be selected by EPA to demonstrate emission correlation for every vehicle that fails the correlation criteria. The allowance of five vehicles per manufacturer is intended to allow EPA to target untested simulation procedures or manufacturers who have previously had problems correlating. For manufacturers with established correlation procedures with a history of good correlation, EPA expects to select only two vehicles per year to demonstrate emission correlation.

The demonstration consists of verifying the NOx and fuel economy correlation between the simulation and the full environmental chamber. The correlation targets NOx because it is the primarily problem with air conditioning operation. Fuel economy is also used because it is a good surrogate for the additional load placed on the engine by the air conditioning system (fuel economy is directly impacted by the total load on the engine). To account for variability in test results from vehicle to vehicle and test to test, the simulation tailpipe NOx emissions must be at least 85 percent of the full environmental chamber and the fuel consumed at least 95 percent. Retests and reapplication of these thresholds are also allowed (see § 86.163-00 of the final regulations for a complete description of these requirements). The combination of an 85 percent NOx criteria and the retests were devised to minimize the impacts of variability on the effectiveness of the correlation program. NOx emission variability is quite large; for a single test, the chance of an accurate air conditioning simulation failing the 85 percent criteria simply due to variability is over 20 percent. The retests reduce the chance of improperly failing a good simulation to only about 1.5 percent. Even if a vehicle fails the entire sequence, manufacturers are allowed an opportunity to present data on other vehicles to demonstrate that the simulation is appropriate and the failure was only a statistical fluke.

If an engine/vehicle fails to pass the criteria, including the retests, the manufacturer must remedy the air conditioning load imposed during the simulation or use full environmental chambers for future testing. Data must also be supplied establishing how many other engine/vehicle combinations are similar to the failing configuration. While there is no immediate consequence beyond determining the proper load, any future data generated on these engine/vehicle combinations, including in-use enforcement testing, must use the corrected procedure. If any vehicle fails to meet the tailpipe emission standards due to a corrected air conditioning load, all applicable vehicles are subject to an emissions recall; however, there would be no recall liability associated with the air conditioning load correction itself. For every engine/vehicle combination which fails this demonstration, EPA may require the manufacturer to verify the correlation between the simulation and the full environmental chamber for an additional two vehicles of EPA's choice.

The results from each manufacturers' correlation demonstrations will also be tracked over time. The manufacturer is expected to target the simulation to at least 100 percent of the emissions from the full environmental chamber. If, over time, the emissions from the simulations are found to be statistically lower than the full environmental chamber, further use of simulations by that manufacturer will not be allowed until the causes of the offset are identified and corrected.

While these acceptance and verification procedures should encourage development of accurate air conditioning simulations in the long run, applying them immediately would create a leadtime problem. No simulations have been developed yet that can meet the criteria and building full environmental chambers is time-consuming and expensive. Thus, it is not practical to impose these requirements in the short run. In addition, full environmental cells take at least two years to build and once they are built there is no further need for a simulation test.

The Agency is faced with three options: (1) delay the implementation of the air conditioning standard until a new simulation is developed which meets our acceptance criteria and can meet our verification procedures; (2) delay the implementation of the rule until full environmental chambers can be built and forever reduce the cost-effectiveness of this rule by the added cost of the full environmental cells or (3) implement the air conditioning standards earlier using a less robust simulation for several years but defaulting back to option 1 or 2 after the first three years of phase-in have passed. While use of a less robust simulation procedure for the first three years of the program without verification may result in some degradation in emission benefits during this period, this is far preferable, from an air quality point of view, to delaying all air conditioning requirements for an additional two years to allow for construction of full environmental chambers. It also provides additional time for an air conditioning simulation to be developed, which could save manufacturers over $40 million dollars per year.

The choice of the simulation procedure to use for this interim period focused on the revised Nissan-II simulation and the Toyota simulation. EPA has some concerns about the ability of the revised Nissan-II procedure used in the ACR3 and ACC3 test programs to properly reflect air conditioning load at idle and deceleration, as well as the fact that the air conditioning unit is not actually operating during the simulation. Nevertheless, EPA prefers this procedure due to the more advanced development of the simulation, the better correlation with the full environmental simulation in the latest round of testing, and the flexibility of the procedure to adjust loads for different vehicles and air conditioning systems. Although the Toyota simulation has correlated well on several test vehicles, the correlation appears to be more variable than the Nissan-II simulation and EPA is concerned that this procedure relies too heavily on the amount of heat ducted to the passenger compartment and, thus, may not work satisfactorily for some vehicle/engine designs.

Because both simulation procedures have strengths and weaknesses, EPA is allowing the use of both the revised Nissan-II approach used in the ACC3 testing program and the Toyota simulation used in the ACR3 testing program, without demonstrating that the procedure meets the acceptance criteria and without imposing the spot check verification for the first three years of the phase-in period. Following the first three years of the phase in period, a simulation procedure must meet the acceptance criteria discussed above and be subject to the spot check verification test program discussed above. Testing in a full environmental chamber will be acceptable at any time during or after the phase in period.

While the short term procedure does not comply with Horiba's and NESCAUM's request to use actual air conditioning operation, the long term requirement for any simulation to correlate with actual air conditioning operation in a full environmental chamber should satisfy their concerns. The requirement to correlate with a full environmental chamber also addresses Horiba's opposition to using the dynamometer to simulate the air conditioning load due to the driveability of the vehicle being impacted differently on the dynamometer compared to the highway, as a procedure could not pass the correlation criteria if this effect occurs.

C. Standards

Summary of Proposal

The NPRM proposed that vehicles maintain existing NMHC and CO emission levels with the air conditioning turned on. The Agency stated that 25 percent of the NOx increase with the air conditioning engaged was likely to be unavoidable without increasing the stringency of the current NOx standard, but proposed controlling the other 75 percent. In the composite standard proposed by EPA, the allowable NOx emission increase of 25 percent with the air conditioning engaged was calculated to be equivalent to an adjustment factor of 1.15 applied to the FTP NOx standard.

The NPRM specifically requested comments on the feasibility of the proposed levels of control and the technology implications of controlling emissions to this level.

Summary of Comments

The Agency received a number of comments regarding the proposed emission standards. NRDC characterized the EPA methodology as a relaxation of the NOx standard by 15 percent, and opposed such a relaxation on the basis that any revisions to the standards should be accompanied by a reduction in emissions. CARB commented that the proposed standards were acceptable, but noted that EPA has no data from vehicles optimized for controlling emissions with the A/C operating.

AAMA/AIAM provided detailed comment on the proposed emission standards. They suggested that the proposed standards were not based on the available test data or on "sound engineering analysis." They also commented that EPA performed no technical feasibility analysis for the A/C NOx standard. The analysis presented by AAMA/AIAM indicated that 74 percent of the A/C NOx increase was due to increased engine-out emissions, which, they argued, is an inherent function of the additional load placed on the engine by the A/C system due to three factors: (1) the increase in fuel consumption the accompanies A/C usage; (2) increased combustion temperatures caused by higher engine loads with the A/C operating; and (3) the necessary limitation of EGR rates at these higher loads due to available manifold vacuum, detonation limits, and fuel consumption effects. AAMA/AIAM did acknowledge that it may be possible to eliminate most of the loss in NOx conversion efficiency which occurred with the A/C operating. Thus, in their estimation, A/C-related emissions could be reduced by a maximum of 26 percent. AAMA/AIAM suggested that the feasibility of the proposed NOx standards was not supported by any test data.

AAMA/AIAM also argued that EPA's approach of turning the A/C compressor off for brief periods of time at high loads actually produced very little in the way of emission reductions, because the EPA analysis did not add back in any additional compressor operation during other parts of the cycle to make up the cooling lost by turning it off. They also believe that EPA did not consider the impacts of such additional cycling on A/C compressor durability or efficiency.

AAMA/AIAM further argued that EPA did not adequately explain the CO increase that was observed with the A/C operating, and that EPA's attribution of the CO increase to commanded enrichment was not supported by the analyses. They also commented that EPA ignored NMHC and CO levels when assessing NOx conversion efficiencies and did not examine differences in vehicle systems to attempt to determine why some did better than others. The also commented that there seemed to be a policy inconsistency between the new standards for controlling NOx due to A/C operation were being proposed by the EPA and EPA's granting of NOx waivers.

AAMA/AIAM concluded their comments by suggesting that EPA should delay implementing A/C standards until: (1) EPA develops a "technically sound and consistent policy on the relationship between NOx and ozone"; (2) EPA designs a an inexpensive test procedure which realistically exercises the A/C system; and (3) EPA gains a consensus understanding of the causes of high A/C-related NOx and its control.

Response to Comments

The agency recognizes the validity of several of the technical criticisms made by AAMA/AIAM in their comments. To address these concerns, the EPA reevaluated the standard setting methodology and the Agency will incorporate revised air-conditioning requirements into a composite standard. The intermediate useful life design target for LDVs and LDT1s would correspond to a stand-alone air conditioning standard of 0.67 g/mile for NMHC+NOx and 3.0 g/mile for CO.

There is some validity to AAMA/AIAM's criticisms that EPA did not adequately explain the CO increases with the air conditioning on, ignored NMHC and CO levels when assessing NOx emissions, did not add back in additional compressor operation to compensate for turning off the compressor at high load points, and did not adequately assess the feasibility of reducing engine-out NOx emissions. In addition, subsequent to the publication of the NPRM, EPA learned that the vehicles used in the NPRM to set standards were tested with low mileage catalysts. As EPA's intent is to set intermediate and full useful life standards, it is important for data to be generated with aged catalysts.

Consequently, EPA and the manufacturers agreed to conduct a new test program for standard setting purposes, using vehicles with aged catalysts and including the SC03 cycle to more properly represent the desired standard setting conditions. The original test data used in the NPRM is referred to as ACR1 (the "AC" stands for air conditioning, the "R" for the test site, Rochester, NY, and the "1" for the first phase of testing). The next set of data is referred to as ACR2. Unfortunately, post-processing of these data indicated that the testing was done at humidity levels considerably higher than intended. As the humidity level has a substantial impact on the load placed on the air conditioning system, the manufacturers retested most of the vehicles with better control and monitoring of humidity levels. Included in this program were two new air conditioning simulations. This data set is referred to as ACR3. Most of these vehicles were retested at the Chrysler environmental chamber, including a third air conditioning simulation. This data set is referred to as ACC3 (where the second "C" is for Chrysler).

One of the two initial goals in conducting these test programs was to set air conditioning standards based upon the tailpipe emission results (the other goal, as discussed in the last section, was to evaluate air conditioning simulations). Unfortunately, examination of the available data indicates that directly setting tailpipe standards has some significant problems:

- The ACR1 data had low-mileage catalysts, rendering the data useless for directly setting useful life tailpipe standards. In addition, the humidity levels for this test program are uncertain.

- The humidity levels for the ACR2 program were not appropriate. As all but one of the vehicles were retested as part of ACR3, this data set was not used for any analysis.

- The ACR3 program tested five Ford vehicles, one Chrysler, and one Toyota. The Chrysler was a Tier 0 vehicle, rendering it useless for setting Tier 1 emission standards.

- Two of the remaining six Tier 1 vehicles were LDT2s, which must be analyzed separately due to the different FTP standards for these vehicles.

- Of the four Tier 1 LDVs, two have suspect emissions. The Ford Escort was identified in the US06 analysis as a "lean-bias" vehicle. The very high NOx emissions exhibited by the Escort in the air conditioning test program confirm that this vehicle is not representative of a vehicle with good air conditioning calibrations. For example, the NMHC+NOx results for the Ford Bronco over SC03 with the air conditioning on (0.47 g/mile) were lower than for the Escort (0.55 g/mile) and the Ford Windstar was only slightly higher (0.62 g/mile). As the Bronco and the Windstar were both LDT2 vehicles with a 57 percent higher FTP NMHC+NOx standard than the Escort; this supports the conclusion from the US06 analysis that the Escort is not representative of proper air conditioning calibrations. The second vehicle, the Toyota Corolla, had extremely erratic emissions. Emission differences of over 50 percent for repeat tests were common on this vehicle, which is also not considered to be representative of proper calibration strategies.

There appears to be a correlation problem on NMHC emissions. The four Ford vehicles in the ACR3/ACC3 test program were also tested in the US06 phase II test program. The average NMHC emissions for these four vehicles in the US06 phase II test program were higher than the average of the entire 22 vehicle LDV/LDT1 data set. In addition, the average NMHC emissions for these four vehicles on the 866 cycle in the ACR3/ACC3 test programs were significantly higher than the average NMHC emissions from the same vehicles in the US06 phase II test program. As a result of these two offsets, the average NMHC emissions in the ACC3/ACR3 testing programs appear to be about twice the average results from the entire 22 vehicle data set in the US06 phase II test program.

The net result of the various problems with the data mean that an LDV/LDT1 standard set directly on the emission results would be based upon just two vehicles from the same manufacturer, Ford, with suspect NMHC correlation, or upon four vehicles including three from Ford and two with suspect emissions.

Neither option was considered to be feasible by the Agency.

Fortunately, one of the standard setting methods investigated, but not used, for US06 standards is much more feasible for setting air conditioning standards. EPA investigated setting US06 standards based upon hot, stabilized FTP emission levels adjusted for the engine-out increase in emissions over US06 and changes in catalyst conversion efficiency. This approach was rejected for US06 because of the large uncertainty in how NOx conversion efficiency on US06 correlated to hot, stabilized FTP driving. The average load on the US06 cycle is over twice the average load on hot, stabilized FTP driving and extremely high loads occur during hard accelerations on US06 that do not exist at all on the FTP. Because of these load differences, EPA was unable to quantify the relative impacts of low, moderate, and high loads on NOx conversion efficiency for the US06 cycle compared to hot, stabilized FTP driving. However, in the case of air conditioning, the impact of load on NOx conversion efficiency is not a substantial issue. This is because air conditioning increases the average load by only about 25 percent. In addition, because the air conditioning load is relatively constant over the range of driving conditions, the proportion of the total load contributed by the air conditioner decreases as the load increases. Because the increased load imposed on the engine by the air conditioner is much smaller than the additional load imposed by the US06 driving cycle and the total load does not deviate greatly from the range of loads encountered on the FTP, it is reasonable to assume that catalyst conversion efficiency should not be significantly impacted by air conditioning operation.

This conclusion is indirectly supported by comments from AAMA/AIAM, which acknowledged that it may be possible to inexpensively eliminate much or most of the loss in NOx conversion efficiency which occurred with the air conditioner on. It is likely that this loss in catalyst conversion efficiency is simply due to frequent minor lean air/fuel excursions, which exist only because the air/fuel ratio has not been as carefully calibrated at loads above that typically seen on the FTP. This effect is similar, and likely related, to the large increase in US06 NOx emissions seen on most LDVs because of a subtle lean bias in the air/fuel calibrations at high loads. Once these minor lean excursions are eliminated, NOx conversion efficiency should be essentially the same with the air conditioner on.

This equivalency in catalyst conversion efficiency means that air conditioning design targets can be set simply by multiplying hot, stabilized tailpipe emissions by the unavoidable increase in engine-out NOx emissions with air conditioning operation. Using the engine-out ratio of emissions with the air conditioning on to air conditioning off implicitly applies the conclusion that catalyst conversion efficiency is not affected. Not only does this simplify the calculation, but it also allows the use of a much larger data set. Because the ACR data is used only to establish an engine-out ratio, the ACR1 data can now be used, as the engine-out emissions in the ACR1 program were not affected by the use of low mileage catalysts. In addition, because the ACR data is being used only to establish the *ratio* of engine-out emissions with the air conditioning on to the engine-out emissions with air conditioning off, there is no need to separate vehicles by emission standard. This allows the use of seven vehicles from the ACR1 program (none of which were made by Ford) to complement all five Ford vehicles from the ACR3 program when establishing the engine-out increase ratio.

The two primary issues with this approach are: (1) to calculate the appropriate baseline emission levels with air conditioning off; and (2) to assess what portion of the observed engine-out emission increase is unavoidable and what portion could be reduced with appropriate emission control.

The largest and most representative data set on which to base LDV/LDT1 emissions with the air conditioner off is the same one used to establish the US06 standards. FTP data was available on 22 of the 23 vehicles used to establish US06 LDV/LDT1 emission standards. The most appropriate data to use are the bag 3 emission results, as bag 3 has the same 10 minute soak period used for air conditioning testing and the 505 cycle is much more similar to the SC03 cycle than is the 866 cycle used for bag 2. As was done for the US06 standards, the bag3 emission results need to be adjusted for the difference between the FTP target emission levels of half the standard (i.e., a headroom factor of

2) and the actual average FTP emissions of the test fleet. This normalizes the test results to the targeted level of half the standards. Table V-1 summarizes the results of these calculations listing the FTP average composite emissions, the average Bag 3 emissions, and the Bag 3 emissions adjusted by the headroom factor of 2.

Table V-1: Average bag emissions from 22 Tier 1 LDVs/LDT1s.

	NMHC	**CO**	**NOx**
Bag 3 (505)	0.054	0.78	0.192
FTP composite	0.136	1.45	0.209
Bag 3 adjusted for x2 headroom	0.05	0.92	0.184

Two other adjustments must also be made to the baseline data. The first is to adjust for the differences between the 505 and SC03 driving cycles. As discussed in the test cycle section, while EPA believes it is essential to have a cycle representative of in-use microtransient operation, the emission differences observed between the SC01 and 505 cycles are likely influenced by other factors in addition to the microtransient difference. While no data exists which directly compares the SC03 cycle to the 505, direct comparisons do exist between the 505 and SC01 cycles on four Tier 1 vehicles from the intermediate soak program. For purposes of standard setting, EPA is making the conservative assumption that all of the emission increase on the SC01 cycle is inherent to the higher acceleration loads and that none of it can be mitigated with elimination of commanded enrichment or improved microtransient emission control. With this assumption, the percent emission increase on SC03 compared to the 505 cycle can be estimated by ratioing the percentage emission increase for SC01 compared to the 505 cycle by the relative increase in PKE for SC03 over the 505 compared that of SC01.

Table V-2: 505 and SC01 Emissions for Four Tier 1 vehicles

	PKE	**NMHC**	**CO**	**NOx**
505	2766	0.041	0.4	0.159
SC01	3913	0.045	0.47	0.192
SC03	3320			
SC01 v. 505 (actual, in percent)	+41.5	+9.8	+17.5	+20.8
SC03 v. 505 (in percent)	+20.0	+4.7	+8.5	+10.0

The second adjustment that must be made to the baseline emissions is to correct the results, which were originally corrected to 75 grains of humidity, to the air conditioning standard level of 100 grains. This adjustment is made by dividing the baseline NOx emissions by 1.133 (the NOx correction factory for a humidity of 100 grains); HC and CO emissions are not affected by humidity. Thus, the baseline emissions for Tier 1 LDV/LDT1 vehicles over SC03 at 100 grains of humidity are shown in Table V-3.

Table V-3: Baseline Tier 1 LDV/LDT1 emissions over SC03 at 100 grains humidity

	NMHC	**CO**	**NOx**
Bag 3 adjusted for headroom	0.05	0.92	0.184
SC03 correction (in percent)	+2.8	+26.2	+15.6
Humidity correction	1	1	1/1.133
Baseline emissions	0.051	1.16	0.188

The second issue is to assess what portion of the observed engine-out emission increase is unavoidable and what portion could be reduced with appropriate emission control. The observed results are listed in Table V-4.

Table V-4: Engine-out emission increase percentage with air conditioning over bag3 (ACR1 data) or SC03 (ACR3 and ACC3 data) with 10 minute soak (all numbers are in percents).

ACR1		**HC**	**CO**	**NOx**
Astro Van	LDT2	-12	14	66
Caprice	LDV	4	24	67
Civic	LDV	-20	45	54
Grand Prix	LDV	0	24	103
Intrepid	LDV	-7	25	74
Saturn	LDV	11	21	74
Transport	LDT2	1	23	53
AVERAGE		-5	24	67
ACR3/ACC3 avg				
Escort	LDV	11	16	57
Mustang	LDV	-22	26	58
Town Car	LDV	1	33	61
Bronco	LDT3	-2	11	34
Windstar	LDT2	-17	16	65
AVERAGE		-7	20	53

In the case of engine-out NOx, the primary control strategy is exhaust gas recirculation (EGR). To assess the impact of increased EGR on engine-out NOx emissions with the air conditioning on, a search was made of published information on the subject and the information in the papers was analyzed.[17] On the basis of these papers, EPA concluded that an EGR increase of 5 percent of total volume could reduce engine-out NOx by about 10 percent, with a corresponding HC increase of 7 percent and virtually no impact on fuel efficiency. However, depending on

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[17] Yasuo Kaneko, Hiroyuki Kobayashi and Reijiro Komagome. “The Effects of Exhaust Gas Recirculation and Residual Gas on Engine Emissions and Fuel Economy,” SAE 750414. Also see H. Kuroda, Y. Nakajima, K. Sugihara, Y. Takagi, and S. Muranaka, "The Fast Burn with Heavy EGR, New Approach for Low NOx and Improved Fuel Economy," SAE 780006.

the starting EGR flow rate, this increase could increase engine vibration and negatively impact driveability. AAMA/AIAM also stated in their comments that EGR rates are limited at higher loads by available manifold vacuum, detonation limits, and fuel consumption effects.

EPA does not believe two of the factors AAMA/AIAM stated limit EGR rates at higher loads, fuel consumption effects and available manifold vacuum, have a significant impact in this instance. The papers reviewed by EPA indicate that, in the range of a relatively modest increase in EGR flow of 5 percent, there should be very little impact on fuel efficiency. In addition, as EPA is adding specific requirements for air conditioning operation to the official test procedures, a calibration strategy that flowed more EGR with the air conditioning on would be perfectly acceptable and would not be considered a defeat device (defeat device requirements only apply to changes in calibration that are not substantially reflected in the test procedures). As for available manifold vacuum, EPA is assuming electronic EGR control will be required on all vehicles in order to flow the maximum feasible EGR with the air conditioner on. With electronic EGR, available manifold vacuum should not be a limiting factor for EGR flow except at WOT and WOT operation is not a significant concern with air conditioning operation over SC03.

The primary limiting factor for EGR flow, except at WOT, appears to be driveability. Whether or not increasing EGR flow impacts driveability is dependant upon the amount of EGR flow included in current calibrations. Ford engineers met with EPA staff to discuss this issue and Ford claimed to have calibrated their EGR flow to the maximum fuel efficiency point throughout the speed/load range of the engine.[18] The papers reviewed by EPA indicate that driveability concerns are already increasing at the maximum fuel efficiency point and that increasing EGR flow beyond this point may degrade driveability to the point at which it is noticeable by the driver.

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[18] See "Memorandum to the FTP Revisions Docket (A-92-64) regarding an April 4, 1996 Meeting between Representatives of Ford Motor Company and John German," available from the docket for review.

Ford claims to have calibrated their EGR for maximum fuel efficiency throughout the speed/load range. Supporting this claim is the fact that is that Ford already uses electronic EGR and closed-loop EGR feedback throughout their product line. In addition, lower engine-out emission increases were seen on average for the Ford vehicles compared to the ACR1 vehicles. In fact, if the average engine-out NOx emissions from the ACR1 vehicles with the air conditioner on are decreased by 10 percent (associated with increased EGR flow of 5 percent), the engine-out NOx increase with air conditioning drops to 50 percent (note that the 10 percent decrease is applied to 167 percent of the average air conditioning off levels, not just the NOx increase, such that a 10 percent decrease yields an engine-out NOx level of 150 percent of the air conditioning off levels). This is very similar to the average engine-out NOx increase for the Ford vehicles of 53 percent, indicating that Ford's EGR calibration strategy with the air conditioner on may already incorporate higher levels of EGR flow. As a result, EPA has concluded that it would not be proper to assume that the Ford vehicles could increase EGR by an additional 5 percent without encountering driveability problems. On the other hand, the performance of Ford's vehicles is supportive of limiting engine-out emission increases with the air conditioning on to 50 percent on all vehicles.

Another way to evaluate the NOx standard with air conditioning operation is by examining the combustion process. Engine-out NOx is a function of the peak bulk gas temperature and the oxygen availability. As air conditioning operation over the SC03 cycle is (or at least will be) virtually all conducted at stoichiometry, engine-out NOx is strictly a function of the peak bulk gas temperature. Engine load has a direct effect on peak temperatures. Exhaust gas recirculation (EGR) can be very effective in reducing temperatures, but too much EGR can increase vibration and affect driveability, especially at higher engine speeds when the combustion process occurs in a shorter period of time. Retarding ignition timing can also reduce combustion temperatures, but it is not considered to be a desirable NOx control strategy because it degrades combustion efficiency.

As reported in the NPRM, air conditioning operation increases the overall, average load on the engine by about 25 percent, as measured by the fuel consumed. If engine-out NOx were a linear function of this load, engine-out NOx would also increase by 25 percent. Unfortunately, engine-out NOx is not linear with load, for two reasons. First, very little NOx is formed at low engine loads. In practical terms, this means that there is a "threshold" level, below which the NOx emissions are negligible.[19] With the air conditioner off, a substantial portion of fuel is consumed at idle, deceleration, and low load cruises, during which very little NOx is formed. The air conditioning load generally increases the total load on the engine well past the threshold level of low NOx, such that the NOx increase is proportionally larger than the load increase. In addition, EGR is most effective at relatively low engine speeds and loads. At higher speeds and loads, the faster combustion process makes engine vibration more sensitive to the amount of EGR. Thus, the amount of EGR that can be tolerated decreases as engine speeds and loads increase beyond a relatively low level. This is the second factor that causes a proportionally larger increase in engine-out NOx due to the load from the air conditioner.

Based upon this thermodynamic discussion and the NOx analyses performed by EPA on the air conditioning test data (discussed previously), EPA has concluded that the load imposed by *current* air conditioning systems results in a 50 percent increase in engine-out NOx emissions. This NOx increase is inherent to the additional load placed upon the engine and how this increased load impacts the peak combustion temperature in the engine. The only way to reduce the emissions further is to reduce overall emissions, such as with improved catalyst formulations, or by reducing the load placed on the engine by the air conditioning system.

In the case of NMHC, both the ACR1 and the ACR3/ACC3 data indicate that engine-out HC actually drops with the air conditioner on. This supports the conclusion in the NPRM that HC levels with the air conditioning on would not increase. In fact, the ACR3/ACC3 data suggest that the HC levels with the air

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[19] Marc Ross, Rob Goodwin, Rick Watkins, Michael Wang, and Tom Wenzel. "Real-World Emissions from Model Year 1993, 2000 and 2010 Passenger Cars," p.55.

conditioning on should be lower by 7 percent. However, as discussed in the preceding paragraphs, the ARC1 vehicles would need to increase EGR flow by about 5 percent, which would increase engine-out HC by about 7 percent, leaving engine-out HC emissions very slightly higher (about 2 percent) with the air conditioning on than off. On balance, the best conclusion is still that reached in the NPRM, that HC emissions should not be affected by air conditioning operation.

In the NPRM, EPA attributed the increase in CO emissions with the air conditioning on to increased periods of brief commanded enrichment and proposed that CO emissions not increase with the air conditioner on. This assumption was challenged by the manufacturers in their comments, stating that CO emissions should be proportional to the overall load and, as air conditioning increases this load, there is an unavoidable increase in CO emissions. While EPA continues to believe that the additional load imposed by the air conditioner triggers brief periods of commanded enrichment that will not occur once vehicles have been recalibrated to comply with the high speed and acceleration requirements, EPA also acknowledges that the mass flow through the engine is likely to have some impact on engine-out CO emissions. As engine-out CO emissions in both the ACR1 and ACR3 programs increased only moderately, the average increase in engine-out CO emissions from the ACR1 and ACR3 test programs (i.e. 22 percent) has been incorporated into the air conditioning CO standards.

Table V-5: LDV/LDT1 design targets for air conditioning over SC03

	NMHC	CO	NOx
SC03 baseline (a/c off)	0.051	1.16	0.188
Allowable increase (in percent)	0	22	50
a/c on design target (SC03)	0.051	1.42	0.282

Similar to US06 standards, stand-alone air conditioning standards would be set by applying a x2 headroom factor to the LDV/LDT1 design target and by ratioing the FTP standards for other truck classes and for full useful life to the FTP 50,000 mile standards for LDV/LDT1. For CO, the LDV/LDT1 standard was rounded off to 3.0 g/mile before being ratioed to the other standards.

Table V-6: Stand-Alone Air conditioning standards over SC03

				Intermediate Useful Life Stds. (g/mi)		Full Life Stds. (g/mi)	
Type	GVWR	LVW	ALVW	NMHC+NOX	CO	NMHC+NOX	CO
LDV	all	all	all	0.67	3	0.94	3.7
LDT1	0-6000	0-3750	all	0.67	3	0.94	3.7
LDT2	0-6000	3751-5750	all	1.05	3.9	1.41	4.9
LDT3	>6000	all	3751-5750	1.05	3.9	1.48	5.6
LDT4	>6000	all	>5750	1.54	4.4	2.15	6.4

Feasibility

As noted, above, two of the six vehicles tested for the ACR3/ACC3 test programs appeared to have suspect calibrations. Thus, it is not entirely appropriate to directly compare the test results from the ACR/ACC programs to the air conditioning design target levels. On the other hand, despite the small data set, such a comparison may be able to shed some light on the feasibility of the air conditioning design target.

Figure V-3 compares the LDV NMHC+NOX test results to the 0.335 g/mile NMHC+NOX design target. Figure V-4 compares the CO LDV test results to the 1.5 g/mile CO design target. Figures V-5 and V-6 repeat these comparisons for LDT2/3 vehicles to a 0.525 g/mile NMHC+NOX and a 1.95 g/mile CO design target. The data presented is the average of the ACR3 and ACC3 data.

Of the four LDVs shown in Figure V-3, three are well above the design target level. However, two of these vehicles had suspect calibrations, as discussed above. Of the two remaining vehicles, the Mustang easily meets the design target level without any modification at all. While the Town Car exceeds the design target level, its NOx emissions tripled with the air conditioner on (0.39 g/mile vs. 0.13 g/mile with air conditioner off). It also had extremely high NMHC emissions. As the engine-out emissions on this vehicle only increased by 61 percent, the catalyst conversion efficiency on this vehicle degraded significantly with the air conditioner on. As discussed earlier, there is no reason why catalyst conversion efficiency should decrease with the air conditioner on. Thus, it appears that all the Town Car has to do to meet the design target level is to avoid any loss in catalyst conversion efficiency with the air conditioning on, which should be achievable simply with better calibrations.

For the two trucks, Figure V-5 indicates that the Bronco also meets the design target level without any modification. The Windstar is less than 20 percent above the design target level and, thus, should be able to meet it simply with better calibration strategies to slightly boost catalyst efficiency. Thus, it appears that all four of the vehicles without suspect calibrations in the ACR3/ACC3 test program should be able to meet the design target level with only calibration changes. While this is a small sample size, it does indicate that the large majority of vehicles should be able to comply with the design target levels without hardware changes. However, this conclusion is tempered by the fact that all four of the vehicles were made by Ford and, as established earlier, the Ford vehicles likely have more sophisticated EGR systems and better EGR calibration that most vehicles. As the design targets were based, in part, on the engine-out emissions of the Ford vehicles, it is reasonable to assume that most vehicles will have to adopt EGR systems and calibrations similar to Ford's in order to limit the engine-out NOx increase to 50 percent with air conditioning operation. EEA estimated that all vehicles would need electronic EGR control and about half of the vehicles without closed-loop EGR (affects an additional 34 percent of the fleet) would have to add it. (EEA also included estimates for EGR vacuum boost systems and electric assisted EGR, but these are only needed to increase EGR flow at or near WOT, which is not necessary for control of air conditioning emissions.) As all vehicles will be adopting electronic EGR control for compliance with Tier 1 emission standards and OBD II requirements and some Tier 1 vehicles, such as Ford's, already have closed-loop EGR, the only incremental EGR technology that will be needed to comply with the air conditioning requirements is closed-loop EGR control on 34 percent of the vehicles.

VI. **Final Standards and Leadtime**

A. Composite SFTP Standards

Summary of Proposal

EPA proposed to retain compliance with the existing FTP and to add a "composite" compliance calculation to bring together elements of the conventional FTP with results from the SFTP. In the composite calculation, emissions from the range of in-use driving are appropriately weighted to reflect the target emissions levels proposed as technically feasible for each control area. Cold start emissions from bag 1 of the FTP were included in the composite to allow manufacturers to maintain existing tradeoffs between cold start and hot, stabilized emissions control and to implicitly maintain the existing "headroom" used by manufacturers to comply with FTP emissions standards. The proposed SFTP standards were the result of appropriately weighing and summing the different components. For total hydrocarbons (THC), non-methane hydrocarbons (NMHC), organic material hydrocarbon equivalents (OMHCE), organic material non-methane hydrocarbon equivalents (OMNMHCE), and Carbon Monoxide (CO), the proposed standards worked out to be the same as the standards applicable under the conventional FTP. For NOx, a multiplicative adjustment factor of 1.15 was applied to the conventional FTP standard to account for the emissions response of vehicles to the new A/C test conditions. The proposed weighing factors for the individual types of driving in the SFTP were:

	THC/NMHC	CO & NOx
Bag 1 (cold start from FTP)	21 percent	15 percent
Bag 4 (866 cycle from SFTP)	24 percent	37 percent

Bag 5 (SC01 from SFTP)	27 percent	20 percent
Bag 6 (US06 from SFTP)	28 percent	28 percent

Comments were also specifically requested on three other basic approaches: 1) stand-alone standards for each control area; 2) combined non-FTP areas of control in a single standard; and 3) replacement of the current FTP with an entirely new FTP that reflects, as accurately as possible, actual driving behavior. The NPRM stated that, if data were submitted that could help establish appropriate in-use compliance margins when establishing emission standards, EPA would reevaluate the most appropriate compliance structure and, if appropriate, may select one of these alternatives in the final rule. Commenters addressing stand-alone standards or the average of stand-alone standards were also requested to address the issue of setting appropriate standards for both half and full useful life.

Summary of Comments

AAMA/AIAM supported the concept of a composite standard encompassing all modes of in-use driving, providing that they were based on cost-effective, stand-alone standards for each component of the composite. They also expressed their belief that the NPRM composite proposal did not satisfy this criteria, for three reasons: 1) EPA apparently attempted to carry over the current numerical Tier 1 standards to its new composite SFTP standards; 2) EPA desired to develop an approach to setting the composite standards which could be automatically carried over to future FTP standards; and 3) EPA desired to avoid the need to develop headroom estimates for certain SFTP components. AAMA/AIAM also stated that an appropriate headroom factor has been developed by industry, making the third point moot. They also disputed EPA's use of a 28 percent weighting factor for US06, stating that the distributions of specific power on US06 indicate that the US06 weight should only be 5-10 percent. AAMA/AIAM presented relationships between US06 and REP05 emissions and recommended that additional testing be performed using advanced Tier 1 vehicles to more accurately determine these relationships, which could then be applied in developing a composite standard.

AAMA/AIAM also presented their own recommendation for a composite standard. They agreed with EPA's proposal that cold-start emissions and warmed-up emissions with the A/C system on should be included. They also agreed that cold-start driving with the A/C system should not be included in the SFTP, as it would not have any impact on cold-start calibrations. However, they recommended that warmed-up emissions with the A/C system off also be included to produce a composite standard that reflects, as closely as possible, overall average in-use emissions and that the US06 test results be converted to their REP05 equivalent before applying the 28 percent weighting factor. In summary, AAMA/AIAM recommended that the air conditioning results be weighed at 33 percent, FTP emissions at 39 percent, and US06 emissions be converted to REP05 equivalent emissions levels and weighed at 28 percent.

NESCAUM did not object to the concept of composite standards, but they did object to the use of bag weights and standard adjustments to reflect the proposed level of achievable emissions control in the NPRM. Instead, NESCAUM urged EPA to adopt an overall scheme that best represents real-world driving, and to use any resultant weightings for all pollutants. NRDC also supported the same overall scheme and specifically opposed the 15 percent "relaxing" of the NOx standards in the NPRM. NRDC stated that any revision to the standard requires a reduction in emissions.

CARB commented that the composite standards, overall, were fair and reasonable. However, they did ask for flexibility to allow CARB to go to stand alone standards of equal or greater stringency.

Response to Comments

The EPA adopted a modified version of AAMA/AIAM's recommended composite methodology in the Final Rule for NMHC+NOX emissions. The composite NMHC+NOX standard is simply the weighted average of the FTP, air conditioning, and US06 standards, weighted at 35 percent, 37 percent, and 28 percent, respectively. See table VI-1 for the numerical standards. For CO, a composite standard is optional with the composite CO standard set equal to the FTP CO standard. Such a CO level ensures that any enrichment allowed during air conditioning operation or US06 by the composite standard would be offset by real in-use CO emission reductions in other driving conditions.

The specific composite scheme proposed by EPA in the NPRM was selected, in part, because it allowed for the existing headroom in the FTP standards to be implicitly continued for the SFTP requirements. As discussed in a previous section, data submitted by AAMA/AIAM has allowed EPA to quantify the FTP headroom. This removes the primary barrier from consideration of other composite schemes, as discussed in the NPRM.

While EPA has adopted a modified version of AAMA/AIAM's recommended composite methodology in the Final Rule for NMHC+NOX emissions, the original AAMA/AIAM proposal was lacking in consistency in some ways. For example, AAMA/AIAM recommended including warmed-up emissions with the A/C system off to produce a composite standard that reflects as closely as possible overall average in-use emissions, but recommends against including cold start driving with the A/C system on despite the fact that this also reflects an important component of overall average in-use emissions. AAMA/AIAM also recommended that additional testing be performed using advanced Tier 1 vehicles to more accurately determine the relationship between REP05 and US06 emissions, but did not include testing on the REP05 cycle in their test program on Tier 1 vehicles. Finally, AAMA/AIAM originally opposed using a 28 percent weight for the US06 cycle and incorporating the higher emissions of US06 compared to REP05 into the level of the composite standard, as was proposed in the NPRM, proposing instead to convert US06 emissions into their REP05 equivalent before applying the 28 percent weighting factor. As these two methods are mathematically identical and converting the US06 emissions to REP05 adds an unnecessary (and possible inaccurate) step to the process, this portion of AAMA/AIAM's proposal was rejected.

The other revision to the manufacturers' proposal was to incorporate revised analyses of the portion of time air conditioning operation occurring during typical ozone exceedance days. This was calculated to be 52 percent of total vehicle operation during typical ozone exceedance days, which had average ambient temperature maximums of 92°F at 43 percent humidity. As US06 constitutes 28 percent of overall miles traveled, this means that the air conditioning results should be weighed at 37 percent of the total (or 52 percent of the 72 percent of miles traveled left after subtracting US06). The weight for the FTP emission results is the remainder, or 35 percent.

FTP emissions are included in the NMHC+NOX composite calculation to allow flexibility to obtain emission reductions at the lowest possible cost. Adding the FTP and setting a single standard to be met as a weighted average of all the emission requirements allows manufacturers to simultaneously optimize hardware and calibration across the entire set of emission requirements. This allows manufacturers to find tradeoffs that lower the cost of compliance without impacting the overall emission benefits.

Requiring a composite of the different emission standards was not deemed to be appropriate for CO emissions, for two reasons. First, the NMHC+NOX standards for air conditioning and US06 were carefully chosen to reflect the maximum feasible emission benefits with existing technology. Compositing such individual standards is not likely to result in a loss of emission reductions, as any higher emissions in one area must be offset by lower emissions in another area and such lower emissions would be reflected in use. However, this is not true for the off cycle CO emission standards, for which some additional allowance was made to minimize problems with catalyst temperatures. In addition, due to the dominance of commanded enrichment on the US06 CO emission levels, both the headroom factor of two and the method of determining full useful life and LDT2/LDT3/LDT4 emission standards may prove to be overstated. Thus, it may be possible for a manufacturer to stack up these allowances in one area in order to increase CO emissions in another area, without any offsetting in-use CO reductions in a different area. For example, the CO standard for US06 is targeted to allow modest amounts of enrichment on medium and low performance vehicles. If the US06 CO standards were composited with a/c and/or FTP CO standards, higher performance vehicles would have the opportunity to introduce enrichment into air conditioning operation by avoiding enrichment and generating low CO emissions on the US06. While this is likely to be a low probability scenario, it is not appropriate to jeopardize easily achievable CO emission reductions. Second, as CO emissions are heavily influenced by commanded enrichment and the CO standards were set with some allowance to avoid temperature problems, the individual CO standards for a/c and US06 operation should be easily met by all vehicles simply by eliminating commanded enrichment. Thus, there are no significant cost tradeoffs that can be made to reduce CO emissions in one area and raise them in another.

One way to mitigate the potential for inappropriate introduction of enrichment with a composite CO standard is to make the composite CO standard more stringent. While EPA does not feel it is appropriate to require the use of a more stringent composite CO standard, the Final Rule does allow it as an option.

The composite NMHC+NOX standard is simply the average of the FTP, air conditioning, and US06 standards, weighted at 35 percent, 37 percent, and 28 percent, respectively. For LDV/LDT1 vehicles with FTP NMHC+NOX standard of 0.65 g/mile, air conditioning of 0.67 g/mile, and US06 of 0.58 g/mile, the weighted average is 0.64 g/mile. Given the similarity to the FTP NMHC+NOX standard of 0.65 g/mile for LDV/LDT1 gasoline vehicles, EPA has chosen to set the composite level at the FTP NMHC+NOX level. This level implicitly implies that all the incremental emission impacts of the SFTP test cycles and air conditioning operation may not exceed the incremental emissions from the cold start.

Standards for light-duty diesel vehicles and light-duty diesel trucks in the LDT1 category are different than those for gasoline-powered vehicles in those categories. The supplemental FTP for diesel LDVs and LDT1s does not include the SC03 cycle, because sufficient test data was not available at this time to create an appropriate air conditioning standard for these diesel vehicles. In addition, the HC+NOX standard is higher for diesel LDVs and LDT1s because of the inherently higher NOx emissions associated with diesel engines. This is similar to EPA's treatment of conventional FTP Tier I standards for diesel LDVs and LDT1s, which are less stringent for NOx emissions. Diesel LDVs and LDT1s will have to comply with the same US06 standards (or optional composite standards) for CO as gasoline-fueled LDVs and LDT1s. The composite SFTP HC+NOX and CO standards will be weighted at 72 percent for the conventional FTP cycle and 28 percent for the US06 cycle. For diesel LDV/LDT1 vehicles with a FTP NMHC+NOX standard of 1.25 g/mile and US06 of 2.1 g/mile, the weighted average is 1.48 g/mile. At this time, due to the absence of relevant test data on which to base a decision, no supplemental standards are being promulgated for light-duty diesel truck classes LDT2, LDT3 and LDT4, and no supplemental standards or test procedures are being promulgated for diesel particulate.

Table VI-1 lists the resultant NMHC+NOX emission standards for all vehicle classes.

Table VI-1: Composite NMHC+NOX Emission Standards

				Intermediate Life Standards (g/mi)	**Full Life Standards (g/mi)**
Type	**GVWR**	**LVW**	**ALVW**	**NMHC+NOX**	**NMHC+NOX**
LDV Gasoline	all	all	all	0.65	0.91
LDV-Diesel	all	all	all	1.48	2.07
LDT1 Gasoline	0-6000	0-3750	all	0.65	0.91
LDT1-Diesel	0-6000	0-3750	all	1.48	2.07
LDT2 Gasoline	0-6000	3751-5750	all	1.02	1.37
LDT3 Gasoline	>6000	all	3751-5750	1.02	1.44
LDT4 Gasoline	>6000	all	>5750	1.49	2.09

As discussed, above, the manufacturer may choose whether to meet individual CO standards for air conditioning and US06 or to meet a single composite CO standard, with CO results from the air conditioning, US06 and FTP tests weighed identically as for calculation of NMHC+NOX compliance. For such a composite standard, the implicit result from the NMHC+NOX standard (i.e. the incremental SFTP emissions may not exceed the incremental emissions from the cold start) is also appropriate for a composite CO standard (i.e. the composite CO standard is set equal to the FTP CO standard). Such a level also ensures that any enrichment allowed during air conditioning operation or US06 by the composite standard would be offset by real in-use CO emission reductions in other driving conditions. As the composite standard is not required, but is simply provided as a manufacturer option, there are no cost implications. However, once the composite option is chosen for use on an engine family, all subsequent compliance will be done using the composite methodology, including in-use enforcement.

Table VI-2: CO Emission Standards

				Intermediate Life Standards (g/mi)			Full Life Standards (g/mi)		
Type	**GVWR**	**LVW**	**ALVW**	**A/C**	**US06**	**Composite (option)**	**A/C**	**US06**	**Composite (option)**
LDV Gas.	all	all	all	3.0	9.0	3.4	3.7	11.1	4.2
LDV-Dies.	all	all	all	-	9.0	3.4	-	11.1	4.2
LDT1 Gas.	0-6000	0-3750	all	3.0	9.0	3.4	3.7	11.1	4.2
LDT1-Dies.	0-6000	0-3750	all	-	9.0	3.4	-	11.1	4.2
LDT2 Gas.	0-6000	3751-5750	all	3.9	11.6	4.4	4.9	14.6	5.5
LDT3 Gas.	>6000	all	3751-5750	3.9	11.6	4.4	5.6	16.9	6.4
LDT4 Gas.	>6000	all	>5750	4.4	13.2	5.0	6.4	19.3	7.3

An exception must be made for engines or vehicle configurations that are not available with air conditioning. For such vehicles, no weight should be assigned to air conditioning emissions. To maintain consistency with tradeoffs between US06 emissions and other operating modes, the US06 weight for vehicles without air conditioning should remain at 28 percent. This implicitly requires that the FTP weight for vehicles without air conditioning be reset at 72 percent. As the design target for

NMHC+NOX air conditioning emissions is very similar to that for the FTP, this substitution should have no significant impact on the stringency of the NMHC+NOX US06 requirements. However, the substitution of FTP for air conditioning weight does not work as well for CO emissions, as the air conditioning design target is a little lower than the FTP design target (1.5 g/mile versus 1.7 g/mile, respectively), effectively increasing the overall stringency of the US06 CO requirements for vehicles without air conditioning using the optional composite method for CO. Given that the composite method is not required for CO compliance, no attempt has been made in the Final Rule to adjust for this offset. Should experience indicate that the composite CO standard is being used and that the offset is a problem for vehicles without air conditioning, EPA will revisit this issue for CO in a future rulemaking.

The provisions in this Final Rule are intended to apply to vehicles meeting the Tier 1 emission standards under section 202 of the Clean Air Act. However, complications may occur should voluntary standards, such as the National Low Emission Vehicle (NLEV) program promulgated by EPA, implement FTP standards prior to SFTP standards. In a situation where the Tier 1 SFTP standards would continue to apply simultaneously with a voluntary, more stringent, FTP standard, the SFTP composite NMHC+NOX standard will be adjusted by the weighted change in FTP emission standards. The formula is:

New SFTP standard = Old SFTP standard - (0.32 * (Tier 1 FTP standard - New FTP standard))

All standard references are based upon NMHC+NOX and the result is rounded to the nearest two decimal places.

Both NESCAUM and NRDC urged EPA to adopt an overall scheme that best represents real-world driving, and to use any resultant weightings for all pollutants. This is essentially the same as their legal arguments that EPA should revise the existing FTP and apply the new procedures to the Tier I standards. NESCAUM's and NRDC's comments in this area were discussed and responded to in the first section on legal interpretation and are not duplicated here. In addition, while NESCAUM did not object to the concept of composite standards, they did object to the use of bag weights and standard adjustments to reflect the proposed level of achievable emission control in the NPRM. The composite scheme in the NPRM which NESCAUM objected to is not being promulgated in the Final Rule. The composite standard in the Final Rule separately determines design targets for each control area and then weighs each control area by its representation of in-use driving behavior. While this method may not go as far as NESCAUM would like, it is certainly closer to their suggested methodology than the composite scheme in the NPRM.

B. Proportional Standards

Summary of Proposal

The NPRM proposed that changes in the achievable levels of control over the SFTP tests would track changes in the underlying FTP standards and, thus, adoption of the central proposal would have the effect of automatically reducing the composite standards in step with any mandatory future declines in the FTP standards.

Summary of Comments

AAMA/AIAM stated there is no technical or legal basis for EPA's proposal that future SFTP and FTP standards (e.g. Tier 2) be linked.

AAMA/AIAM also stated that, while temperatures with two-seconds of WOT stoichiometric control on US06 are manageable for Tier 1 vehicles, the two- second timer may need to be reevaluated for reduced standards (i.e. Tier 2 or LEV).

CARB stated that the standards proposed by EPA were reasonable, although for LEV-like vehicles the proposal to hold NMHC to FTP bag 2 levels may be too stringent and the proposal to hold NOx to composite FTP levels may be too lenient. CARB requested a modification of the proposed regulatory language to require the composite standards for LEV vehicles to help ensure that in California non-FTP emissions are controlled to the same level as LEV FTP emissions.

Response to Comments

In light of the technical analyses used in setting appropriate standards, the Agency has decided to drop the proportional standard provision from the Final Rule. The EPA believes that the issue of SFTP standards should be revisited as part of setting Tier 2 emissions standards.

Based upon the technical analyses conducted to set standards for the final rule, there is substantial evidence that SFTP NOx emissions should be roughly proportional to FTP NOx emissions. Unlike NMHC and CO emissions, only a relatively small proportion of overall NOx emissions during the FTP occur during the cold start. Data presented earlier in section VI.D indicate that hot, stabilized NOx emissions from Tier 1 LDV/LDT1 vehicles are about 0.14 g/mile on the FTP, which is 70 percent of the overall target level of 0.2 g/mile. Analyses conducted by the vehicle manufacturers on a limited number of LEV prototypes indicate that the proportion of NOx emissions from hot, stabilized driving over the FTP is roughly the same as calculated for Tier 1 vehicles. In addition, the sections on US06 design target levels and A/C design target levels, above, both demonstrate a strong correlation between hot, stabilized NOx levels on the FTP and the appropriate design level for US06 and A/C emissions. As the SFTP NOx emissions have a strong correlation with hot, stabilized FTP NOx emissions and hot, stabilized NOx emissions are roughly 70 percent of the total FTP NOx emissions, there appears to be a sound technical basis for linking future SFTP NOx standards to FTP NOx standards.

The case for NMHC is not as strong. Roughly 70 percent of NMHC emissions occur during the cold start; hot, stabilized NMHC emissions have relatively little impact on overall FTP NMHC emissions. On the other hand, hot, stabilized NMHC emissions are very small compared to hot, stabilized NOx emissions. Thus, for a combined NMHC+NOX SFTP standard, the correlation of the SFTP NOx emissions to the FTP NOx emissions will dominate. Inclusion of NMHC emissions will likely weaken the correlation, but the impact should be small and proportional standards should still be viable for an NMHC+NOX standard.

Proportional standards do not work at all for CO. CO emissions on the US06 cycle are dominated by brief periods of commanded enrichment, which the standard allows for engine and catalyst cooling. The need for these periods of commanded enrichment will not change just because the FTP CO standard changes, nor will the impact of commanded enrichment on the amount of CO generated. As discussed in section III.B, commanded enrichment accounts for about 80 percent of the total CO emissions on the US06 cycle. Thus, a change in FTP CO emissions will only have a minor impact on SFTP CO emissions.

Despite the strong correlation between FTP and SFTP NOx emissions, the Agency has decided to drop the proportional standard provision from the Final Rule for the following reasons:

- The finding of strong correlation between FTP and SFTP NOx emissions is based upon the use of current technology. It is quite possible that technologies may be developed in the future in response to the SFTP requirements that could have a different impact on SFTP NOx emissions than on FTP NOx emissions. One example of a new technology that would dramatically change the relationship between FTP and SFTP emissions is a more efficient air conditioning system.

- SFTP CO standards would have to be addressed separately.

- CARB is currently making their own assessment of appropriate standards for LEVs and their standards will likely be used for the NLEV program, if it is put into place. The standards that will be finalized by CARB are currently uncertain and the level chosen by CARB may have an impact on future development of SFTP technology and calibration strategies.

- Certain technical issues, such as impacts of emission variability, may need to be revisited as the standards become more stringent.

Based on these considerations, the Agency believes that the issue of SFTP standards should be revisited as part of setting Tier 2 emissions standards.

C. Leadtime and Phase-In

Summary of Proposal

The NPRM proposed that the US06 and air conditioning requirements apply to 40 percent of each manufacturer's combined production of LDVs and LDTs for the 1998 model year, 80 percent in 1999, and 100 percent in 2000. Small volume manufacturers would not have to comply until the 2000 model year. The intermediate (i.e. 60 minute) soak requirement would be required for all vehicles starting with model year 2001, including small volume.

Comments were specifically requested (1) on the impact of this phase-in schedule when considered with other programs and (2) providing suggestions for other schedules which will coordinate programs more effectively.

A separate phase-in schedule was proposed for the improved road load simulation (including the electric dynamometer), removal of the 5500 ETW test weight cap (which is enabled by adoption of the electric dynamometer), and the new criteria for allowable speed variation for FTP compliance determination. All three of these provisions were proposed to be implemented in the 1998 model year.

Summary of Comments

AAMA/AIAM proposed a six-year phase-in period to comply with the SFTP requirements. LDV/LDT1/LDT2 classes were proposed to start with the 2000 model year (AAMA/AIAM subsequently sent EPA a letter revising the recommended start date to the 2001 model year in response to the delay in the court deadline for the final rule).[20] LDT3/LDT4 classes were proposed to start with the 2002 model year. AAMA/AIAM stated the two year delay for the LDT3/LDT4 classes is needed because: 1) little data has been gathered on the heavier LDTs over US06 or with A/C operation and, given their high weight, design as working trucks, and testing at half payload, they may not behave as expected over the new cycles; 2) these vehicles have significantly longer product life cycles than lighter vehicles and, thus, there are fewer

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[20] Available from public docket No.A-92-64 for review.

opportunities to re-engineer these vehicles; and 3) this type of delay has been applied in the past.

AAMA/AIAM also stated that EPA's proposed phase-in schedule did not consider the need to build new facilities and to increase testing capacity. They felt that EPA's proposed phase-in schedule was unrealistic, in part, because EPA appeared to assume that the cost of test facilities and vehicle development is independent of the time allotted for implementation and because EPA significantly underestimated the amount of testing required to develop and certify new calibrations. AAMA/AIAM emphasized that the speed of the phase in significantly affects the total amount of engineering and testing resources needed at any one time, as requiring a vehicle to be redesigned to meet the standards before it was due for redesign for other purposes imposes significant additional costs. Consequently, AAMA/AIAM believes that a more aggressive schedule than the one they proposed would impose unnecessary costs, including the waste of valuable human resources, for little or no environmental gain. AAMA/AIAM also stated that test procedure adjustments (TPAs) for both fuel economy and emissions must be developed before manufacturers can establish their final product plans and that, for fuel economy in particular, these TPAs must be available 18 months before the start of the model year.

Ford submitted comments which supported AAMA/AIAM's position on phase-in, including proposing the same phase in schedule as AAMA/AIAM.

CARB stated that the proposed phase-in schedule would be acceptable as long as hardware modification is required for less than 20 percent of the fleet.

Land Rover stated that EPA should not apply the SFTP requirements to LDT3 and LDT4 vehicles until such time as sufficient data regarding driving habits can be obtained and the full implications of the resulting test procedures on this class of vehicle can be determined. Land Rover also felt that it is crucial that at least a two year delay in the implementation schedule for HLDTs (beyond that for cars) to achieve the SFTP should be made. In support of this additional leadtime, Land Rover noted that all they sell in the U.S. are LDT3 and LDT4 vehicles.

Rolls-Royce commented that the removal of the 5500 ETW cap would pose unique hardships for their company, as their existing dynamometers have a maximum inertia limit of 5625 pounds while many of their vehicles will fall into 6000 and 6500 inertia weight categories. In order to accommodate leadtime for dynamometer replacement and to conduct new testing over the US06, Rolls-Royce requested that EPA change the ETW cap removal implementation for small volume manufacturers to coincide with the small volume phase-in for the other SFTP revisions.

Response to Comments

Revisions in the standards and test procedures, which were based on comments and new data, have resulted in revisions to the proposed leadtime and phase-in. The requirements of this rule are phased-in, applying to 40 percent of each manufacturer's separate production (or at the manufacturer's option, combined production) of LDVs and light LDTs (LDT1s and LDT2s) for MY2000, 80 percent in MY2001, and 100 percent in MY2002. The requirements apply to 40 percent of each manufacturer's production of heavy LDTs (LDT3s and LDT4s) in MY2002, 80 percent in MY2003, and 100 percent in MY2004. Small volume manufacturers would not have to comply until MY2002 for LDVs and light LDTs, and MY2004 for heavy LDTs. All of the rule's requirements would apply during this phase–in period. The Agency recognizes that this phase-in schedule could create an additional burden for auto manufacturers if the National Low Emission Vehicle(National LEV) Program goes into effect as proposed with a MY2001 implementation nationwide (60 FR 53734, October 10, 1995). The Agency intends to address this issue by proposing language in an upcoming National LEV rulemaking that, contingent upon a National LEV program that is "in effect," would harmonize the above phase-in schedule with the MY 2001 nationwide implementation of National LEV. EPA expects such action would also harmonize with CARB's planned SFTP requirements for LEVs.

AAMA/AIAM raised a number of reasons why additional leadtime was needed. These comments fall into two basic categories. The first was the need to build new facilities and increase testing capacity. The second is the need to redesign vehicles and the cost savings to the manufacturer if such redesign could be coordinated with planned product redesign for other purposes.

While EPA disagrees with AAMA/AIAM's position that the Agency failed to consider the time to build new facilities and increase testing capacity in the NPRM, the final rule contains changes that will minimize the impact of test facilities and testing capacity on leadtime. Two different air conditioning simulation procedures that can be conducted in a standard test cell are included in the final rule, the air conditioning test has been shortened by almost 15 minutes, the intermediate soak has been dropped, and the dynamometer phase-in is being extended dramatically. As a result, no special air conditioning testing procedures or facilities are needed for the first three years and the overall testing burden with all of the new requirements should increase by less than 50 percent. If this is broken down into a three year phase-in, the increase in testing and facility burden is no more than 20 percent in any one year, which, while not insignificant, should not be unduly burdensome.

The change in the CO standard to minimize catalyst and engine temperature problems also greatly reduces the burden on vehicle manufacturers to redesign their vehicles, with the attendant development work. Assessment of the impact of elevated catalyst temperatures on catalyst deterioration and the impact of high engine temperatures on material durability would have been one of the major burdens facing manufacturers if the CO standard in the NPRM had been finalized. The additional enrichment allowance in the final rule greatly reduces the time and effort manufacturers need to assess the temperature impacts, simplifies the calibration changes needed, and eliminates the need for hardware changes. In fact, 5 of the 32 vehicles in the test program would meet the proposed CO standards with existing production calibrations, such that no temperature assessment of any kind would be needed.

As discussed earlier in the standard setting sections, about 35 percent of the 32 Tier 1 vehicles tested could meet the US06 design targets with, at most, minimal calibration changes. Two of the six vehicles in Phase 3 of the air conditioning testing would meet the air conditioning design targets with existing production calibration. While many of the vehicles that could easily meet the US06 design targets may not be able to meet the air conditioning design targets as easily, and vice versa, there is a correlation between good NOx control on the US06 cycle and with the air conditioning on. Thus, the Agency seriously considered requiring a small portion of each manufacturers fleet to begin complying with the standards for the 1999 model year. This was rejected because some manufacturers have yet to install the improved dynamometers necessary to generate accurate US06 emissions, elimination of commanded enrichment also requires recalibration of the spark timing and complete revalidation of the revised calibrations, and the manufacturers have to comply with the new Lean-Best Torque enrichment constraint.

The 2000 model year gives the manufacturers three years from date of publication to implement the changes before production and at least a year and a half before final calibrations begin to be assessed. This should be sufficient time for manufacturers to install appropriate test facilities, identify their best vehicles, recalibrate the high load points to eliminate commanded enrichment and, if necessary, refine the air/fuel control.

On the other end of the spectrum are vehicles that may need significant hardware changes to comply with the new requirements. The US06 analysis identified up to 10 percent of the vehicles may need significant hardware changes to comply with the design target level. Some vehicles with relatively high hot, stabilized NOx emissions and smaller engines, such as the Ford Escort in the ACR3 test program, may also need significant hardware changes to meet the air conditioning design targets. Significant hardware changes require an additional two to three years of leadtime to identify, develop, retool, and verify hardware changes and to recalibrate the emission controls. The costs, as pointed out by AAMA/AIAM, are also decreased if these changes can be done in conjunction with other planned changes and if engineering and testing resources are not spread too thin trying to do everything at once. Thus, the Agency is allowing an extra two years of leadtime, MY2002, before requiring the final 20 percent of the manufacturers fleet to comply with the requirements. To allow manufacturers to expend a consistent effort over time to comply with the requirements, it is desirable to spread the requirements over the intervening years. Thus, the Agency is requiring that 40 percent of each manufacturers fleet comply with the requirements for the MY2000, 80 percent for MY2001, and 100 percent for MY2002.

As noted, below, in section VII, the electric dynamometer requirements follow the same phase-in schedule as the SFTP requirements in the Final Rule. As the removal of the ETW cap is dependent upon the improved dynamometer, this requirement must also follow the SFTP phase in. Thus, any family certified under the SFTP phase-in schedule must also comply with the improved road load simulation and the ETW cap removal, although use of the pre-existing dynamomter requirements is allowed for Part 600 fuel economy testing only for phase-in years 2000 and 2001. In addition, the improved road load simulation and the removal of the 5500 ETW cap apply to engine families not covered by the SFTP standard (alternative fuel vehicles and diesel LDT2s, LDT3s, and LDT4s), effective MY2002 for LDVs and LLDTs and MY2004 for HLDTs.

EPA disagrees with Land Rover's comments that EPA should not apply the SFTP requirements to LDTs over 6000 GVWR until such time as sufficient data regarding driving habits can be obtained and the full implications of the resulting test procedures on this class of vehicle can be determined. Nine LDTs over 6000 GVWR were included in the Spokane and Baltimore driving surveys. These vehicles were specifically analyzed by EPA and the results reported in the support documents to the NPRM. EPA found that these vehicles were driven similarly to LDVs and lighter LDTs at speeds up to 50 mph, but were not driven as frequently at higher speeds or as aggressively at high speeds. This information was used by EPA to propose that the heavy LDTs be tested at loaded vehicle weight over the US06, instead of at half payload as is done on the FTP. This change was directly related to the available information on heavy LDT driving habits and the implications of the driving habits. Thus, the Agency believes that Land Rover's comments in this area are not applicable.

EPA does agree with comments received from both Land Rover and AAMA/AIAM in support of the need for additional lead time for LDTs over 6000 GVWR and the precedent set in previous rulemakings allowing an extra two year phase in for these vehicles. Thus, the phase-in for LDTs over 6000 GVWR (LDT3 and LDT4) in the final rule does not begin until the MY2002, with 40 percent of each manufacturers fleet complying with the requirements for the

MY2002, 80 percent for MY2003, and 100 percent for MY2004.

As proposed in the NPRM, small volume manufacturers do not have to comply with the requirements until the last year of the phase-in, or MY2002 (MY2004 for trucks over 6000 GVWR). In recognition of the comments from Rolls Royce on the leadtime for removal of the ETW cap, the final rule clarifies that the MY2002 (MY2004 for trucks over 6000 GVWR) implementation for small volume manufacturers applies to all the new requirements, including electric dynamometers and removal of the ETW cap.

It should be noted that all vehicles under 6000 GVWR are subject to the same phase-in schedule. Thus, LDVs and LDTs under 6000 GVWR can be combined, at the manufacturer's option, into a single group for determining compliance with the phase-in requirements. It should also be noted that, consistent with earlier phase-in efforts, the phase-in must be verified with actual production figures.

D. Diesel and Alternative Fueled Vehicles

Summary of Proposal

The NPRM stated that because very little emission data currently exists on the emission impacts of fuels other than gasoline over the SFTP, EPA considered exempting alternative and/or diesel fuel vehicles from the SFTP requirements. However, the Agency decided that such vehicles would be able to comply with SFTP requirements and requested any information and data related to applying the NPRM requirements to alternative and diesel fuel vehicles.

Summary of Comments

AAMA/AIAM stated that the driving surveys used by EPA were based solely on gasoline vehicles and did not include any alternative or diesel fuel vehicles. Therefore, AAMA/AIAM argued that the Agency could not conclude whether alternative and diesel fuel vehicles were operated in the same manner as gasoline vehicles, and thus, whether the SFTP is appropriate for these types of vehicles.

AAMA/AIAM also stated that EPA did not assess the environmental impact of alternative and diesel fuel vehicles off-cycle emissions. They also pointed out that EPA had no US06 or air conditioning emission data for alternative-fueled vehicles and had not provided an engineering assessment of how alternative fuel vehicles could meet the proposed standards. AAMA/AIAM concluded that alternative and diesel fuel vehicles should be exempt from the SFTP, and not doing so could potentially eliminate both vehicle types from the U.S. market.

In their comments, Mercedes-Benz stated that based on data they provided to EPA, diesel fuel vehicles could not meet the gasoline-generated SFTP standards. They argued that diesel fuel vehicles should either be exempt from the SFTP or that the EPA should develop an appropriate diesel-only HC + NOx standard with sufficient headroom.

Response to Comments

i. General

EPA acknowledges that neither alternative or diesel fuel vehicles were included in the driving surveys. The primary goal of the driving survey was to gather data on in-use driving characteristics on a large, representative sample of vehicles and drivers. To meet these objectives, EPA's contractor recruited vehicles from centralized Inspection and Maintenance (I&M) stations. Both alternative and diesel fueled vehicles were excluded in the I&M programs, and thus, were not eligble for the survey. However, the EPA feels that under the conditions that the surveys were conducted (i.e., no altitude or extreme temperature variations), there is no reason to believe that alternative or diesel fuel vehicles would be operated in a manner different from gasoline vehicles. EPA has received no information to indicate that alternative or diesel fueled vehicles are driven in a manner that would suggest different cycles. Therefore, EPA believes that the SFTP driving cycles are appropriate for these types of vehicles.

EPA believes that SFTP requirements should apply to alternative and diesel fueled vehicles. EPA interprets section 206(h) of the Act to require the inclusion of all types of light-duty vehicles in the SFTP, regardless of fuel type. In addition, EPA has always required diesel fuel vehicles to comply with the same or similar requirements as gasoline vehicles and does not generally believe that diesel or alternative fueled vehicles should be exempted from rules that apply to gasoline-powered vehicles and trucks. However, EPA agrees with comments from AAMA/AIAM that without any off-cycle emission data for alternative fuel vehicles, it is impossible to determine feasibility of these vehicles meeting the proposed SFTP standards. In addition, the promulgation of standards for alternative fuel vehicles could potentially hinder the expansion of alternative fuel vehicles in the US market. There are too many unknowns about alterative fuel vehicles and their emission performance over the SFTP. For example, what would be the durability impact of alternative fuel vehicle emission components over off-cycle conditions? Would they be similar or worse to gasoline vehicles? Would there have to be unique standards for the various types of common alternative fuels - CNG, LPG, methanol, and ethanol? Because of these and numerous other unanswered questions, it would be equally impossible for the Agency to develop any type of unique alternative fuel vehicle SFTP standards, separate from the proposed standards. EPA believes that alternative fuel vehicles are, on average, inherently cleaner than most gasoline and diesel vehicles and encourages the continued development of alternative fuel vehicles. Therefore, alternative fuel vehicles will be exempt from the initial SFTP requirements. EPA plans to evaluate and test these vehicles as part of it's Tier II study, and if EPA finds standards to be appropriate, EPA will promulgate such standards at that time.

In regards to diesel fuel vehicles, EPA's data are limited to LDVs. This is due to the fact that diesel vehicles pose unique testing problems not found in gasoline vehicles. Those vehicle manufacturers that produce diesel LDV's have found ways to overcome these problems. Unfortunately, those manufacturers who produce light-duty diesel trucks were unable to resolve these unique problems in time to obtain any emission data. Therefore, EPA does not have any data on light-duty diesel trucks. As a result, EPA will exempt light-duty diesel truck classes LDT2, LDT3, and LDT4 from the initial SFTP requirements. As discussed below, diesel LDT1s will be required to meet the same requirements as diesel LDVs. The EPA believes such treatment is appropriate as it is consistent with Tier 1 standards and there are no technological reasons to consider LDT1s separately. Further, the absence of data for LDT1s is because no manufacturer is currently producing a diesel LDT1. The EPA plans to evaluate and test light-duty diesel trucks in the exempted classes as part of it's Tier II study, and if EPA finds diesel standards to be appropriate, EPA will promulgate such standards at that time.

ii. Standards for Diesel LDVs and LDT1s

In their comments, Mercedes supplied EPA with US06 and air-conditioning emission data for the two diesel passenger cars. After publishing the NPRM, a 1.9L diesel Volkswagen Passat was tested at EPA to collect US06 emission data. Although EPA has some limited SFTP emission data for diesel fuel light-duty vehicles, there are some concerns over the Agency's ability to promulgate standards based on this data. Currently, there are only two to three LDV diesel engines sold in the US: the Mercedes E300D and C250D-Turbo (there is some question as to whether the C250D-Turbo is available or not), and the Volkswagen TDI engine, avalable in the Golf, Jetta, and Passat. EPA has US06 cycle emission data for all three engines, but only has air-conditioning data for the two Mercedes engines and that data is over the LA4 cycle (i.e., bags 1 and 2 of the FTP) rather than the SC03 cycle. EPA feels that there is no way to relate the LA4 data to the SC03 cycle without being arbitrary. In addition, without any air conditioning data for the Volkswagen TDI (which is the most widely available engine, and in the only low-cost diesel-equipped vehicles) there is no way for the Agency to know whether all of the available diesel fuel LDV's could even meet any proposed emission standards. Therefore, diesel fuel light-duty vehicles will be exempt from the SFTP air-conditioning requirements. As stated above, EPA will evaluate and test these vehicles as part of it's Tier II study, and if necessary, appropriate standards will be promulgated.

The US06 emission data for the diesel LDV's indicate that NMHC and CO levels are well below gasoline vehicle levels. The EPA believes that diesel LDV's should have no trouble meeting the SFTP CO standards discussed in section VI.A. Diesel NOx levels, however, are 3-4 times higher than the gasoline vehicle levels.

Diesel engines produce higher levels of NOx emissions than gasoline engines primarily because NOx reduction catalysts do not work in the inherently lean air/fuel mixture of the diesel engine. This leaves retarding fuel injection timing and EGR as the main diesel NOx control strategies, although turbo-charging the engine can slightly reduce NOx emissions.

In their comments, Mercedes stated that their electronically controlled EGR system operates under a broad range of engine load conditions, including areas outside of the FTP, and that their EGR calibrations are optimized for all operation, including high speed and load operation. This is a result of the fact that the German government requires vehicles sold in Germany to meet emission requirements over high speed and load conditions. However, even optimized, their use of EGR is limited during high speed and load operation because of increased particulate matter (PM) formation. Thus, there is a sensitive PM/NOx tradeoff under high speed and load operation. EPA has no additional technical information to refute Mercedes claims that they have optimized the amount of EGR that can be used during high speed and load conditions. Based on the extremely low emission results of Mercedes and Volkswagen gasoline-powered vehicles over the US06 cycle and the fact that German manufacturers have had incentive and time to develop high speed and load operation emission control strategies, EPA sees no reason to doubt that Mercedes vehicles have been optimized for the lowest NOx levels possible over the US06 cycle at this time. Therefore, the EPA believes it is not currently feasible for LDV diesels to meet the SFTP NMHC+NOx standard for gasoline vehicles. Thus, there will be a separate and unique NMHC+NOx standard for diesel LDV's.

Based on the Mercedes' comments, EPA feels that it is only technically feasible for diesel-fueled LDV's to meet a NMHC+NOx standard that is designed to be a capping standard. That is, EPA feels that at this time, diesel LDV's are unable to reduce NOx emissions resulting from high speed and load operation, due to technological limitations. Therefore, the standard will be set such that it caps the amount of NOx emissions diesel LDV's will be allowed to emit over high speed and load operation.

Even though EPA has no data for LDT1, they will be required to meet the same standards as the LDV. For the Tier I standards, LDV and LDT1 have the same standards. EPA is not aware of any technological reason to consider LDT1s differently from LDV's. Currently, there are no diesel LDT1 vehicles sold in the US.

The average US06 NOx emissions for the three diesel LDV's are 1.42 g/mi, while the average US06 NMHC emissions are 0.007 g/mi. The methodology chosen by the Agency for developing the US06 NMHC+NOx standard is to simply add the average NMHC level with the average NOx level and multiply the result by a certification headroom factor. However, because the standard is intended to be a capping standard, EPA must insure that all three LDV models can meet the standard. The Volkswagen Passat had an average US06 NOx emission level of 1.70 g/mi, which exceeds the average of all three vehicles of 1.42 g/mi. Therefore, EPA has decided that instead of using the average value of 1.42 g/mi, the Volkswagen value of 1.70 g/mi will be used in the above methodology, thus insuring that all of the existing LDV models sold in the US marketplace should be capable of meeting the standard.

The methodology chosen by the Agency for developing the US06 NMHC+NOx standard for gasoline vehicles is to add the average NMHC level with the average NOx level for well-calibrated vehicles and multiply the result by a certification headroom factor. However, because the diesel standard is intended to be a capping standard, the EPA must insure that all three LDV models can meet the standard. The Volkswagen Passat had an average US06 NOx emission level of 1.70 g/mi, which exceeds the average of all three vehicles of 1.42 g/mi. Therefore, EPA believes that it is appropriate to use the Volkswagen NOx emissions of 1.70 g/mi. NMHC emissions for diesel vehicles are inherently very low, and thus, are not a limiting factor in complying with emission standards. The average NMHC emission level of 0.007 g/mi will be added to the NOx emission level of 1.70 with the sum multiplied by the diesel headroom factor of 1.22 to yield a US06 standard level of 2.1 g/mi. While NMHC+NOx standards were not promulgated for US06 separately, this US06 standard level of 2.1 g/mi for diesel LDVs/LDT1s is used in the calculation of NMHC+NOx composite standard. The diesel LDV/LDT1 *composite* NMHC+NOx standard is equal to a US06 standard level of 2.1 g/mi weighted at 28 percent added with the conventional FTP diesel standard of

1.25 g/mi(NOx=1.0, NMHC=0.25) weighted at 72 percent, yielding a numerical value of 1.48 g/mi (see section VI.E. on Composite Standards).

VII. **Electric Dynamometer**

A. Change to Single-Roll Electric Dynamometers for Compliance Testing

Summary of Proposal

The NPRM stated that each of the test cycles is to be run on a system providing accurate replication of real road load forces at the interface between drive tires and the dynamometer over the full speed range. Furthermore, the new US06 cycle requires significantly higher power absorption capacity, due to the higher power requirements of this aggressive driving cycle. The NPRM proposed the use of a large-diameter single roll dynamometer with electronic control of power absorption to meet these requirements for both the new SFTP and current FTP testing, but any system would be allowed that yields equivalent or superior test results. This new requirement was proposed to take effect for the 1998 model year.

Summary of Comments

AAMA/AIAM supported the changeover to single-roll electric dynamometers for certification and compliance testing purposes. However, they presented a number of arguments in support of their contention that the proposed implementation date of 1998 for all FTP and SFTP testing is infeasible. Their primary concern with implementing the requirement for the 1998 model year was that vehicle modifications will be required to maintain compliance with the current Tier 1 emission and US fuel economy standards. This concern was based upon the average results of the "EPA/Industry Dynamometer comparison Study - Nine Vehicle Fleet" and AAMA/AIAM's contention that EPA performed no testing or engineering analyses to demonstrate that compliance with the applicable standards is feasible. AAMA/AIAM also emphasized the difficulty in installing enough new electric dynamometers to support testing of the entire fleet in the 1998 model year.

Response to Comments

Improved dynamometers are an essential part of US06 testing. Thus, the electric dynamometers must be phased-in no later than the US06 phase-in. EPA proposed a faster implementation of the improved dynamometers for FTP testing purposes primarily because it would mitigate the problem of having to maintain two different sets of dynamometers simultaneously. While EPA does not agree with the manufacturers' comments that it is not feasible to implement the dynamometers early, EPA does agree that this would increase the difficulty in installing enough new dynamometers to support testing of the entire fleet and ensure that modifications to the vehicle are not needed in the first model year. Thus, phase-in of the improved dynamometers has been changed in the final rule to coincide with the US06 phase-in.

B. Equivalent Test Weight (ETW) Cap

Summary of Proposal

The proposed change in dynamometers to improve accuracy allows modification of the equivalent test weight requirements to remove the cap. The Agency proposed in the NPRM, a minor procedural change that would remove the current 5500-pound test weight cap, to be implemented in the 1998 model year with the improved road load simulations.

Summary of Comments

No comments were received on the ETW cap removal, expect for a request from Rolls Royce concerning leadtime.

Response to Comments

The comments from Rolls Royce are addressed in the "Phase-in and Leadtime" section. As no other responses were received, the removal of the ETW cap is adopted for the final rule, as proposed in the NPRM.

C. Equivalent Test Weight for Electric Dynamometers

Summary of Proposal

Electric single-roll dynamometers have the ability to simulate the inertia associated with the exact vehicle weight. While the NPRM did not propose revising the current 125/250 pound equivalent test weight (ETW) classes used for vehicle testing, it did ask for comments on the feasibility of testing vehicles at their exact loaded vehicle weight instead of using ETW classes.

Summary of Comments

AAMA/AIAM recommended that EPA retain the 125/250 pound and 500 pound increments defining ETW and inertia weight classes for administrative purposes and, potentially, for actual testing as well. AAMA/AIAM stated that the use of ETW classes for administrative purposes allows a reduction in the number of tests performed by the manufacturer. AAMA/AIAM also recommended retaining the existing ETW and inertia weight classes for testing purposes since they are used in the current method for calculating CAFE, for carryover/carryacross, and for determining the need for or lack of running change testing based on vehicle weight changes.

Response to Comments

While EPA continues to believe that simulation of the exact vehicle weight has some merit, there are implementation issues, such as those raised by AAMA/AIAM, that would require substantial effort to resolve. As these issues require the implementation of new procedures that were not addressed in the NPRM and no comments were received in support of simulation of exact vehicle weight, EPA will not change ETW or inertia weight classes at this time. Any testing performed on new dynamometers will simulate the existing discreet classes.

D. Road-Load Determination

Summary of Proposal

The NPRM proposed to use the existing method of determining road-load forces on vehicles, with the requirement that the existing method must be extended to a much wider speed range (15-115 km/hour). The proposed regulatory language also stated that, for each vehicle test sequence, the dynamometer setting shall be verified by comparing the force imposed during dynamometer operation with actual road load force (i.e. each test vehicle would be required to generate its own dynamometer coefficients).

Summary of Comments

AAMA/AIAM recommended continued use of the current approach for the determination of road-load horsepower curves, although with the speed range increased to cover loading from 70 to 10 mph, with the resulting dynamometer coefficients used for groupings of similar vehicles. They also recommended retaining the current 55-45 mph coastdown quick check with its 7 percent tolerance on the dynamometer to verify that the dynamometer setting is correct. Later, if appropriate after additional experience is gathered, AAMA/AIAM stated the quick check test could be modified and new acceptance criteria developed.

AAMA/AIAM stated that using vehicle specific dynamometer coefficients, instead of retaining the current approach, would enable manufacturers to more closely duplicate the load that the engine experiences for all vehicles, regardless of the load (friction) inherent to the vehicle. In addition, they stated that quick check monitoring would not be necessary because the electric dynamometer is self monitoring. Despite these potential advantages, AAMA/AIAM recommended against using this approach because it would require significantly more time to determine dynamometer power absorption (DPA) settings and it is uncertain if it would provide more accurate loading on a whole than the current procedure.

Volkswagen supported the vehicle specific coefficient method and asked that it be provided as an option for manufacturer use, if desired.

Response to Comments

EPA will continue to allow grouping of similar vehicles for purposes of determining on-road road-load forces. However, EPA disagrees with AAMA/AIAM's assertion that there is uncertainty about whether vehicle-specific dynamometer coefficients would provide more accurate loading on a whole than the current coastdown quick check procedure. As AAMA/AIAM points out, vehicle specific dynamometer coefficients more closely duplicate the actual road-load because they compensate for differences in the inherent friction of each vehicle. In addition, the existing quick check procedure cannot verify proper dynamometer loading over the new 70 to 10 mph extended speed range. EPA believes that the increased accuracy of vehicle specific dynamometer coefficients more than compensates for the additional time needed to determine the DPA setting, especially since the DPA would have to be determined only once for each vehicle rather than each test, the procedure can be automated, and the dynamometer coefficients are easily transferable from one dynamometer to another. Thus, the requirement for each official test vehicle to have its own specific dynamometer coefficients is retained in the final rule. EPA will continue to cooperate with vehicle manufacturers in developing appropriate verification procedures consistent with the extended speed range and improved dynamometer accuracy.

E. Dynamometer Coefficient Adjustments for Ambient Temperature

Summary of Proposal

The NPRM did not address the issue of changing road-load and dynamometer coefficients based upon ambient temperature, implicitly endorsing the current procedure. Currently, for testing at 20°F, the track force coefficients are adjusted 10 percent upward to account for the differences in vehicle friction and aerodynamic drag losses resulting from significantly lower ambient temperatures. No adjustments are made for testing at 50, 95, or 105°F.

Summary of Comments

AAMA/AIAM raised a concern that, for each temperature at which testing is required, the potential exists for track coefficients to be corrected and dynamometer coefficients determined. AAMA/AIAM recommended that: 1) track force coefficients be determined according to the standard track coastdown procedures (i.e., adjusted to standard temperature and pressure) for FTP testing; 2) an adjustment factor be used to simulate track coefficients for 20°F testing and a dynamometer coefficient derivation procedure be run at 20°F; and 3) for all other testing, no temperature adjustment factors be used and the dynamometer derivation be performed between 68°F and 86°F.

Response to Comments

EPA concurs with AAMA/AIAM's recommendations, which are, in essense, simply to continue using existing practices, with an incremental improvement to the existing load adjustment at 20°F. This position is consistent with existing practices, thus, no regulatory changes are included in the final rule. EPA will work with AAMA/AIAM to develop the 20°F track coefficient and dynamometer coefficient derivation procedure for 20°F testing proposed by AAMA/AIAM.

F. A/C Horsepower Adjustment

Summary of Proposal

The current FTP adds load as a percentage (10 percent) of the base dynamometer power absorption curve to simulate air conditioning load. The agency believes that the current method of A/C simulation on the FTP is not representative of real A/C loads and significantly under-represents the magnitude of in-use A/C loads. In addition, the current 10 percent load increase will be difficult, if not impossible, to duplicate on the large, single roll dynamometer being implemented with this rule. Thus, the NPRM proposed to drop the 10 percent air conditioning load factor for the existing FTP.

Summary of Comments

AAMA/AIAM recommended elimination of the current A/C dynamometer power absorption unit (PAU) increase of 10 percent for City and Highway emissions testing, based upon the lack of a defined methodology for A/C adjustment on single-roll dynamometers during the FTP and actual testing with the A/C unit operational as part of the SFTP. AAMA/AIAM expressed the necessity to include the impact of elimination of the 10 percent load adjustment in the overall determination of test procedure adjustments. AAMA/AIAM also stated that, if EPA were to retain the current load adjustment for A/C with the electric dynamometer over the current FTP, that the adjustment would need to be lower than 10 percent to reflect the higher DPA values on the electric dynamometer caused by lower tire rolling losses.

Response to Comments

EPA agrees with all of AAMA/AIAM's comments. While it would be desirable to implement a proper representation of average annual air conditioning load for use in FTP and fuel economy testing, development of such a factor was not presented in the NPRM. EPA intends to address the issue of proper a/c factors for FTP and fuel economy testing as part of a subsequent rulemaking addressing test procedure adjustments issues. Until then, the 10 percent dynamometer increase for air conditioning simulation is deleted, as proposed in the NPRM. CAFE adjustments for the temporary deletion of the 10 percent dynamometer load adjustment will also be considered in the subsequent rulemaking on test procedure adjustments.

VIII. **Miscellaneous Technical Issues**

A. <u>Microtransient Driving Control (DPWRSUM)</u>

Summary of Proposal

The EPA proposed to remove language specifying "minimum throttle movement" when conducting emission tests and replace it with "appropriate throttle movement" and require a specification of allowable speed variation, which also impacts both SFTP and FTP testing. For each test cycle, a range of acceptable speed variation is created using the DPWRSUM (short for "delta power sum", or the sum of the positive power changes) variable. Each driving cycle has a unique value of DPWRSUM, which is compared to the DPWRSUM calculated from the driver's trace (what the vehicle actually drove) to determine a valid test. EPA specifically asked for comments on the proper method for setting the lower DPWRSUM threshold for a valid test.

Summary of Comments

AAMA/AIAM commented on the EPA's proposal to use DPWRSUM as a criteria for setting limits on the range of speed variation for the test cycles. AAMA/AIAM provided a analysis of test data which concluded that the DPWRSUM measure was technically flawed. Further, it was AAMA/AIAM's contention that DPWRSUM criteria may impact fuel economy and the ability to comply with Tier I emission standards, and thus, that EPA must make fuel economy and emission adjustments. AAMA/AIAM also stated EPA had failed to establish an environmental need for DPWRSUM or perform a cost effectiveness analysis. AAMA/AIAM concluded by recommending that EPA drop the DPWRSUM criteria.

In a May 2, 1996 meeting requested by AAMA/AIAM, additional data was presented by Chrysler. The test data compared DPWRSUM values on the FTP and US06 for a single vehicle driven "normally" and driven with intentional throttle "dither." Chrysler concluded that the data that DPWRSUM does not identify tests with inappropriate throttle movement. AAMA/AIAM also submitted a suggested revision to the proposed regulatory language change which they believed should be "The vehicle shall be driven with the appropriate acceleration pedal movement necessary to reasonably achieve the speed versus time relation ship prescribed by the driving schedule. Excessive accelerator pedal perturbations are to be avoided." Accompanying the suggested regulatory language was supportive preamble language which sought to recognize differences in vehicles' ability to follow the microtransients in the driving cycle, in particular trucks.

In their comments ARB believed it was inappropriate to use the DPWRSUM value associated with the nominal driving trace as the upper threshold value. ARB felt that doing so would "encourage driving behaviors with less throttle and speed variation than the cycle itself." ARB recommended the upper DPWRSUM threshold be significantly greater than nominal driving trace value and that the nominal trace value should be at the mid-point of the allowable range. ARB's suggested changes were intended to ensure that the driving cycles were driven, on average, with the speed and throttle variation fully representative of the intended driving pattern. In the same light, ARB supported the proposed regulatory language change regarding minimal throttle movement.

Response to Comments

On several points, EPA agrees with AAMA/AIAM regarding technical flaws with the use of DPWRSUM as proposed. As both AAMA/AIAM and ARB pointed out, the use of a drive cycle's nominal DPWRSUM value as the upper threshold, as proposed in the NPRM, is inappropriate. The technical analysis provided in AAMA/AIAM's comments clearly illustrates that for the UDDS, HWFET, and SC01 cycles, DPWRSUM values greater than the driving cycle's nominal value are typical and appropriate.

The EPA will not finalize the DPWRSUM criteria for several reasons. First, EPA has not been able to establish appropriate threshold values; commenters were only able to provide input on the problem with the proposed upper threshold. More importantly, based on EPA's review of test data provided by Chrysler, DPWRSUM does not appear to adequately identify large differences in throttle variation. However, EPA believes it is desirable to have a quantifiable speed- or throttle-based measure to ensure that vehicles are driven in an appropriate manner, thus, it is EPA's intent to revisit this issue as part of the Tier II Study.

Both ARB and AAMA/AIAM's comments on the proposed language change regarding throttle and pedal movement recognize the need to change "minimum" to appropriate. Thus, the EPA will change the regulatory language to include "appropriate," whereby "appropriate" is intended to convey that in-use there exists a range of throttle variation reflecting differences in drivers and vehicles, and this variation should be incorporated in the testing conditions. EPA recognizes the manufacturer's concern that excessive throttle variation should be avoided and the Agency will, in part, incorporate AAMA/AIAM's suggested language into the final regulatory language. However, the EPA believes it is equally important that appropriate throttle movement should exclude behavior which smooths the minor speed variations found in the driving cycles. The revised regulatory language is shown below:

> Sec. 86.128-98 (d) The vehicle shall be driven with appropriate accelerator pedal movement necessary achieve the speed versus time relationship prescribed by the driving schedule. Both smoothing of speed variations and excessive accelerator pedal perturbations are to be avoided.
>
> 86-082-2(b). (g) Practice runs over the prescribed driving schedule may be performed at test point, provided an emission sample is not taken, for the purpose of finding the appropriate throttle action to maintain the proper speed-time relationship, or to permit sampling system adjustment. Both smoothing of speed variations and excessive accelerator pedal perturbations are to be avoided.

B. Selective Enforcement Audit (SEA) Requirements

Summary of Proposal

The proposed changes to the federal test procedure apply to testing conducted during Selective Enforcement Audits (SEAs). During the SC01 cycle, manufacturers conducting SEA testing of engine families required to comply with the intermediate soak must soak the vehicle for at least 60 minutes. EPA will have the option of testing any soak duration between 10 and 60 minutes for SEA testing.

Summary of Comments

American Honda Motor Company, Inc. (Honda) commented that the NPRM "did not clearly indicate whether the SEA test must be carried out according to the Supplemental FTP (SFTP)." In addition, Honda commented that such a requirement would cause "significant hardship and expense" and requested that EPA allow an [unspecified] alternative procedure. Honda supplied confidential information related to its estimates of the costs associated with constructing a laboratory in Japan which would be capable of conducting the SFTP.

Response to Comments

As stated in Section III of the February 7, 1995 NPRM, the proposed SFTP would apply to testing conducted during certification, Selective Enforcement Audits (SEA), and in-use enforcement (recall). This requirement was proposed as the best means of ensuring that vehicles are adequately designed and sufficiently durable to meet the applicable standards not only in prototype certification but in actual use.

In response to Honda's comments concerning the costs associated with the laboratory facilities required to conduct the SFTP, EPA assumes that manufacturers will have such laboratory capabilities in place (either in-house or thru contract) to conduct design and certification testing. As EPA does not require that the testing of vehicles selected for SEA-and thus the testing laboratory- be at the location at which the vehicles were produced, vehicles selected for audit could be shipped to any adequate in-house or contract laboratory. With these facts in mind, EPA believes that the incremental cost of conducting the infrequent SEA tests which EPA might require is not significant.

C. Defeat Device Policy

Summary of Proposal

Although EPA did not propose any revisions to the defeat device policy, comments were requested on whether the increased sophistication of vehicle computers necessitates replacing existing defeat device control language with a requirement for proportional emission control under conditions not directly represented by the FTP and SFTP.

Summary of Comments

AAMA/AIAM recommended maintaining the current defeat device policy and stated that no additional defeat device criterion are needed because the existing EPA Advisory Circulars and multitude of certification test requirements, augmented by the proposed SFTP, effectively preclude the incidence of defeat devices.

SEMA commented that modifying the language on defeat devices to include proportional control is beyond EPA's authority, not supported by data, and would cause unnecessary and unreasonable harm to the aftermarket industry.

Response to Comments

EPA requested comments on defeat device policy in the NPRM to provide input for future defeat device policy direction, as such, no action is taken in this final rule. EPA did not receive any comments indicating a concern with the existing defeat device policy. In addition, EPA concurs with AAMA/AIAM's comment that the new SFTP requirements will help prevent the incidence of defeat devices, as the new requirements extend the range of operation included in the test procedure.

On the other hand, SEMA's comment that including proportional control would cause unnecessary and unreasonable harm to the aftermarket industry has disturbing implications. No harm should occur unless the aftermarket industry deliberately introduces changes to the control system that result in step functions in the emissions of the engine. Such step functions in emissions are precisely what EPA is concerned about. EPA also disagrees with SEMA's comment that proportional control is beyond EPA's authority. While there are no changes in defeat device policy in the final rule, SEMA's comments indicate that EPA may need to further investigate the need for proportional controls in the future.

D. US06 Shift schedules for manual transmission vehicles

Summary of Proposal

The Agency proposed that manufacturers determine the appropriate shift points for their manual transmission applications and submit the shift schedules for EPA approval. In general, EPA will allow manufacturers to specify upshift points, but downshifting will not be permitted unless the vehicle is unable to stay within the driving tolerance on the speed trace in the existing gear.

Summary of Comments

EPA did not receive any specific comments on this issue.

However, AAMA/AIAM provided additional test data on Tier I manual transmission vehicles performed over the US06 driving cycle.

Response to Comments

The purpose of not permitting downshifting unless the vehicle is unable to stay within the driving tolerance on the speed trace in the existing gear, as proposed in the NPRM, was to ensure that the vehicle did not use commanded enrichment during extended WOT events caused by a failure to downshift in use. However, this prohibition on downshifting runs counter to the revision to the CO standard in the Final Rule to allow more enrichment at WOT for temperature protection. Thus, the Final Rule removes the prohibition on downshifting. All shift points on US06 are determined by the manufacturer, subject to EPA approval.

E. Test Procedure Flexibilities

Summary of Proposal

The NPRM proposed three testing flexibilities to minimize testing costs and calibration development time: (1) run the 866 cycle with full air conditioning simulation in place of Bag 2 of the FTP, (2) use any combination of the intermediate soak bag in place of Bag 3 of the FTP, and (3) establish criteria for exempting vehicles from the intermediate soak requirements.

Summary of Comments

EPA did not receive any comments on this issue.

Response to Comments

In the final rule, the 866 cycle is no longer part of the air conditioning requirements, making the first flexibility moot, and the intermediate soak requirements have been dropped, eliminating the second and third flexibilities. Thus, the testing flexibilities are no longer applicable to the procedures adopted in the Final Rule and have been deleted.

IX. **Regulatory Impact Analysis**

This section of the Response to Comments provides summaries of the proposal, public comments, and the EPA's response to those comments on cost, benefit, and cost-effectiveness issues. All aspects of the Intermediate Soak proposal are discussed separately in the Intermediate Soak section of this document.

The section on costs includes discussions of 1) Testing Load, 2) Facilities Costs, 3) Recalibration/Certification, 4) Redesign/DDV Testing and Reporting/Mechanical Integrity Testing, 5) Hardware, and 6) Cost Totals.

The section on benefits has two parts; the first provides a response to comments for general benefit issues, which include Attainment of NAAQS Standards, NOx Waivers, Exclusion of OTR and CA, Temporal Relationships, and Migration. The second part provides responses to comments on issues related to the individual control measures for air conditioning and aggressive driving.

The third section contains responses to comments related to cost/effectiveness methodology, including Regional vs. National Analysis, Comparisons with Other Rules, and the Final Cost/Effectiveness Values.

A. Costs

1. Baseline Number of FTP Tests per Year

Summary of Proposal

The EPA assumed in its proposal that there are, on average, 200 annual recalibration tests and 12 annual deterioration factor tests for each of 319 engine families, plus 3000 annual certfication tests, for a estimated total of 70,628 annual tests for the FTP. The EPA assumed revising the FTP would double this test load.

Summary of Comments

AAMA/AIAM calculates the total number of current FTP tests by adding the tests done by Ford (40,700), GM (64,200) and Chrysler (16,530), to get a big three total of 121,430 tests per year. AAMA/AIAM assumes that US manufacturers are 75 percent of the total market and that the other manufacturers conduct similar numbers of tests per market share. Using these assumptions, the total number of current tests is 161,907. AAMA/AIAM also assumes that there will be a 1 percent testing growth per year for 12 years, for a total of 182,440 annual tests. AAMA/AIAM also assumes that 6 percent of these tests would be for certification and 94 percent for development.

Response to Comments

In the NPRM, the EPA used the best available information to estimate the number of tests done by the manufacturers for the current FTP. Because manufacturers have unique knowledge regarding testing levels, the Agency defers to their estimate of existing FTP test burden. However, the EPA has no evidence that there will be a growth in the number of engine families or in the number of tests per engine family in the future, as assumed by AAMA/AIAM. In fact, much publicity has been given to manufacturer efforts to simplify their product lines for cost reasons. In addition, while there has been growth in the number of tests per family in the recent past, this growth has occured in response to the numerous mandates in the 1990 CAAA and is not likely to continue into the future. Thus, EPA does not agree with AAMA/AIAM assumptions regrading testing growth and is, thus, using AAMA/AIAM's estimate of the current annual test load (i.e. 161,907 tests) for calculating its facility and testing costs. The EPA accepts the AAMA/AIAM assumptions that 6 percent of the total tests are done for certification (9,714) and 94 percent for development (152,193). The EPA continues to assume that the SFTP will double the current test load.

2. Facility Costs

Summary of Proposal

The proposed test procedure requirements were expected to result in three types of facility costs: those for upgrades from existing twin-roll dynamometers to 48" single-roll electric dynamometers, at $0.5 million each; those for construction of completely new exhaust emission test facilities to handle the increased testing demands, at $2 million per cell; and those for construction of temperature control emission test cells (modified evaporative cells) for A/C related testing, at $0.7 million per cell.

The EPA assumed 4,500 tests per year for the FTP (reported to the EPA), with 104 days of testing and two emission tests per day, resulting in 22 cells to be upgraded (4,500/(104 * 2)), at a cost of $11 million ($0.5 million*22). The EPA also assumed that the SFTP would double the test load, creating a need for 22 additional test cells to be built (for a total of 44 cells), at a cost of $44 million ($2 million*22). For A/C related testing, the EPA assumed that 30 cells would need to be modified at a cost of $10.5 million ($0.7 million*30). The calculated total cost in the original RIA for Test Facilities was $65.5 million. The EPA amortized this over a 10 year period at 7 percent for an estimated annual cost to the industry of $9.3 million.

Summary of Comments

The AAMA/AIAM comments dispute EPA's assumed facility costs and give their own estimates. For the electric dynamometer, AAMA/AIAM agrees that the dynamometer itself costs $0.5 million but claims there is an additional $0.8 million cost when upgrading, for a total cost of $1.3 million each. AAMA/AIAM also estimates the cost of building a new exhaust emission test cell to be $3.9 million. For A/C test facilities, AAMA/AIAM estimates that a new full environmental cell would cost $8 million.

AAMA/AIAM also disputes the number of tests associated with the FTP and SFTP. In their comments submitted July 19, 1995, AAMA/AIAM estimates that there are 250,000 tests performed (6 percent certification and 94 percent development) for the FTP. In a subsequent submittal, dated February 14, 1996 (available for review from public docket No.A-92-64), AAMA/AIAM revised their estimates of tests per year for the FTP to 161,907, the number of test days per year at 246, the number of shifts per day at 3, certification tests as 6 percent of total, and development tests as 94 percent of total. AAMA/AIAM also calculated the following test per shift estimates:

Table IX-1: AAMA/AIAM Test per Shift Estimates

Procedure	**Development Tests**	**Certification Tests**
FTP	6	3
FTP/US06	4	2
FTP/US06/AC simulation	3	1.3
FTP/US06/AC FEC	2	1.3

Based on 250,000 tests contained in their original July 1995 comments, AAMA/AIAM estimated the current FTP facility burden to be 30-40 cells. Using the new February 1996 estimates, AAMA/AIAM revised its FTP burden to 64 cells. Using the above test per shift information, AAMA/AIAM calculates that the SFTP will increase the test cell requirements as follows: FTP/USO6 will increase the total requirements to 108 cells, FTP/USO6/AC 10 minute soak with A/C simulation will increase the burden to 148 cells, and FTP/USO6/AC with full environmental cell will increase the burden to 207 cells (AAMA/AIAM assumes that the A/C test will be performed with USO6 and FTP together in a full environmental cell). Using their burden estimates and their estimate of cell costs, AAMA/AIAM calculates an incremental test facility cost increase between the A/C simulation and A/C full environmental cell at $628 million (non-amortized), which equates to $41.87 per vehicle based on 15 million vehicles per year.

Response to Comments

Because of AAMA/AIAM's expertise in quantifying facility burdens and associated costs, the EPA recognizes the merit of their comments related to current facility costs. After reviewing the AAMA/AIAM comments, the EPA has agreed to use many of their estimates and has incorporated those into its RIA. The following lists the comments that the EPA has accepted and used, explains the comments that it did not accept, and shows the new cost calculations incorporating those changes.

EPA has accepted AAMA/AIAM estimates for 1) 48" single roll electric dynamometer upgrades at $1.3 million, 2) construction of a new exhaust emission cell at $4 million (from the February 1996 submittal), and 3) construction of new full environmental cells for A/C testing at $8 million per cell.

While EPA accepts AAMA/AIAM's estimate of the number of FTP tests currently conducted per shift, EPA does not believe that AAMA/AIAM appropriately calculated the number of tests that could be conducted including the new SFTP requirements. EPA constructed its own analysis of the number of tests that could be run per shift, using the following assumptions:

- 9 hour shift
- 1 hour for lunch
- 42 minutes to conduct an FTP
- 10 minutes to conduct SC03, plus a 10 minute soak
- 10 minutes to conduct US06
- 26 minutes to conduct the highway test, including the prep cycle
- an additional 10 prep cycle when US06 is run after the FTP, when neither the highway cycle or SC03 are also included in the sequence, for a bag change
- 30 minute set-up time before the first test sequence of each shift
- 15 minutes to remove vehicle from cell after test sequence
- 15 minutes to set up next vehicle before test sequence
- an additional 15 minutes to setup each vehicle in full environmental cell
- an SC03 prep cycle before the soak in full environmental cell

EPA believes this methodology is a conservative estimate of the number of tests that can be run each day, because 1) the cycle test times are fixed, 2) the setup and vehicle removal times are taken from the manufacturers’ submission of the FTP test sequence, 3) the additional 10 minute prep cycle for conducting the US06 in sequence with only the FTP assumes that manufacturers do not upgrade laboratory equipment to allow for processing four bags consecutively, and 4) it assumes that a new vehicle is used for every test sequence. Based upon these assumptions, Table IX-2 lists the number of test sequences that can be conducted per shift as calculated by the EPA.

Table IX-2: EPA Test per Shift Estimates

Procedure	**Development Tests**	**Certification Tests**
FTP	6	3
FTP/US06	5	3
FTP/US06/AC simulation	4	2.5
A/C in a Full Environmental Cell	6	6

In every case except for the development FTP/US06 sequence, there are 15-60 minutes left over in the shift, beyond what is needed to conduct the specified number of test sequences. This allows an additional safety margin and time for occassional dynamometer road-load setting sequences. The development FTP/US06 sequence only has 7 minutes left over, but manufacturers who are squeezed for time can easily gain an additional 50 minutes per shift simply by installing equipment that allows four bags to be obtained in sequence. The 2.5 tests per shift for FTP/US06/AC simulation reflect a strategy where one test cell can have only two test sequences, but these are followed by additional prep cycles for FTP tests to be run the next day, while a second test cell conducts three test sequences, but only one FTP prep cycle. The number of A/C tests in a full environmental cell are the same for development and certification, as the only difference between the development and certification test sequences are the highway cycle and the FTP prep cycle, neither of which is conducted in the full environmental chamber.

The EPA uses two scenarios in its cost effectiveness analysis (RIA) to calculate test facility costs. The first scenario is for the use of full environmental cells for A/C testing and the second is for an A/C simulation. Using the above assumptions and estimates, the EPA calculates the following test cell burden for FTP revisions:

Table IX-3: EPA Test Cell Burden

		FEC		***Simulation***
	FTP	**FTP/US06**	**A/C**	**FTP/US06/AC**
Development	50	59	50	74
Certification	10	10	5	12
Total	60	69	55	86

For the full environmental cell (FEC) A/C scenario, the A/C test is assumed to be performed by itself in a full environmental cell and the FTP/USO6 tests are assumed to be done together in a standard exhaust emission cell. For the full environmental cell scenario, 9 new exhaust emission cells would need to be built at $4 million per cell for a cost of $36 million, 60 exhaust emission cells would need to be upgraded at $1.3 million per cell for a cost of $78 million, and 55 full environmental cells would need to be constructed for A/C testing at $8 million per cell for a cost of $440 million. The calculated total cost for the full environmental cell scenario for test facilities is $554 million. The EPA amortized this over a 10 year period at 7 percent for an estimated annual cost of $78.9 million, or $5.26 per vehicle.

For the A/C simulation scenario, the A/C test is assumed to be performed with the FTP/USO6 test cycles in a standard exhaust emission test cell. In the A/C simulation scenario, 26 new exhaust emission cells would need to be built at $4 million per cell for a cost of $104 million, 60 exhaust emission cells would need to be upgraded at $1.3 million per cell for a cost of $78 million, and 30 full environmental cells would need to be constructed for A/C correlation purposes at $8 million per cell for a cost of $240 million. The calculated total cost for the A/C simulation scenario for test facilities is $422 million. The EPA amortized this over a 10 year period at 7 percent for an estimated annual cost of $60.1 million, or $4.01 per vehicle.

After amortization, the incremental facility cost increase between the simulation and the full environmental scenario is $18.8 million per year, or $1.25 per vehicle.

EPA's estimate for the full environmental cell scenario of $5.26 per vehicle is far lower than the $41.87 per vehicle estimated by AAMA/AIAM. While there are substantial differences in the number of tests per shift estimated by AAMA/AIAM compared to EPA, the major difference is that AAMA/AIAM assumed that the FTP and US06 tests would also be conducted in the FEC. This dramatically raises the number of FECs required and the cost, which, in EPA's judgement, is not a reasonable assumption.

3. <u>Recalibration/Certification</u>

Summary of Proposal

In the NPRM, the EPA assumed that each engine family would need to be recalibrated to comply with the SFTP requirements. The effort required was assessed to be one full person-year at $120,000 each for engine control software reprogramming, for each of 319 engine families, yielding total reprogramming costs of $38.3 million.

It was also assumed that each engine family requires an average of 200 emission tests per family, that 20 percent of these engine families would have undergone some form of recalibration for reasons unrelated to the proposed test procedure changes, that inclusion of the proposed test procedure would double testing costs from $1000 to $2000, and that 20 percent of the families will incur incremental recalibration testing costs of $2000 minus $1000 because they would have been tested under the current test procedure independent of this rulemaking. Based upon these assumptions, the estimated testing cost associated with engine recalibration was $115 million. Thus, including reprogramming, the total recalibration costs were $153 million. Amortized over the 5 year engine family life at 7 percent interest, the estimated annual recalibration costs were $37 million.

For certification, the EPA assumed that the SFTP would double the cost per test from $1000 to $2000 dollars and estimated (based on manufacturers' tests reported to EPA) that 3000 certification tests would be performed per year, for an increased testing cost of $3 million annually. The EPA also estimated an increased reporting burden of $2.2 million. Adding the testing and reporting cost increases gave a total incremental certification cost of $5.2 million per year.

Summary of Comments

AAMA/AIAM did not raise any objections to the methodology used by the EPA to calculate the cost of recalibration and most of the assumptions. However, AAMA/AIAM did use different estimates for the FTP test burden of 182,440 tests (161,907 when not multiplied by a yearly increase in tests), and used a different method to calculate the cost per test. AAMA/AIAM assumed that the per shift testing costs are $3600 for exhaust emission cells and $7200 for full environmental cells. AAMA/AIAM divided the cost per shift by the number of tests per shift to get a cost per test. AAMA/AIAM's estimates of the tests per shift were presented in Table IX-1. Using these estimates of the cost per shift and the number of tests per shift, AAMA/AIAM calculated the following cost per test.

Table IX-4: AAMA/AIAM Cost per Test Estimates

Procedure	**Development Tests**	**Certification Tests**
FTP	600	1200
FTP/US06	900	1800
FTP/US06/AC simulation	1200	2700
FTP/US06/AC FEC	2700	3600

Response to Comments

Certification

As discussed in an earlier section, EPA has accepted the AAMA/AIAM estimate of the FTP test burden of 161,907 tests per year, as well as the estimated number of certification tests done annually of 9,714.

The EPA also accepts AAMA/AIAM $3,600 estimate of the cost per shift for a standard test cell, based upon their expertise in conducting such testing. However, EPA disagrees with the $7,200 cost per shift estimate for a full environmental cell. AAMA/AIAM’s cost per shift estimate for FEC was based on the cost of conducting new, never before tried, test procedures for this rulemaking. The EPA considers these costs to be high because they were first time tests. Over time, manufacturers will be able to develop procedures for standardized testing in a full environmental chamber, much as has been done already for FTP testing. However, in recognition of the increased complexity of the equipment used in a full environmental cell, EPA estimates the cost per shift will be 20 percent higher than for a standard test cell.. Thus, EPA has used $3,600 as the cost per shift for exhaust emission cells and $4,320 for the full environmental cells ($3,600*20 percent) in its analyses. Based on EPA's test per shift estimates and cost per shift estimates, the resulting costs per test are:

Table IX-5: EPA Cost per Test Estimates

Procedure	**Development Tests**	**Certification Tests**
FTP	600	1200
AC in FEC	720	720
FTP/US06	720	1200
FTP/US06/AC simulation	900	1440

Using the 9,714 test number and the costs per certification test shown above the testing costs for the two scenarios were calculated. For the simulation scenario the certification testing cost increase is $2.3 million per year. For the FEC scenario the testing cost increase is $0.0 for US06 and $6.9 million for A/C.

Associated with the increased testing burden will be an increased reporting burden. Assuming an increased reporting burden of 3 person-weeks per engine family at $120,000 per person-year, the increased reporting burden for the simulation scenario is estimated at $2.4 million annually. For the FEC scenario the increased reporting burden is also $2.4 million annually for both A/C and US06.

Adding these costs results in an estimated increased certification cost of $4.7 million annually for the simulation scenario and $11.7 million annually for the FEC scenario. Dividing these costs by the assumed 15 million vehicle sales results in an estimated increase of $0.26 per vehicle associated with increased certification demonstration for the simulation scenario and $0.78 for the FEC scenario.

Recalibration

The Agency assumes that each engine family produced for sale in the U.S. will require some level of engine control recalibration to comply with the proposed test procedures. Assuming that each engine family recalibration effort requires 1 full person-year at $120,000 per person-year (including salary, benefits, etc.) for engine control software reprogramming, and using the current 340 federally certified LDV and LDT engine families (the EPA has revised this number after recounting the federally certified LDV and LDT engine families), the estimated cost of reprogramming is $40.8 million for both the simulation and full environmental cell scenario’s.

Associated with this recalibration effort will be considerable emission testing (148,000 tests) over the proposed test procedures to evaluate and verify the recalibration effort. Assuming that each engine family recalibration effort requires an average of 435 emission tests per family (calculated from testing burden information submitted by AAMA/AIAM), and assuming that 60 percent of these engine families would have undergone some form of recalibration for reasons unrelated to the proposed test procedure changes over the three year phase in period (20 percent per year), and using testing costs of $900 for the proposed A/C simulation scenario, $720 for the A/C FEC scenario and $600 for the current test procedure (note that 60 percent of the families will incur incremental recalibration testing costs of $900 minus $600 for the simulation and $720 minus $600 for the FEC because they would have been tested under the current test procedure independent of this rulemaking), the estimated testing cost associated with engine recalibration for the simulation scenario is $80 million and for the FEC scenario is $159.9 million.

Adding these two costs results in an estimated cost for recalibration for the simulation scenario of $120.8 million and for the FEC scenario $200.7 million. For the simulation scenario the recalibration costs are divided equally between A/C and US06. For the FEC scenario A/C recalibration costs are $127 million and the US06 costs are $73.7 million. Amortizing these costs over the assumed 5 year engine family life at 7 percent interest gives an estimated annual recalibration cost of $29.4 million for the simulation and $49 million for the FEC scenarios. Dividing by the assumed 15 million vehicles sold results in an estimated $1.96 per vehicle for the simulation and $3.26 per vehicle for the Full Environmental Cell.

4. Redesign, DDV Testing and Reporting, Mechanical Integrity Testing

Summary of Proposal

The NPRM assumed that the Soak/Start requirements would require hardware changes that would necessitate redesigning the exhaust configuration of the engine family, DDV testing and reporting, and mechanical integrity testing. The Agency also assumed that there would be no hardware changes for US06 and A/C and thus no associated redesign, DDV, or mechanical integrity costs.

Summary of Comments

AAMA/AIAM disputed the Agency's assumption that there would be no hardware changes caused by US06 and A/C (see hardware costs discussion in a later section, below). AAMA/AIAM stated that there would be an associated $16 per vehicle testing cost with hardware changes. AAMA/AIAM did not break down or supply any further information regarding this cost number.

Response to Comments

Because there are hardware changes for A/C (Closed Loop EGR, increased Catalyst Loading) and US06 (increased Catalyst Loading) that would require exhaust emission system changes, the EPA assumes that there will be redesign, DDV, and mechanical integrity costs associated with A/C and US06. Redesign and mechanical integrity costs do not include dynamometer testing costs, but DDV testing and reporting costs include dynamometer testing.

In the discussion on setting air conditioning standards, above, EPA concluded that 34 percent of vehicles will need hardware changes (closed-loop EGR) to comply with the air conditioning design targets. The EPA also estimated that 10 percent of vehicles would require increased catalyst loading in response to the SFTP. 10 percent of 66 percent (the percentage of vehicles not being redesigned for closed loop EGR) equates to 6.6 percent of the vehicles needing redesign, DDV, and mechanical integrity tests associated with increased catalyst loading. The costs for redesign, DDV, and mechanical integrity testing associated with increased catalyst loading are allocated equally to US06 and A/C.

Based on certification data gathered and analyzed by EPA as part of the analysis of costs for the final rule, EPA has revised its estimate of 3 exhaust configurations per family to 1 per family. The estimate of 3 exhaust configurations per family used in the NPRM was not verified and, based upon actual certification data, appears to be in error.

The Agency calculated the redesign costs assuming that each exhaust configuration redesign effort requires 4 person-months at $120,000 per person-year, and using 37.3 percent (34 percent plus 3.3 percent which is half of the redesign needed for catalyst loading) of the 340 federally certified engine families for A/C and 3.3 percent of the 340 for USO6, the estimated redesign cost is $5.5 million. Amortizing this cost over the 5 year engine family life at 7 percent interest results in an estimated annual redesign cost of $1.3 million. Dividing these costs by the assumed 15 million vehicles sold results in an estimated $0.09 per vehicle. Because hardware changes are the same under both the simulation and FEC scenarios the redesign costs are also equal.

Each of the redesigned engine families will, presumably, require a new deterioration factor. This requires a durability demonstration vehicle (DDV) operated over 100,000 miles, with emission tests conducted every 10,000 miles, and appropriate reporting of results. To remain conservative, it is assumed that none of the engine families redesigned in response to the proposed action would have required a new deterioration factor for independent reasons and, therefore, costs are incurred for each redesigned engine family.

As was assumed in the NPRM the EPA again uses a rate of 30 mph over 100,000 miles at $60 per person-hour, the estimated cost for mileage accumulation on durability data vehicles for both the simulation and FEC scenarios is $27.6 million.

Assuming 30 emission tests per DDV (1 per 10,000 miles plus 2 voids), which equates to 414 tests, at $300 per emission test for the simulation, $720 for the A/C part of the FEC and $120 for the USO6 part of the FEC (as proposed, durability demonstration will be done against the current FTP), the estimated testing cost for the simulation is $1.2 million. The estimated testing cost for the FEC scenario is $2.74 million. As it did in the NPRM the Agency assumes the reporting burden associated with DDVs at 60 hours per DDV. Assuming $60 per person-hour, the estimated cost of reporting associated with these DDVs is $.54 million for both the simulation and FEC scenarios.

Adding these costs results in an estimated cost for durability demonstration of $29.4 million for the simulation scenario and $30.9 million for the FEC scenario. Amortizing these costs over 5 years at 7 percent interest gives $7.2 million per year associated with the simulation scenario and $7.5 million per year for the FEC scenario. Dividing these by the estimated sales of 15 million vehicles gives an estimated per vehicle cost of $.48 associated with the simulation scenario and $.50 for the FEC scenario.

Associated with each of the redesigns outlined above will be mechanical integrity testing. This involves mileage accumulation time and effort to verify the integrity of the new designs. Using the appropriate assumptions outlined above for percentage of engine families redesigned and the number of exhaust configurations per family, etc., and assuming a rate of 30 mph over an average of 50,000 miles at $60 per person-hour, the estimated cost associated with mechanical integrity testing is $13.8 million.

Amortizing the total cost over the 5 year engine family life at 7 percent interest gives an estimated annual cost of $3.4 million dollars for mechanical integrity testing. Dividing this cost by the assumed 15 million vehicle sales gives an estimated $.22 per vehicle associated with mechanical integrity testing. Mechanical Integrity Testing costs are the same for the simulation and FEC scenarios.

For the A/C simulation scenario the new annual cost for redesign is $1.3 million; for DDV testing and reporting $7.2 million; for mechanical integrity testing, $3.4 million; for a total annual cost of $11.9 million.

For the A/C full environmental cell scenario the new annual cost for redesign is $1.3 million; for DDV testing and reporting $7.5 million; for mechanical integrity testing, $3.4 million; for a total annual cost of $12.2 million.

5. <u>Hardware Costs</u>

Summary of Proposal

The EPA in its NPRM RIA estimated that there were 15 million vehicles sold outside of California. The EPA also assumed that 51 percent of the engine families would have to add insulation to one catalyst, and 11 percent of engine families would have to insulate 2 catalysts. It was estimated that the hardware cost associated with the addition of a catalyst would be $50 per vehicle, while the addition of catalyst insulation would be $7 per vehicle. Because the redesign costs for both of these hardware changes was considered to be the same, the EPA concluded that the manufacturers would opt for the cheaper catalyst insulation hardware change. In a stand alone scenario the increased hardware cost was estimated at $121 million per year associated with Soak/Start.

The EPA assumed that there would be no hardware changes necessary for A/C and US06 in the NPRM RIA. The A/C requirements were expected to be met through engine control recalibration.

Summary of Comments

AAMA/AIAM members developed their own cost estimates for meeting the A/C and US06 requirements of the revised FTP. The AAMA/AIAM average industry cost for A/C hardware changes is $69 per vehicle; this cost includes a $16 per vehicle cost for additional development and certification testing. The AAMA/AIAM comments did not include any breakdown of these costs, but they did name three emission control devices that the manufacturers would need to incorporate: improvements to A/C compressors to reduce engine load; larger/more heavily loaded catalysts to reduce NOx emissions; and larger exhaust gas recirculation (EGR) valves with electronic control systems to reduce NOx emissions.

The AAMA/AIAM average industry cost estimate for US06 hardware changes was $76 per vehicle; this cost includes a $5 per vehicle cost for additional development and certification testing. The AAMA/AIAM comments did not include the details of these costs but listed 5 types of emission controls that the manufacturers would have to use: improved materials for exhaust manifolds, valves and valve seats; new catalyst washcoat and noble metal formulation to withstand the higher temperatures associated with stoichiometric operation at high loads; larger/more heavily loaded catalysts to reduce NOx emissions; larger EGR valves with electronic controls to reduce NOx emissions; and higher axle ratios to recover power losses due to stoichiometric operation.

AAMA/AIAM also incorporates Retail Price Equivalencies

(RPEs) into their cost calculations and argue that the EPA has done so in the past as part of its policy and should do so for the SFTP RIA.

Response to Comments

AAMA/AIAM did not dispute the assumption of 15 million non-California vehicles sold in the United States. The EPA continues to use this vehicle number in its cost-effectiveness calculations.

The EPA hired a contractor (EEA) to research and calculate hardware related costs for the SFTP. Based on the assumptions concerning standards and procedures from the NPRM, EEA, through a survey of the manufacturers and suppliers, estimated (assuming stoichiometric control at WOT for eight seconds) the hardware components needed, their costs and the market penetration.

EEA analyzed a variety of hardware costs for the engine and catalyst associated with extended stoichiometric control at Wide Open Throttle (WOT). The change in the CO standard from the NPRM makes these hardware changes unnecessary. The emission requirements of the SFTP rule will not require extended stoichiometric control at WOT.

In the discussion on setting air conditioning standards, above, EPA concluded that most vehicles will need to upgrade and recalibrate EGR systems to flow more EGR with the air conditioner operating. To accomplish this, EEA estimated that all vehicles would need electronic control of the EGR system and that some vehicles would need vaccum reservoirs, electric assist, and/or closed-loop EGR systems. However, electronic control of the EGR system is expected to already be present on all vehicles to meet Tier I emission standards and OBD II requirements. In addition, the purpose of vacuum reservoirs and electric EGR systems is to flow more EGR at or near WOT. As the design targets set by EPA do not require increased EGR flow at or near WOT, neither of these technologies are needed. EPA has incorporated EEA's estimate of the proportion of the fleet, 34 percent, that will need to add closed-loop EGR for better EGR control into the hardware cost estimates.

The EPA also estimated that 10 percent of vehicles would require increased catalyst loading in response to the SFTP. The component cost of increased catalyst loading are allocated equally to US06 and A/C. An estimate of the cost of the closed-loop EGR systems was supplied by EEA.

The estimate of the cost of increasing the catalyst loading was made by consulting data from two SAE papers and using confidential data submitted by manufacturers as part of the certification process.

SAE Paper 900271, “Three-way Catalyst Concepts with Optimized Low Precious Metal Loading” by B. Engler, E. Koberstein, and E. Lox (SAE 900271) provides some data about catalysts cost and the effects of catalyst loading of NOx conversion efficiencies. Although the cost data was based on 1989 numbers, the underlying costs of the precious metals are somewhat less that current market costs; consequently, the catalyst costs in the paper are used without modification.

The highest cost catalyst formulation from SAE 900271, Table 1 is $37.7/liter of catalyst size. This high-cost catalyst is a 5/1 Pt/Rh precious metal ratio catalyst of 50 g/cubic foot (1.78 g/liter) loading rate. Current confidential certification information shows that a 5/1 Pt/Rh ratio is a common precious metal ratio and typical catalyst loading rates are between 1 and 2 g/liter. Palladium catalyst are also in use but the lower cost of palladium would result in a lower catalyst cost even at the double loading rate often seen for palladium versus platinum in the catalyst; consequently the analysis was focused on Pt/Rh catalysts. Based on this information, the SAE 900271 cost figure of $37.7/liter seems to represent a reasonable current cost for a robust catalyst.

The sizing of catalysts vary among applications. A review of confidential information submitted by Ford, GM, Chrysler, Nissan, Toyota, Honda, VW/Audi, and Porsche (as part of a separate initiative to revise the certification process) show that typical catalyst sizing is somewhat less than 1 liter of catalyst per liter of engine displacement for Tier 1 and TLEV vehicles.

The sales-weighted average engine displacement is 2.3 liters.[21]

To determine the amount of loading increase necessary, we set our target at a 25 percent overall reduction of NOx emissions.

In Figure 3 of SAE 900271, the authors present data on the relationship between NOx conversion percentages and precious metal loading for an optimized catalyst after thermal aging equal to 60,000 km. A linear regression of that data, shows that a 15 percent increase on catalyst loading would reduce NOx emissions by 25 percent.

SAE Paper 872096, “Optimization of Catalyst Systems with Emphasis on Precious Metal Usage” by P. Öser and H. Völker in Table 14 present data showing a relationship between NOx conversion percentages and precious metal loading for an aged catalyst of a ‘former’ design. A linear regression of that data, shows that a 15 percent increase on catalyst loading would reduce NOx emissions by 23 percent. This confirms the figures from SAE 900271 which are used in the cost analysis.

The cost of catalyst loading used in the RIA is $37.7 / liter of catalyst (the SAE 900271 cost data) x 1 liter of catalyst / liter of engine displacement (typical catalyst-engine sizing) x 2.3 liters (the average engine displacement) x .15 (to get a 25 percent reduction in NOx emissions) = $13.00.

Table IX-6 summarizes the component cost and market penetration of the hardware changes.

Table IX-6

Component	**Component Cost**	**Market Penetration**	**A/C share**	**US06 share**

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[21] EPA Technical Report: “Light-Duty Automotive Technology and Fuel Economy Trends Through 1993" by J. Dillard Murrell, Karl H. Hellman, and Robert M. Heavenrich, May 1993, EPA/AA/TDG/93-01

Closed Loop Control EGR	$9	34 percent	100 percent	0 percent
Catalyst Loading	$13	10 percent	50 percent	50 percent

The EPA has also applied a Retail Price Equivalency (RPE) to the hardware costs associated with the SFTP. Using guidelines laid out in the Jack Faucett report (10/85 Contract No. 68-03-3244), done for the EPA, on RPE for motor vehicle emission control equipment, the EPA for this rulemaking has multiplied the hardware costs by 1.29 to get the RPE (see the Jack Faucett report for more detailed information on RPE calculations).

Based upon the component cost, market penetration, and air conditioning vs. US06 emission share from Table IX-6, the RPE factor of 1.29, and 15 million vehicles per year, the EPA has calculated the hardware cost to be $71.8 million per year for air conditioning emission control and $12.6 million per year for US06 emission control.

In addition to the per vehicle piece cost of the hardware, there are also one-time costs associated with retooling. Based on information in EEA’s hardware cost report, written for the SFTP, the EPA has calculated the tooling costs associated with the hardware components and penetrations listed above. EEA estimated, from tooling and engineering costs it received from two manufacturers, that there is a $20 million tooling and engineering cost per engine family (EEA uses 50 engine families instead of 340) associated with the hardware changes assumed by EEA. EEA estimated that half of the $20 million cost would be for tooling and half for engineering. Engineering is assumed by the EPA to be included in recalibration, redesign, and mechanical integrity costs. Using the $10 million cost estimate for tooling and 50 total engine families EEA’s total cost for tooling is $500 million. EEA’s tooling costs are based on 10 hardware changes per family, with varying market penetrations for each (average penetration is 63.8 percent). Using EEA’s cost and penetration estimates the EPA has calculated a total tooling cost per hardware change of $78.3 million. Because the EPA lacks any data to the contrary the Agency expects that the tooling cost per change to be relatively consistent with EEA. The EPA, as explained above, estimates only two hardware changes per family, both of them relatively minor. Using the same market penetrations as listed above, 34 percent for Closed Loop EGR (A/C) and 10 percent for Catalyst Loading (split between USO6 and A/C), the EPA calculates a total tooling cost of $34.5 million, amortized at 7 percent for 5 years yielding an annual cost of $8.4 million for tooling. $7.4 million of this cost is allocated to air conditioning and $1.0 million to US06 emission control. Dividing this cost by the estimated sales of 15 million vehicles gives an estimated per vehicle cost of $.56 for both the simulation and FEC scenarios.

Using the above hardware cost estimates, associated tooling costs, and RPE methodology the EPA calculates estimated annual costs of $8.4 million for tooling and $84.4 million for hardware.

6. Cost Totals

Summary of Proposal

The proposed cost totals, in dollars per vehicle, were based on 15 million cars sold per year outside California. The total annual cost for the SFTP in the NPRM was $222.1 million per year for a per vehicle cost of $14.81 (stand alone).

Summary of Comments

AAMA/AIAM have estimated the cost per vehicle for the proposed SFTP to be $69 for A/C and $76 for USO6 for a total cost per vehicle of $145.

Response to Comments

The cost totals, in dollars per vehicle, are based on 15 million vehicles sold per year, which is the number of vehicles sold outside of California per year, and is simply the sum of the costs assessed in each of the previous sections on cost.

A/C Simulation Scenario: The total annual cost is $198.9 million per year: $153.4 million for A/C and $45.5 million for USO6; for a total per vehicle cost of $13.26: $10.23

for A/C and $3.03 for US06

A/C Full Environmental Scenario: The total annual cost is $244.5 million per year: $192.6 million for A/C and $52 million for US06; for a total per vehicle cost of $16.30: $12.84 for A/C and $3.46 for US06

The difference between the A/C simulation scenario and the full environmental cell scenario is $3.04 per vehicle.

B. Benefits

1. Attainment of NAAQS Standards

Summary of Proposal

The EPA, in an effort to attain and maintain National Ambient Air Quality Standards (NAAQS), concluded that a national rule regulating off cycle emissions was beneficial to achieving that goal.

In the NPRM the EPA stated that there was a need for SFTP revisions due to many factors, including; the fact that many air quality regions have failed to attain the NAAQS, particularly for ozone and CO; and that there has been an increase in the number of vehicles and mileage in the in-use fleet which, even though single vehicles have experienced significant emission reductions, has increased total emissions from the motor vehicle fleet

Summary of Comments

AAMA/AIAM argue that benefits are only important relative to NAAQS levels i.e. there are no benefits in reducing emissions in areas that are below NAAQS levels or areas that are projected to reach those levels without SFTP. AAMA/AIAM believe that the EPA must show the benefits of the SFTP rule only in relation to achievement of NAAQS levels, which (they argue) is the CAA and EPA guideline for exposure levels.

AAMA/AIAM argue that most moderate-and-worse ozone non-attainment areas outside of California and the Northeast have either requested attainment status on the basis of national ambient air quality data or have performed urban airshed modeling to demonstrate that NOx controls would be detrimental to attainment of the ozone standard in its particular region. AAMA/AIAM believe that these waivers and modeling show that there is no need for a new costly rule making for NOx emission reductions like the SFTP.

Response to Comments

The EPA believes that the arguments for a national rule for off cycle emissions, stated in the NPRM and reiterated above, are still valid. The following is further reasoning for having a national rule that would help to lower emissions and help non-attainment areas achieve and maintain NAAQS levels.

The precursors to ozone and ozone itself are transported long distances under some commonly occurring meteorological conditions. Specifically, concentrations of ozone and its precursors in a region and the transport of ozone and precursor pollutants into, out of, and within a region are very significant factors in the accumulation of ozone in any given area. Regional transport may occur within a state or across one or more state boundaries. Local stationary source NOx and/or VOC controls are key parts of the overall attainment strategy for non-attainment areas. However, the ability for an area to achieve ozone attainment and thereby reduce related health and environmental effects is often heavily influenced by the ozone and/or precursor emission levels of upwind areas. Thus for many of these areas, attainment of the ozone NAAQS will require control programs much broader than strictly locally-focused controls in order to take into account the effect of emissions and ozone far beyond the boundaries of the actual non-attainment area. In addition, the mobile nature of automobiles, and the fact that vehicles travel into and out of nonattainment areas, make national regulation of such sources necessary. Finally, national regulations are needed to prevent significant deterioration in areas of current attainment.

For this reason, effective ozone control requires an integrated strategy which combines cost-effective reductions in emissions from both mobile and stationary sources at the local, state, regional and national levels. The SFTP is a cost-effective national measure that will be beneficial towards reducing the precursors of ozone and the achievement and maintaining of NAAQS standards.

2. NOx Waivers

Summary of Proposal

The EPA in the SFTP NPRM did not address the NOx waiver issue directly but did assume that in order for all areas to reach NAAQS levels a national rule was necessary. The NPRM did not exclude areas because they were given or may receive NOx waivers.

Summary of Comments

AAMA/AIAM argues that NOx benefits cannot be taken from non-attainment areas that have received NOx waivers. The manufacturers argue that the EPA, by approving NOx waivers, is stating that reducing NOx in those areas is not beneficial in relation to achieving NAAQS levels.

Response to Comments

The Clean Air Act Amendments (CAAA) include new provisions in section 182(f) to control emissions of nitrogen oxides (NOx) and specifies circumstances under which the new NOx requirements would be limited or would not apply. Section 182(f)(1) provides that the new NOx requirements shall not apply if the Administrator determines one of three tests: net air quality benefits are greater in the absence of NOx reductions from the sources concerned; in non-attainment areas not within an ozone transport region, additional NOx reductions would not contribute to ozone attainment in the area; or in non-attainment areas within an ozone transport region, additional NOx reductions would not produce net ozone air quality benefits in the transport regions.

EPA recently issued guidance on ozone demonstrations, based on a two-phase approach for the submittal of ozone SIP attainment demonstrations. Under Phase I, the state is required to conduct limited UAM modeling and submit a plan implementing a set of specific local control measures to achieve major reductions in ozone precursors. Phase II involves a two year process during which the EPA, the states, regional associations, and other interested parties can improve emission inventories and modeling as well as identify regional measures which may be needed to supplement the local controls of Phase I.

As a part of these Phase I submittals, some states have indicated that on the basis of preliminary information, locally-based stationary source NOx controls in those non-attainment areas would not be helpful -- or, in a few cases, would be detrimental -- to attainment of the ozone NAAQS.

Section 182(f) of the CAA will not apply if the administrator determines that reducing NOx within a non-attainment area would not contribute to attainment of the ozone NAAQS within the same non-attainment area. Section 182(f) also requires the EPA to limit the assessment of state petitions to the extent that NOx reductions within a non-attainment area are likely to have on that specific local area's ability to meet the NAAQS (i.e., the Act does not permit an assessment of pollutant transport in to and out of the area.). However, in their modeling supporting their overall attainment demonstrations under Phase II, states will need to project the levels of ozone and precursors that are transported into the area. In Phase II for the current process, it is ultimately necessary for states and EPA to consider both the impact of NOx controls at both the local and regional levels in assessing how attainment can be achieved. The EPA estimates that broad, regional ozone and NOx control in upwind areas will be necessary for Phase II demonstrations even where Phase I modeling results currently indicate that local NOx controls may be unnecessary or detrimental.

It is very important to view EPA's granting of exemptions from local NOx controls in some areas under Phase I of the attainment process in the broader context of the ultimate Phase II determinations.

There are three reasons why the granting of NOx waivers and implementing NOx control programs on regional and national scales is not contrary. The first is that since most of the NOx waiver petitions contain non-modeling analyses and many petitions with modeling analyses are completing improved Phase II modeling analyses, EPA's approval of each NOx exemption has been granted on a contingent basis.

Second, EPA has not considered regional scale NOx issues when acting on state petitions for exemptions from local NOx controls. Because NOx has been shown to be effective in reducing regionally-transported ozone, the broader modeling under Phase II is likely to show that many areas will need regional NOx controls to counter expected growth and maintain or reach attainment.

Third, the EPA has separate authority under the CAA (section 110(a)(2)(D)) to require a state to reduce emissions from sources where there is evidence showing that transport of such emissions would contribute significantly to non-attainment or interfere with maintenance of attainment in other states.

Therefore, the EPA believes that decisions about initiating new NOx control programs which have a regional/national-scale effect are appropriately made based on the best understanding available at the time of the broad attainment needs of all areas.

3. Exclude OTR and CA (overlapping rules)

Summary of Proposal

The EPA in the SFTP NPRM did not exclude the Ozone Transport Region (OTR) from the Regulatory Impact Analysis. All benefits and costs were calculated under the assumption that the OTR needed to comply with the EPA SFTP rule.

The EPA did not include California in its costs and benefits calculations in the NPRM RIA. California was not included because it has its own FTP regulations and standards.

Summary of Comments

The manufacturers argue that since the OTR is going to follow California standards the EPA cannot include the estimated emissions reductions from OTR states as a benefit from FTP revisions, since the revisions will not have an effect in those states.

Response to Comments

The EPA reiterates its intent that all vehicles, including National LEVs, will become subject to any off cycle or SFTP standards and procedures promulgated under authority of Section 206(h).

EPA anticipates that CARB will act soon after the final federal Revised FTP rule to adopt California off-cycle requirements, but with standards that are of appropriate stringency for vehicles that are certified to LEV emission standards with the conventional FTP. Once SFTP requirements are part of the California LEV program, EPA will analyze the cost/benefit implications of off-cycle controls for LEVs in the National LEV context. Because harmonization of federal and California FTP revisions is an important component in meeting EPA's overall harmonization objective, EPA would then initiate a rulemaking with the intent to harmonize the Federal and California SFTP requirements, though EPA would use its own analyses to determine the appropriate SFTP requirements for NLEV vehicles.

Because vehicles sold in the OTR are currently, in general, tested under EPA’s testing authority and because the intent of NLEV is for all vehicles (including those sold in OTR) to be under EPA’s testing authority, the EPA has decided to include the OTR in the cost and benefit calculations and continue to exclude California.

4. Migration

Summary of Proposal

In the NPRM RIA the EPA, because the SFTP was considered a national rule, did not discuss migration issues or make any calculations related to vehicle migration.

Summary of Comments

AAMA/AIAM, based on their proposal that OTC should be excluded from the analysis, argue that the effects of vehicle migration in the OTC should not be included because they are already incorporated into regional models.

Response to Comments

In its final rule the EPA is including the OTC in its analysis of costs and benefits (see Exclude OTR and CA section). The RIA includes a national and regional analysis, neither incorporate vehicle migration into their calculations. Vehicle migration is not an issue in the regional analysis because all vehicles will follow SFTP guidelines.

5. Baseline for Benefit Calculations

EPA evaluated the cost effectiveness of the proposed rule using available data. For the A/C and aggressive driving control areas the EPA used available Tier O data. In the case of intermediate soak, EPA used data on Tier 0 and Tier 1 vehicles. One of the Tier 1 vehicles met theoretical Tier 2 standards and used a close-coupled catalyst, a technology which is expected for LEVs and potentially for Tier 2 vehicles. In the NPRM, EPA also asked for emission data on LEV technology vehicles due to the significant redesign costs associated with the requirement.

Summary of Comments

AAMA/AIAM comments included cost effectiveness estimates using Tier 2 vehicles as a baseline for estimating benefits. AAMA/AIAM argued that it is necessary to consider Tier 2 scenario since it is likely that Tier 2 standards will be in place by 2004, if not before.

Response to Comments

EPA believes it is most appropriate to consider cost effectiveness based on the best available data and applicable standards. Therefore, EPA's cost effectiveness analysis looked at the cost and benefits for Tier 1 vehicles, using data provided by AAMA/AIAM. Intermediate soak, however, is a unique case in which it is relevant to consider the potential cost effectiveness for Tier 2 vehicles. As discussed in the intermediate soak section, there are significant amortized retooling costs associated with controlling intermediate soak emissions and these up-front costs become prohibitive if Tier 2 standards did indeed become applicable. This is not true in the case of A/C or aggressive driving control.

6. Benefits by Control Area (Aggressive Driving, IS, and A/C)

i. Aggressive Driving Benefits

Summary of Proposal

The benefits from in-use driving control include both aggressive driving and microtransient control. EPA estimated in-use emissions using new cycles developed to characterize the full range of in-use driving behavior. The potential emission impact was the difference between in-use emissions and the hot stabilized emissions generated by the LA4 (UDDS). The EPA concluded that the LA4 under-predicts actual in-use hot stabilized emissions by 0.043 g/mi NMHC, 2.8 g/mi CO, and 0.083 g/mi NOx for current technology, properly operating vehicles. Proposed control of aggressive driving and microtransient operation would control all of the NMHC increase and 75 percent of the CO and NOx increase. In addition, NMHC and CO benefits are adjusted by 0.012 g/mi and 0.3 g/mi respectively, to reflect control associated with commanded enrichment during A/C operation. On a gram per mile basis, the agency estimated the emission benefits to be 0.055 for NMHC, 2.39 for CO, and 0.062 for NOx.

Summary of Comments

Direct Benefits

AAMA/AIAM raised a number of concerns in their comments regarding the EPA's benefit calculations for the control of aggressive driving. In elaborating on their concerns, AAMA/AIAM generated their own emission estimates to contrast with the EPA's estimates. AAMA/AIAM calculated benefits associated with their own suggested standards, as well as their own estimate of benefits associated with the EPA proposal, after correcting for what AAMA/AIAM believed were errors in the Agency's assumptions or methodology.

AAMA/AIAM questioned the Agency's determination that 75 percent of the excess NOx and CO emissions would be controlled and they cited the lack of any discussion how these percentages were derived. In turn, AAMA/AIAM did not believe EPA had demonstrated an appropriate link between the level of emission control and the emission benefits claimed by the Agency. They also felt that it was inconsistent for EPA to claim emission reductions for emissions generated on the Remnant and ST01 cycles, in that EPA claimed these emissions were due to microtransient operation and AAMA/AIAM argued that the control of aggressive driving would primarily impact commanded enrichment.

AAMA/AIAM stated that EPA's emission benefit calculations using Tier 0 vehicles were not relevant to the rulemaking and emissions from Tier I and Tier II vehicles should be considered. While acknowledging the uncertainty in their own methodology to establish Tier 1 benefits, AAMA/AIAM used REP05 and US06 emissions from the Tier 0 test program to establish US06/REP05 ratios which were then used to infer REP05 emissions from US06 emissions results from the Tier 1 test program. Using this general approach, AAMA/AIAM estimated alternative emission benefits for NMHC, CO and NOx, as described below.

AAMA/AIAM argued that the EPA assumed US06 NMHC emissions could be reduced to bag 2 levels and REP05 emissions reduced to hot LA4 levels, but the EPA did not quantitatively relate US06 and REP05 emissions, and thus, EPA understated NMHC benefits. AAMA/AIAM compared Tier 0 and Tier I emissions for REP05 and concluded that the impact of controlling aggressive driving CO emissions may not be reduced for Tier I vehicles and reducing US06 emissions to full FTP levels will likely reduce REP05 emissions all the way to hot LA4 levels. AAMA/AIAM analyzed the impact of stoichiometric calibration on REP05 NOx emissions and showed a dis-benefit.

A/C related benefits on US06

AAMA/AIAM commented that they believed the EPA erred by the inclusion of CO benefits from eliminating commanded enrichment during A/C operation because CO emissions are not an air quality concern during the summer months when air conditioners are typically used.

For NMHC benefits associated with eliminating commanded enrichment during A/C operation, AAMA commented that the uncertainty in how such emissions would be controlled caused them to conclude that the emission benefits should be allocated 50/50 to aggressive driving control and A/C control.

Microtransient enrichment

AAMA/AIAM's review of the EPA's analysis of microtransient operation concluded that the EPA had failed to support the contention that ST01 and REM01 excess emissions relative to LA4 emissions could be eliminated. AAMA/AIAM felt that EPA's analysis of throttle variation on the Mercedes and EPA's DPWRSUM analysis did not provide adequate justification.

AAMA/AIAM argued that the EPA did not consider other factors besides microtransients and throttle movement which might explain differences. AAMA/AIAM felt that NOx differences between the cycles indicate that other factors are important, and thus, no NOx reduction can be attributed to control microtransient enrichment. AAMA/AIAM estimated a range of potential benefits for CO with their best estimate of 0.66 g/mi. AAMA/AIAM argued that there were no NMHC benefits because SC01 (which includes ST01) emissions were found to be equivalent to bag 3 levels and thus no additional control of ST01 emission would be achieved by holding SC01 emissions to bag 3 levels, as proposed by the EPA.

AAMA/AIAM summarized the conclusions of their detailed technical analysis in table form which showed their estimates for the various benefits scenarios. The table is reproduced below:

Table IX-7: AAMA/AIAM Aggressive Driving Benefits Table for US06 Standards

	NMHC		**CO**		**NOx**	
	US06	**REP05**	**US06**	**REP05**	**US06**	**REP05**

Tier 1 Baseline (g/mi)	0.206	0.083	16.33	7.01	0.419	0.37
	Post Control Levels (g/mi)					
EPA Proposal (EPA)	----	0.028	----	2.7	----	0.3
EPA Proposal (AIR)	0.018	0.007	1.7	1.06	0.2	0.156
Full Stoichiometry	0.046	0.019	1.6	1.0	0.527	0.412
AAMA/AIAM proposal	0.04	0.016	2.5	1.55	0.46	0.36
	Benefit (g/mi)					
EPA Proposal (EPA)	----	0.055	----	4.31	----	0.07
EPA Proposal (AIR)	0.188	0.076	14.63	5.95	0.219	0.213
Full Stoichiometry	0.16	0.064	14.73	6.01	-0.108	-0.042
AAMA/AIAM proposal	0.166	0.067	13.83	5.45	-0.041	0.01

Response to Comments

For the final rule the Agency has revised the emission benefits to reflect the final standards which are revised from the NPRM. The revised benefit estimates also incorporate data from new test programs and a number of the comments provided by AAMA/AIAM, as discussed below.

The EPA used US06 phase II data on Tier 1 vehicles provided by AAMA/AIAM in their comments. The Agency's methodology used in calculating the final emission benefits is consistent with the one used for the NPRM; however, several assumptions were needed due to the limited number of driving cycles used in AAMA/AIAM 's phase II test program. In the NPRM, Tier 0 data for three cycles were used to represent in-use operation: ST01, REM01 and REP05, as well as the FTP cycle (UDDS). The proposed control cycle, US06 was designed to control the "excess" emissions associated with the three inventory cycles. In the phase II test program, manufacturers only tested the US06 cycle and the UDDS. Given this limitation, the EPA employed the US06/REP05 ratioing methodology used by the manufacturers to estimate REP05 emissions. To estimate emissions associated with ST01 and REM01, the EPA reduced the Tier 0 data on these cycles by the ratio of Tier 1 to Tier 0 NMHC and CO emissions for bag 2 of the FTP. This adjustment reflects the impact of the Tier 1 standards on hot, stabilized emissions, assuming that the impact on bag 2 reflects the reductions on ST01 and REM01, as they are all hot stabilized driving cycles. Bag 3 contains driving that is more representative of ST01 and REM01 than bag 2, but EPA judged it inappropriate to use the bag 3 data for NMHC and CO adjustments due to impacts of the hot start on relative Tier 0 and Tier 1 bag 3 emissions. In recognition that bag 3 NOx emissions are not significantly impacted by the hot start and that bag 3 captures operation which otherwise would be excluded and in doing so may lead to an overstatement of emission benefits, NOx emissions were adjusted using the ratio of bags 2 and 3. EPA feels this correction is appropriate as it reflects changes in the control of hot stabilized emissions as demonstrated by emissions on the hot stabilized portion of the FTP. These steps provide a baseline estimate of Tier I in-use emissions. It should be noted that this methodology greatly reduced the baseline emission inventory impacts for the ST01 and REM01 cycles for Tier I vehicles, especially for NMHC and CO, as presented in Table IX-8.

To calculate the actual benefits associated with the proposed control, the Agency used US06 emissions for each Tier 1 vehicle at the proposed control level (the lower of the US06 design targets or the actual vehicle's emission in production calibration) and converted these emissions to a REP05 estimate using the manufacturers' methodology. The difference in the controlled and uncontrolled REP05 emissions weighted by its fraction of in-use operation (28 percent) yields the REP05-related emission benefit. The REP05-related benefit represents control of 88 percent of the REP05 increment above the LA4 for NMHC, 72 percent for CO, and 78 percent for NOx. These percentages are applied to the Tier 1 inventory contributions for ST01 and REM01 to calculate their emission benefit. The Tier 1 benefit estimates are 0.024 g/mi for NMHC, 1.501 g/mi for CO and 0.073 g/mi for NOx.

This methodology provides a direct link between the level of control and the emission benefit, and thus, it addresses one of the concerns raised by AAMA/AIAM. Also, EPA does not claim NMHC or CO benefits associated with controlling commanded enrichment during A/C operation due to the revisions in the final standards. The table below summarizes the benefit calculations.

Table IX-8

	NMHC	CO	NOx
Contribution to Tier 0 Inventory (g/mi)			
ST01	0.013	0.476	0.019
REM01	0.015	0.696	0.038
REP05	0.015	1.609	0.026
Ratio of Tier 1 to Tier 0 hot stabilized emissions	0.372	0.338	0.806
Contribution to Tier 1 Inventory (g/mi)			
ST01	0.005	0.161	0.014
REM01	0.005	0.235	0.028
REP05	0.017	1.694	0.051
Uncontrolled REP05 emissions (unweighted)	0.078	6.622	0.345
Controlled REP05 emissions (unweighted)	0.025	2.277	0.203
Ratio of REP05 benefit to contribution (in percent)	88	72	78
Tier 1 Emission benefits (weighted)			
REP05	0.015	1.217	0.04
ST01	0.004	0.116	0.011
REM01	0.005	0.169	0.022
Total	0.024	1.501	0.073

As discussed above, the EPA incorporated a number of AAMA/AIAM's comments into the revised benefits calculations; however, the Agency disagrees with AAMA/AIAM on the issue of benefits associated with ST01, REM01, and microtransient operation. EPA believes that emission reductions over US06 will translate into emission reductions over in-use operation represented by ST01 and REM01. All three of these cycles contain microtransient operation, or small scale speed deviations, as well as higher loads which are all characteristic of in-use operation, but not represented in the UDDS. Many vehicles have NMHC and CO emissions increases during microtransient operation due to momentary enrichment, while other vehicles see NOx increases resulting from short-duration lean excursions. As discussed in the standard setting section, EPA believes improved air-fuel control will reduce these emissions. It is reasonable to believe that the increment of ST01 and REM01 emissions above that on the LA4 will be reduced proportionally to the reduction of REP05 emissions above that on the LA4, especially since US06/REP05 emissions represent a majority of the emission benefits for all three pollutants.

It should also be noted that all of the emission benefit calculations in support of this Final Rule are based upon data from properly operating vehicles with 50k deteriorated components. Data from in-use testing, such as incorporated by the MOBILE model, indicate that average in-use emissions are much higher, due to the disproportionate impact of vehicles with malfunctions or higher deterioration. While EPA did not have any data to assess the impact of malfunctions and higher deterioration on the off-cycle emission inventory or the emission reductions associated with this rule, it is virtually certain that the higher in-use baseline emissions will translate into larger emission benefits from control of off-cycle emissions, perhaps by a factor of two or more. This means that the emission benefit calculations in support of this rule, not just for aggressive driving but also for air conditioning operation, are likely to be extremely conservative.

ii. Air-conditioning Benefits

Summary of Proposal

Eight Tier 1 vehicles equipped with HFC-134a A/C refrigerant systems were used as the basis for estimating the emission benefit associated with control of A/C related emissions. On a hot, stabilized LA4, the average increases were 0.011 g/mi for NMHC, 0.30 g/mi for CO, and 0.205 g/mi for NOx. As discussed in the NPRM, the NMHC and CO emissions increases were allocated to control of emissions associated with aggressive driving. EPA proposed to control 75% of the NOx increase and the benefit was also adjusted for air conditioner usage and compressor on-time for a typical ozone nonattainment day. The adjusted NOx benefit was 0.092 g/mi.

Summary of Comments

The Agency received numerous and detailed comments from AAMA/AIAM regarding the Agency's calculation of in-use emission benefits that would result from controlling A/C-related emissions at the proposed levels. These comments focused on two aspects of the EPA analyses. First, the commenter suggested that the meteorological conditions used for the test programs, as well as for the proposed test procedure, are inappropriate because such a "worse-case" procedure is not warranted. Second, the commenter argued that the use of these meteorological conditions to estimate in-use emission impacts was carried out inappropriately by the Agency, and that generally the Agency's estimation of in-use benefits was flawed. The commenter presented their own detailed analysis of how to estimate in-use emission benefits that would result from control of A/C-related emissions.

Response to Comments

The set of meteorological conditions selected for the variety of investigative test programs was determined through a cooperative effort involving the parties represented by the commenter and was not developed solely by EPA, as the commenter implies. These test conditions were developed to assess the potential real-world impact of air conditioner operation on vehicle emissions under meteorological conditions approximating those of peak ozone formation. The EPA and the parties represented by the commenter acknowledged this and pooled the best data and analyses available at the time and arrived jointly at an acceptable set of meteorological conditions. In addition, the parties represented by the commenter provided the resources to conduct testing at their facilities that would simulate these conditions.

The Agency disagrees with the commenter's suggestion that a compliance test procedure based on the selected "worse-case" conditions is not warranted. Given the known non-linear effect of load on NOx emissions, the Agency selected meteorological conditions close to the 90th percentile to ensure adequate control of A/C-related emissions throughout the range of conditions that are characteristic of ozone nonattainment days. Additional discussion of the selection of the levels of the meteorological parameters can be found in the NPRM (60 FR 7404, February 7, 1994).

The Agency agrees with some of the comments regarding the proper methodology for estimating in-use emission benefits resulting from controlling A/C-related emissions and has reviewed and revised the calculation of in-use benefits for the final rule. However, the Agency does not agree with many of the commenter's suggestions and found much of the commenter's analysis to be inaccurate or inappropriate. A detailed discussion of the Agency's revised analysis follows.

The Agency agrees with the commenter that the calculation of in-use benefits should not be based on days with maximum temperatures of 95 ± 5° F, as was the case in the NPRM. Such days do not adequately represent the "typical" ozone nonattainment day and use of such days probably caused an overestimate of the emissions benefits in the NPRM. The comment prompted the Agency to return to the available data to better estimate both the average maximum daily temperature and the average daily relative humidity for ozone exceedance days and to base the analysis of emission benefits on such days. The Agency’s available data for this analysis consists of the 15 highest daily maximum ozone concentrations for 44 cities for each of the years 1988 through 1992 (3300 data records). The ozone readings in this database were integrated with meteorological data from the National Climatic Data Center, including daily maximum temperature, a.m. and p.m. wind speed, relative humidity, and cloud cover. Relative humidity is expressed as a 10 a.m. - 4 p.m. average. Analysis of these data, after eliminating data from ozone attainment days, reveals that the "typical," or average ozone nonattainment day experiences a 92° F maximum temperature and a 10 a.m. - 4 p.m. average relative humidity of 43 percent.

The Agency disagrees with the suggestion by the commenter that the cities in the database that are in California and the

Ozone Transport Region (OTR), as well as those cities that are marginal or moderate nonattainment areas, should be eliminated from the analysis. Additionally, the commenter's analysis, which excluded these cities, was not performed on the appropriate subset of the data. The database contains the 15 highest ozone readings for each city for each year in the five year period and many of these readings, while among the highest for a given city, may not exceed the National Ambient Air Quality Standard for ozone, and should therefore be excluded. The commenter did not restrict the analysis to the ozone exceedances in the database, which should be the focus; they instead chose to include all of the ozone readings, leading to an underestimate of the maximum temperature of ozone nonattainment days. The Agency investigated excluding the California and OTR cities from the analysis and found no net impact on the average temperature and humidity parameters. In addition, using the commenter's methodology, including the population-weighting approach that they recommend, but appropriately limiting the data to ozone exceedances only (as discussed above), results in an average daily maximum temperature of 91° F for the typical ozone nonattainment day, rather than the 89° F obtained by the commenter. The Agency does not view this result to be significantly different from that obtained by the preferred methodology.

The analysis conducted by the Agency for the NPRM did not assume, as the commenter suggests, that all driving occurred at the daily maximum temperature, and in fact adjusted the emissions benefits to account specifically for this and other factors. The Agency used data from a survey of A/C usage conducted in the early autumn of 1994 in Phoenix, Arizona to determine the proportion of total driving during a typical ozone nonattainment day during which the A/C compressor was engaged. This "factor" (the use and determination of which is discussed below) inherently accounts for variations in temperature, humidity, solar load, A/C usage, and the distribution of driving throughout the entire day. The Agency continues to believe that this is a valid approach for estimating emission benefits.

The commenter performed a similar adjustment, but in doing so misinterpreted what EPA presented in the NPRM and used the data incorrectly, causing them to further underestimate the emission benefits. The primary problem with the commenter's analysis was a lack of understanding of the difference between the definitions of A/C activity <u>on a day</u> with a given maximum temperature and A/C activity <u>at</u> a given temperature. The Agency reported in the NPRM a finding that, <u>on days with a maximum temperature of 95° F</u>, A/C usage by drivers was 77 percent. The commenter applied this finding as if it represented A/C use <u>at 95° F</u>, which, assuming as they did that A/C use is zero at 70° F and that A/C use is linear with temperature, resulted in a finding by the commenter that A/C use at 85° F (the average A/C use temperature, according to the commenter) would be 46 percent. In fact, A/C use at 95° F is about 94 percent, and if the commenter's analysis were carried out using the appropriate figure the result is a finding that A/C use at 85° F is approximately 56 percent. Correction of this error alone causes the commenter's estimate of in-use NOx benefits to increase by more than 20 percent.

Using the data collected in Phoenix, the Agency constructed a model to estimate the proportion of "compressor-engaged" driving for days with a maximum temperature of 92° F and a daily average relative humidity of 43 percent (a "typical" ozone nonattainment day, as was defined above), using the following methodology. The focus on the time during which the A/C compressor is engaged, or cycled on, is due to the Agency's belief that use of the A/C system impacts vehicle emissions due to the load of the compressor. Therefore, it is the periods during which the compressor is engaged that are contributing to an increase in emissions.

Given that there were only a few days during the Phoenix survey period that came close to actually matching the definition of a "typical" ozone nonattainment day, the Agency used a regression model to predict compressor activity (specifically, the proportion of a day's driving during which the compressor was engaged) on the basis of daily maximum temperature and daily 10 a.m. - 4 p.m. average relative humidity. It is worth noting, however, that of the four days during the survey period which had maximum temperatures of 92° F, two had a 10 a.m. - 4 p.m. average relative humidity somewhat close to the 43 percent of a typical ozone nonattainment day. On these days the relative humidities of 40 and 46 percent, which bracket the 43 percent target, caused the A/C compressor to be engaged 45 and 65 percent of the time, respectively, or an average compressor-engaged factor of about 55 percent. However, the Agency is unwilling to rely on only two days of data to provide an accurate estimate of compressor activity and proceeded with a regression analysis using the entire set of 45 days for which A/C usage data was collected. Some of the relevant regression results are shown in Table IX-9.

Table IX-9

Variable	**Coefficient**	**Std. Error**	**T**
Intercept	-2.48	0.404	-6.132
Relative Humidity	0.41	0.252	1.616
Maximum Temperature	0.03	0.004	8.244

The R-square of the regression is 0.6298. The equation defined by the regression was then used to predict that the level of compressor activity on a day where both the temperature and humidity match those of the typical ozone nonattainment day would be 52 percent of all driving during such a day (+/- eight percent at a 95 percent confidence level). This is lower than the factor used in the NPRM, but not as low as the demonstrably incorrect figure suggested by the commenter. This 52 percent factor is then incorporated into EPA's revised calculation of A/C-related emission benefits according to the methodology described below.

Data from the variety of investigative test programs were used to estimate the NOx emission benefits of A/C control, using the following methodology. The Agency found that the A/C compressor was engaged for 100 percent (or very close to it) of these emission tests in most cases, and for those tests where the compressor was engaged for less than 100 percent the NOx emissions were adjusted upward to represent the maximum possible emissions increase due to A/C load. The resulting emissions impact approximates the impact that would be observed if drivers always had the A/C operating and if the compressor was continuously engaged. These NOx emission impacts were estimated separately for A/C control during non-FTP operation (represented by the REP05 cycle) and FTP operation (represented by bag 3 of the FTP and the SC03 cycle). The NOx emission impacts on FTP and non-FTP driving are then weighted for in-use driving, resulting in an in-use increase of 0.208 g/mi. As noted above, this is viewed as the maximum likely increase due to A/C operation.

As explained in the standard-setting section, the level of emission standards in the final rule will allow a 50 percent increase in NOx emissions when the A/C is operating over the SC03 cycle. As shown in Table IX-10, NOx emissions increased by 100 percent with the A/C operating during on-cycle driving, so a 50 percent “allowable” increase also translates to 50 percent of the 100 percent increase being controlled by the final regulations. The Agency believes that the final rule will also control 50 percent of the increase seen on off-cycle driving. The calculation of the in-use NOx benefit is detailed in Table IX-10. First, EPA calculated the NOx increase caused by A/C operation for both on- and off-cycle driving. Bag 3 of the FTP and the SC03 cycle represent on-cycle driving and data from the REP05 cycle represent off-cycle driving. The Agency then calculated the observed emissions increase and, for on-cycle driving, adjusted the increase to express it as if the compressor had been engaged for 100 percent of the test time. No such adjustment is needed for the REP05 test results, as the compressor was effectively engaged for 100 percent of those tests. The adjusted results indicate the maximum potential increase due to A/C operation, a necessary step for the calculation of in-use benefits using the compressor activity factor described earlier in this section. The weighted increase of on-cycle and off-cycle driving is calculated to be 0.208 g/mi. Using the described control philosophy, the unadjusted emission benefit is 50 percent of the increase, or 0.104 g/mi. Applying the A/C compressor activity factor described above results in an adjusted NOx benefit for Tier 1 vehicles of 0.054 g/mi.

Table IX-10

Type	**NOx**
On-cycle driving (bag 3, SC03)	
A/C off	0.242 g/mi
A/C on	0.484 g/mi
A/C increase	0.242 g/mi
A/C increase, adjusted to 100% cycling	0.250 g/mi
Off-cycle driving (REP05)	
A/C off	0.269 g/mi
A/C on	0.372 g/mi
A/C increase	0.102 g/mi
Total increase, weighted	0.208 g/mi
Fraction of increase controlled	0.50
Unadjusted emission benefit	0.104 g/mi
A/C usage adjustment	0.52
Emission benefits for Tier 1 vehicles	0.054 g/mi

C. Cost/Effectiveness

1. Regional vs. National Rule

Summary of Proposal

The SFTP was considered a national rule in the NPRM. The EPA used national analysis when calculating its cost/effectiveness (excluding CA) in the RIA.

Summary of Comments

AAMA/AIAM argues that the Regulatory Impact Analysis (RIA) overestimates the benefits because it includes attainment areas and NOx waiver areas. According to the Manufacturers the non-attainment areas without NOx waivers are the only areas that will benefit from the SFTP.

AAMA/AIAM argue that the EPA should use a regionalized benefit/cost analysis that excludes attainment areas and NOx waiver areas.

Response to Comments

The EPA believes that the SFTP cost effectiveness analysis should be based on a nationwide scenario. The EPA has also calculated a second cost-effectiveness scenario that uses a regional approach. The regional cost-effectiveness was done to show that taking out marginal attainment areas has little impact on the SFTP rule cost-effectiveness.

The reasoning behind a national rule and analysis is as follows:

There are benefits beyond NAAQS

There are benefits of reduced emissions in attainment areas for health, forestry, and agriculture. New research in these areas is showing that ambient air levels below NAAQS have adverse effects.

Emissions in attainment areas can be transported in the air to non-attainment areas

Research such as the Southern Oxidant Study and others are showing that transportation of emissions into Non-Attainment areas from outside is having an impact on their ability to reach Attainment (also see response to comments section on NAAQS and NOx waivers).

Automobiles migrate from region to region (they are not stationary sources)

Modeling for OTC-related issues has shown that migration of automobiles is a significant issue.

Emission reductions in attainment areas can help keep them in attainment and counteracts VMT growth

Traditionally national CAA rules have used national analysis and cost/ton yardsticks for evaluating effectiveness

Regionalizing SFTP analysis would create a situation in which a yardstick for effectiveness would not be available. There have been other rulemakings with regional analysis but they were regional, not national programs (IM, and RFG rules).

Areas asking for NOx waivers are generally still supportive of the need for upwind NOx controls

The EPA has also calculated a regional ozone control strategy cost-effectiveness in which the emissions benefits from the SFTP are adjusted for the fraction of emissions which occur in the regions that are expected to have an impact on ozone levels in ozone nonattainment areas (excluding California). Air quality modeling indicates that these regions include all of the states that border on the Mississippi River, all of the states east of the Mississippi River, Texas, and any remaining ozone nonattainment areas west of the Mississippi River not already included. Approximately 86 percent of the nationwide NOx and VOC emissions from LDV and LDT occur in these regions (these calculations do not include California which is not considered under this rule). Therefore, for the regional ozone control strategy cost-effectiveness calculations, the per-vehicle NOx and NMHC emission reductions were multiplied by a factor of .86 (i.e., reduced by 14 percent) to account for the impact that the proposed new engine standards will have on ozone levels in ozone nonattainment areas.

Table IX-11: Distribution of LDV LDT NOx Emissions Affecting Nonattainment Areas

Area	**Percent of National (Excluding CA) LDV and LDT emissions in area**
States east of the Mississippi River	65.9
States bordering Mississippi on west	9.3
Texas	7.5
Western NAA in other states	2.9
Total	85.7

2. Comparisons with other rules (ie. national or local rules)

Summary of Proposal

The EPA in the NPRM does not explicitly compare the cost-effectiveness of the SFTP to other similar CAA rules.

Summary of Comments

AAMA/AIAM argue that the EPA made a significant error by not comparing the cost per ton of the SFTP rule to those of other programs.

Response to Comments

The cost-effectiveness of the SFTP may be compared to other CAA measures that reduce NOx emissions. Title I, of the 1990 CAAA, requires certain areas to provide for reductions in VOC and NOx emissions as necessary to attain the NAAQS for ozone. In addition EPA anticipates that more stringent reductions in NOx emissions will be necessary in certain areas. The cost-effectiveness of these measures is generally estimated to be in the $100 to $5,000 per ton of NOx reduced (USEPA, the Clean Air Act Section 183(d) Guidance on Cost Effectiveness, EPA-450/2-91-008, November 1991).

The cost effectiveness of controlling NOx emissions from other on-highway mobile sources has been estimated. The Tier I Light Duty Vehicle standards were estimated to cost $6,018, and the recently promulgated on-board diagnostics regulation is estimated to cost $1,974 per ton of NOx reduced from malfunctioning in-use light-duty vehicles.

In summary, the revised cost effectiveness of the SFTP (see cost-effectiveness estimates section, below) included in this rule remains favorable relative to the cost effectiveness of several other NOx control measures required under the CAA.

3. Cost-Effectiveness Estimates

Summary of Proposal

In the NPRM RIA the EPA evaluated cost/effectiveness by calculating the cost per ton of pollutant reduced for NMHC, CO, and NOx. The following are the cost/ton ratios in the NPRM RIA for USO6 and A/C (in dollars):

Table IX-12

Control Area	**NMHC**	**CO**	**NOx**
USO6	74	2	65
A/C	NA	NA	144
Total	930	2	445

Summary of Comments

AAMA/AIAM using their cost estimates and regional (exclude

CA and OTC and areas with NOx waivers) benefit methodology calculated their own cost per ton of emissions reduced for each control area. The following are AAMA/AIAM cost/ton ratios:

Table IX-13

Control Area	**NMHC**	**CO**	**NOx**
US06	50,000	2,600	30,000- 64,000
A/C	NA	NA	130,000

AAMA/AIAM did not give total cost per ton ratios for the SFTP rule.

Response to Comments

In calculating the cost/ton ratios for the final SFTP rule the EPA incorporated the cost changes mentioned above (facilities, hardware, and etc.). The EPA also recalculated the benefit numbers based on the new standards (see standards section). The EPA has also calculated the cost/ton ratios for a national and regional analysis with a sensitivity analysis for A/C simulation vs. Full Environmental Cell (FEC) A/C procedure.

The following are the final cost per ton ratios for the SFTP, by control area and pollutant, for the A/C simulation and FEC scenarios and by national and regional analysis methodologies:

Table IX-14: Dollar Per Ton Estimates for the SFTP, A/C Simulation Scenario

Control Area		**NMHC**	**CO**	**NOx**
US06	National	456.6	7.3	150.1
	Regional	530.9	8.5	174.5
A/C	National	NA	NA	2,050
	Regional	NA	NA	2,384
Total	National	456.6	7.3	959
	Regional	530.9	8.5	1,115

Table IX-15: Dollar Per Ton Estimates for the SFTP, Full Environmental Cell Scenario

Control Area		**NMHC**	**CO**	**NOx**
US06	National	522	8.3	171.6
	Regional	607	9.7	199.6
A/C	National	NA	NA	2,574
	Regional	NA	NA	2,992
Total	National	522	8.3	1,194
	Regional	607	9.7	1,388

It should be noted that the emission benefits in these cost effectiveness calculations are likely to be understated, as discussed above, because they do not consider the impact of in-use vehicles with malfunctions and higher deterioration on the off-cycle emission inventory. In addition, the costs included in the cost effectiveness calculations do not consider the potential fuel economy benefits to the consumer from control of commanded enrichment. The NPRM estimated the lifetime fuel economy savings to be $16.56, based upon an estimated 0.51 percent reduction in fuel consumption from control of commanded enrichment, miles driven and survival rates from the MOBILE model, a 7 percent discount factor, and a gasoline cost of $0.80 per gallon, excluding state and federal taxes. No benefit was claimed in the NPRM because the Agency assumed this benefit would be roughly negated by the value consumers would place on the small performance loss associated with elimination of commanded enrichment. In the Final Rule, the performance loss was largely eliminated by raising the CO standard (see discussion in section on US06 CO standard setting, above) to allow commanded enrichment most of the time at WOT. Although the Final Rule would still control part-throttle commanded enrichment, this has no impact on the performance of the vehicle. As the Final Rule is estimated to still control about 80 percent of the CO benefit from commmanded enrichment, it would be reasonable to conclude that the consumer would save about $13.45 ($16.56 times 80 percent) in fuel over the vehicle lifetime. As this cost reduction is no longer offset by a loss in vehicle performance, the Agency is being extremely conservative by not incorporating the potential fuel cost savings into the overall cost estimates. Considering both factors, the potential reduction in costs associated with the fuel savings and the potential emission benefit increase associated with higher in-use emissions, the cost-effectiveness estimates presented in Tables IX-14 and IX-15 are extremely conservative.

Figures

Appendix I

CO and Air/Fuel Ratio Over US06: Stoichiometric Calibration

Appendix II

CO, NOx, Exhaust Volume and Air/Fuel Ratio Over US06: Stoichiometric Calibration

Appendix III

CO, NOx, Exhaust Volume and Air/Fuel Ratio Over US06: Production Calibration