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DRAFT

Regulatory Impact Analysis

Federal Test Procedure Revisions

January 31, 1995

U.S. Environmental Protection Agency

Office of Air and Radiation

Office of Mobile Sources

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1. Introduction

Under Executive Order 12866,[1] the Agency must determine whether the regulatory action is "significant" and therefore subject to review by the Office of Management and Budget (OMB) and the requirements of the Executive Order. The Order defines "significant regulatory action" as one that is likely to result in a rule that may:

> (1) have an annual effect on the economy of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or State, local, or tribal governments or communities;
> (2) create a serious inconsistency or otherwise interfere with an action taken or planned by another agency;
> (3) materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights and obligations of recipients thereof; or,
> (4) raise novel legal or policy issues arising out of legal mandates, the President's priorities, or the principles set forth in the Executive Order.

Pursuant to the terms of Executive Order 12866, it has been determined that this rule is a "significant regulatory action" because compliance with the proposed regulations could have an annual effect on the economy in excess of $100 million. As such, this action was submitted to OMB for review. Changes made in response to OMB suggestions or recommendations will be documented in the public record.

The Environmental Protection Agency (EPA) is proposing that passenger cars and light trucks be tested for compliance with emission standards over a new test procedure. The proposed test procedure does not replace existing test procedures, but rather adds to them. Associated with the additional testing burden are costs of compliance, development, and vehicle modifications, resulting in associated emission reductions. The proposed regulations are applicable to all light-duty vehicles and light-duty trucks starting with the 1998 model year.

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[1] 58 FR 51735, October 4, 1993.

This RIA briefly addresses the air quality problems and needs within the United States. However, the primary purpose of this RIA is to present the Agency's cost, emission reduction, and cost effectiveness estimates associated with the proposed regulations and the various regulatory and control options considered. Consequently, detailed discussion of the proposed requirements, the options considered, and technological feasibility should be found in the preamble and supporting documents contained in the public docket for this rulemaking.

2. Statement of Needs and Consequences

The cornerstone of the Clean Air Act is the effort to attain and maintain National Ambient Air Quality Standards (NAAQS). Regulation of emissions from on-highway, area, and stationary sources prior to enactment of the Clean Air Act Amendments (CAAA) of 1990 has resulted in significant emission reductions from these sources. However, many air quality regions have failed to attain the NAAQS, particularly for ozone and carbon monoxide (CO). This is due to many factors, including the number of vehicles on the road and a corresponding increase in the number of miles driven by the in-use fleet which, even though single vehicles have experienced significant emission reductions, has increased total emissions from the motor vehicle fleet.

2.1. Urban Air Pollution

Automobiles are a well known major source of volatile organic compounds (VOC) and oxides of nitrogen (NOx), both of which are precursors of ground level ozone, or smog. Motor vehicles are also a mojor source of CO emissions. While significant progress has been made over the past two decades in controlling automobile emissions, as of August 1994, 93 air quality control regions still failed to meet the national ambient air quality standard (NAAQS) for ozone, and 36 regions failed to attain the NAAQS for CO.[2]

The Clean Air Act, as amended (CAA, or Act), contains a large number of provisions to further improve ambient air quality. Section 206(h) of the Act requires that EPA review its regulations for the testing of motor vehicles and revise them if necessary to ensure that motor vehicles are tested under circumstances reflecting actual current driving conditions. The Agency has completed this review process and published its findings in May of 1993.[3] As a result of that review effort, the Agency has determined that it is necessary to revise the existing

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[2] 40 CFR Part 81.

[3] EPA, Office of Air and Radiation, *Federal Test Procedure Review Project: Preliminary Technical Report*, 420-R-93-007, May 1993.

test procedures to ensure that motor vehicles are indeed tested under circumstances reflecting actual current driving conditions. Further detail on the inadequacy of the current test procedures, and how the proposed test procedures address these inadequacies, can be found in the preamble to this rulemaking.

2.1.1. Ozone

Ozone is a powerful oxidant which affects humans by irritating the respiratory system and reducing lung function. Ozone has been shown to cause symptoms such as cough, headache, chest pains, sore throat, and eye irritation, which may restrict normal daily activities. In addition to temporary symptoms, laboratory studies suggest that ozone may also permanently damage lung and other tissues. The ozone precursor NO_2 has also been shown to increase the frequency of respiratory infection.[4]

Ozone also affects plants and materials. Oxidation by ozone can impair plant tissue function and reduce the yield of some crops. Some tree species suffer injury to needles or leaves, lowered productivity, and in severe cases, individual trees can die.[5] Tropospheric ozone, or ozone existing in the lower atmosphere, also contributes to the greenhouse effect.[6]

2.1.2. Carbon Monoxide

The primary effect on humans of elevated ambient CO levels is a decrease in the ability of blood to carry oxygen throughout the body. It may also reduce the ability of muscle tissue to store oxygen for use during sudden exertion. In general, under high levels of ambient CO, these mechanisms will tend to exacerbate cardiovascular stress, leading to a decrease in

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[4] Jane Hall, et.al, "Economic Assessment of Health Benefits from Improvements in Air Quality in the South Coast Air Basin," a report to the South Coast Air Quality Management District, June 1989.

[5] U.S. Congress, Office of Technology Assessment, *Catching Our Breath: Next Steps for Reducing Urban Ozone*, 1989.

[6] Schneider, Stephen, *Global Warming* (San Francisco: Sierra Club) 1989.

maximum exercise time in healthy persons and decreased time to angina attacks in angina patients. High ambient levels of CO also have deleterious effects on the central nervous system, decreasing vigilance, visual perception, manual dexterity, learning ability, and the ability to perform complex tasks. Fetuses and newborns may be especially sensitive to the presence of CO in the blood; even exposures to moderate levels of CO may produce deleterious effects on the fetus such as reduced birth weight and increased newborn mortality.[7]

2.2. Sources of Ozone and CO

2.2.1. Ozone

Ozone is produced in the troposphere by photochemical reactions of non-methane volatile organic compounds (VOCs) and oxides of nitrogen (NOx). Most studies indicate that reductions of both VOC and NOx will lead to reductions of ozone, except under specific circumstances.[8,9] A National Academy of Sciences Study[10] states that, "Control of NOx......, although it is predicted to lead to an increase in ozone in some places, such as downtown Los Angeles and New York City......will probably be necessary in addition to or instead of VOC control to alleviate the ozone problem in many cities and regions." Even under those circumstances where a NOx decrease can result in an ozone increase, the ozone increase occurs only until a "ridgeline" is reached, after which further NOx control results in reduced ozone

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[7] EPA, Office of Air Quality, Planning and Standards, *Regulatory Impact and Analysis of the National Ambient Air Quality Standards for Carbon Monoxide*, EPA 450/5-85-007, June 1985.

[8] *Rethinking the Ozone Problem in Urban and Regional Air Pollution*, National Research Council, 1991.

[9] B.J. Finlayson-Pitts and J.N. Pitts, Jr., "Atmospheric Chemistry of Tropospheric Ozone Formation: Scientific and Regulatory Implications," *Air and Waste*, Vol. 43, August 1993.

[10] *Rethinking the Ozone Problem in Urban and Regional Air Pollution*, National Research Council, 1991.

concentrations. In areas with relatively high VOC/NOx ratios, typical of suburban and rural areas, decreasing NOx concentrations at constant VOC concentrations is very effective in ozone reduction.[11]

Unless properly designed and maintained, motor vehicles can emit significant amounts of VOCs through both fuel evaporation and exhaust emissions. Gasoline itself is a VOC. Current-technology vehicles capture evaporative emissions in a charcoal canister which must be periodically purged into the intake manifold and burned in the combustion process. Exhaust VOCs are reduced by high voltage ignition, improved fuel mixing, and catalytic after-treatment, among other measures.

Oxides of nitrogen (NOx) are formed in the combustion chamber when oxygen and atmospheric nitrogen combine at high temperatures. NOx emissions are traditionally reduced by lowering peak combustion temperatures through small amounts of exhaust gas recirculation or through other measures, and by catalytic exhaust after-treatment.

Motor vehicles are estimated to contribute approximately 25% of VOC emissions nationally and 36% of VOC emissions in urban areas.[12] Small "area sources" such as bakeries, dry cleaners and consumer solvents contribute 25% and large point sources such as petroleum refineries contribute 10% of VOC emissions nationwide.[13] Motor vehicles also contribute significantly to NOx, with an estimated contribution of roughly 29% nationally and 33% in some urban areas.[14] Nonroad sources, including

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[11] B.J. Finlayson-Pitts and J.N. Pitts, Jr., "Atmospheric Chemistry of Tropospheric Ozone Formation: Scientific and Regulatory Implications," *Air and Waste*, Vol. 43, August 1993.

[12] EPA, *Nonroad Engine and Vehicle Emission Study -- Report*, 21A-2001, November 1991.

[13] *ibid.*

[14] *ibid.*

construction and farming equipment contribute roughly 15% nationally.[15] These numbers indicate that motor vehicles are a major source of ozone precursor emissions in ozone non-attainment areas.

2.2.2. Carbon Monoxide

Carbon monoxide is created when a carbon-based fuel is burned with air. Gasoline is a mixture of various hydrocarbon compounds. When burned with sufficient oxygen, gasoline combustion produces carbon dioxide (CO_2) and water (H_2O). However, when burned with insufficient oxygen, some of the carbon will form CO.

Motor vehicles are by far the most significant source of CO in urban areas. In CO non-attainment areas, motor vehicles typically account for 42% of wintertime CO emissions nationally, and as high as 80% in some urban areas during the winter months.[16] Other sources of CO are residential fuel use and nonroad engines, including construction and farm equipment and recreational equipment. These numbers indicate the importance of CO controls on motor vehicles.

2.3 Consequences of the Proposed Action

Discussion on control of off cycle emissions; closing the discrepancy between MOBILE model predictions and air quality monitors, etc, or a brief rehash of whatever discussion appears in the preamble.

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[15] *ibid.*

[16] *ibid.*

3. Environmental Impact

3.1. Methodology

The methodology used to estimate the emission reductions associated with the proposed federal test procedure revisions was to determine the expected lifetime emission reductions per vehicle sold after implementation of the proposed regulations.

3.2. Baseline Emissions

Baseline emissions for this analysis are taken from the extensive test programs conducted by the Agency and the original equipment manufacturers in support of the FTP Review Project. Several test programs were conducted to evaluate actual in-use driving patterns,[17] and various test cycles were developed in an effort to determine the emissions of typical vehicles under such driving conditions. The weighted averages of the emission results of these test vehicles over the various test procedures developed constitute the baseline emissions used in this analysis.

3.3. Emission Reductions

The emission reductions used in this analysis were calculated by subtracting the achieveable level of control for each control area from the baseline test vehicle emissions over the additional test procedures being proposed. These test vehicle reductions were then weight averaged in an attempt to simulate the reductions associated with the actual in-use vehicle fleet mix. It should be noted that these test results were derived for an average vehicle with a 50K mile catalyst and do not include any allowance for enforcement margins. Thus, the emission benefits calculated here are likely to be understated.

The average emission factor reductions per vehicle associated with the proposed regulations, as discussed in previous sections of this document, are shown in Table 3.1. Note that the emission factor reductions for US06 include NMHC and CO

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[17] EPA, *Federal Test Procedure Review Project: Preliminary Technical Report,* 420-R-93-007, May 1993.

reductions which are actually a result of the proposed controls associated with A/C operation. These reductions are 0.012 g/mi NMHC and 0.30 g/mi CO and are attributed to US06 rather than A/C because they actually result from elimination of commanded enrichment during A/C operation. Therefore, to remain consistent with the rest of the analysis (i.e., US06 controls require elimination of commanded enrichment so any costs associated with elimination of commanded enrichment should be attributed to US06), these emission factor reductions have been attributed to US06, rather than A/C control.

Table 3.1
Average Emission Factor Reduction
Per Vehicle

Control Area	NMHC (g/mi)	CO (g/mi)	NOx (g/mi)
US06	0.055	2.39	0.062
Soak/Start	0.022	0.02	0.037
Air Conditioning	0.00	0.00	0.150

These emission reduction numbers constitute the emission reductions associated with the proposed requirements in g/mi. These g/mi values were then multiplied by the average annual mileage accumulation rates to determine the average annual emission reductions per year in each vehicle's life. Multiplying these numbers by the appropriate discount rates[18] and survival

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[18] Discounting transforms future costs and benefits into their "present values," that is, into what they are worth today. Direct comparisons between costs and benefits then can be made to determine whether a particular regulation

rates results in the expected annual emission reduction per vehicle. Adding these expected annual reductions over an estimated lifetime of the vehicle results in the estimated lifetime emission reduction per vehicle. Spreadsheet calculations of these lifetime emission reductions are shown in Appendix A, with the results shown in Table 3.2.

Also included in the calculations for emission reductions associated with A/C control, and shown in Table 3.2, is a factor to account for compressor "on" time versus "off" time. That is, even with the A/C turned "on," the compressor is not always operating, and it is the compressor's operation that actually causes an increase in vehicle emissions. Therefore, emission reductions will be realized only during compressor operation. Agency test data suggests that the compressor "on" time is roughly 61 percent of the total drive time during typical ozone exceedances. As a result, a 61 percent factor has been applied to the emission reduction calculation associated with the proposed A/C controls. It should also be noted that no attempt was made to account for the lower air conditioning usage during the rest of the year. The impact of air conditioning on emissions differs from most emission factors in that it has a disproportionate impact during typical ozone exceedances. To properly compare the cost effectiveness of controlling air conditioning emissions to other emission factors that are more consistent year around, it is necessary to use methodologies that target typical ozone exceedances.

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appears to be justified. A discount rate of 7% has been used throughout this analysis.

Table 3.2
Vehicle Lifetime Emission Reductions
Pounds Per Vehicle

Control Area	NMHC	CO	NOx
US06	10.1	441	11.4
Soak/Start	4.1	4	6.8
Air Conditioning	0.0	0	16.9
Total	14.2	445	35.1

Using the emission factor reductions shown in Table 3.1, including the 61 percent factor for A/C compressor operation discussed above, it is possible to estimate the tons per summer day emission reductions in various years as a result of the proposed test procedure modifications. This was done using estimates taken from the Agency's Fuel Consumption Model of vehicle miles travelled (VMT)[19] for different model year vehicles during each year of interest. These annual VMT estimates were first divided by 365 to get the daily VMT, and were then multiplied by 1.05 to account for a slightly higher VMT during summer months. These results were then multiplied by the emission factor reductions shown in Table 3.1, including the 61 percent A/C factor, for all model years during which the proposed test procedure changes will result in emission reductions. During the 1998 through 2000 model year phase-in period, the results have been multiplied by factors of 0.32, 0.64, and 0.80,

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[19] Tables of the VMT estimates by model year used in these calculations can be found in Appendix B.

respectively, to reflect the 40-80-100 percent phase-in of US06 and A/C requirements, and the 80 percent contribution of US06 and A/C controls to the overall program. These calculations are shown in Appendix B for model years 2005, 2010, 2015, and 2020, and are summarized in Table 3.3. The percent reduction columns in Table 3.3 compare these estimated ton per summer day emission reductions to the baseline emissions for the light duty fleet (cars and trucks).

Table 3.3
Fleet Emission Reductions
Tons/Summer Day and % Reduction in Light-Duty Fleet Emissions

	NMHC		CO		NOx	
Year	tpsd	%	tpsd	%	tpsd	%
2005	404	4.3	12655	11.3	1000	8.6
2010	577	6.2	18047	15.3	1427	12.0
2015	694	7.2	21717	17.3	1717	13.6
2020	765	7.5	23938	17.8	1892	14.0

The percentage emission reductions shown in Table 3.3 were calculated by first adding the off-cycle g/mi emission increases to the current MOBILE5a emission factors assuming national averages and summer temperatures, and including the effects of Phase II reformulated gasoline, the presence of an enhanced inspection and maintenance program, revised evaporative emission test procedures, and Tier I emission standards. The addition of the off-cycle emission increases to the current MOBILE5a emission factors represents the true baseline fleet emission factors. These baselines were then compared to the off-cycle emission factors after control of high speed/transient emissions, intermediate soak emissions, and emissions during A/C operation. The MOBILE5a outputs and the calculations of reductions in light-duty fleet emission factors are shown in Appendix C for model years 2005, 2010, 2015, and 2020.

4. Economic Impact

The proposed additions to emission test procedures will impose several costs on the original equipment manufacturers. These costs include added hardware for improved emission control and associated development and redesign costs, improved engine control calibrations, and increased costs associated with the certification process including durability data vehicle testing and reporting. These costs are analyzed under the proposed composite method of compliance, with consideration given to costs associated with a stand alone approach to test procedures and emission standards.

The cost estimates correspond to costs incurred by the manufacturer in complying with the proposed requirements. These costs can be divided into fixed and variable costs. Fixed costs are those costs made prior to vehicle production and are relatively independent of production volumes. The fixed costs considered in this analysis are those for engine control recalibration, vehicle redesign, mechanical integrity testing on redesigned engine families, certification durability demonstration, annual certification costs, and test facility upgrades and construction. Variable costs are costs for the necessary emission control hardware and are, by nature, directly dependent on production volume. The following analysis assumes that each federally certified engine family has roughly a 5 year lifetime, ie., recalibration and redesign efforts are not routinely conducted every year on every engine family, but rather every five years. The analysis also assumes an annual sales figure of 15 million vehicles outside the State of California. Spreadsheet calculations of all costs associated with the proposed test procedure changes can be found in Appendix D.

4.1. Recalibration Costs

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 319 federally certified LDV and LDT engine families, the estimated cost of reprogramming is $38.3 million.

Associated with this recalibration effort will be considerable emission testing over the proposed test procedures to evaluate and verify the recalibration effort. Assuming that each engine family recalibration effort requires an average of 200 emission tests per family, and assuming that 20 percent of these engine families would have undergone some form of recalibration for reasons unrelated to the proposed test procedure changes, and using a testing cost of $2000 for the proposed test procedure and $1000 for the current test procedure (note 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), the estimated testing cost associated with engine recalibration is $115.0 million dollars.

Adding these two costs results in an estimated cost for recalibration of $153.3 million. Amortizing this cost over the assumed 5 year engine family life at 7 percent interest gives an estimated annual recalibration cost of $37.3 million. Dividing by the assumed 15 million vehicles sold results in an estimated $2.49 per vehicle.

4.2. Redesign Costs

As outlined in the Technical Support Document contained in the docket for this rulemaking, the Agency has assumed that some engine families will require redesign to comply with the proposed requirements. Under the composite approach, it is assumed that 93 percent of all engine families will require redesign to comply with the Soak/Start requirements (via changes to the catalyst system).

Due to the nature of the expected Soak/Start redesign efforts (moving catalysts, adding insulation to existing catalysts, etc.), they entail redesigning the exhaust configuration of the engine family. Based on certification data, the Agency estimates there is an average of 3 exhaust configurations per engine family. Assuming that each exhaust configuration redesign effort requires 4 person-months at $120,000 per person-year, and using 93 percent of the 319 federally certified engine families, the estimated redesign cost is $35.6 million for Soak/Start related redesign. Amortizing this cost over the 5 year engine family life at 7 percent interest results in an estimated annual redesign cost of $8.7

million. Dividing this cost by the assumed 15 million vehicles sold results in an estimated $0.58 per vehicle associated with Soak/Start.

Under a stand alone test procedure approach, virtually all engine families would require redesign to comply with the Soak/Start requirements. With the appropriate assumptions outlined above, this would result in an estimated redesign cost of $38.3 million for Soak/Start. Amortizing this cost over the 5 year engine family life at 7 percent interest results in an estimated annual redesign cost of $9.3 million. Dividing this cost by the assumed 15 million vehicles sold results in an estimated $0.62 per vehicle associated with Soak/Start.

4.3. Mechanical Integrity Testing on Redesigned Engine Families

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 $89.0 million associated with Soak/Start.

Amortizing the total cost over the 5 year engine family life at 7 percent interest gives an estimated annual cost of $21.7 million dollars for mechanical integrity testing. Dividing this cost by the assumed 15 million vehicle sales gives an estimated $1.45 per vehicle associated with Soak/Start.

Under a stand alone test procedure approach, with all engine families requiring redesign for Soak/Start, the estimated redesign cost would be $95.7 million. Amortizing and dividing by vehicle sales results in an estimated $1.56 per vehicle associated with Soak/Start.

4.4. Certification Durability Demonstration

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 (but not each exhaust configuration within that family).

Again, assuming a rate of 30 mph over 100,000 miles at $60 per person-hour, the estimated cost for mileage accumulation on durability data vehicles is $59.3 million associated with Soak/Start. Assuming 12 emission tests per DDV (1 per 10,000 miles plus 2 voids) at $1000 per emission test (as proposed, durability demonstration will be done against the current FTP), the estimated testing cost is $3.6 million associated with Soak/Start. The Agency estimates the reporting burden associated with DDVs at 60 hours per DDV.[20] Assuming $60 per person-hour, the estimated reporting burden associated with these DDVs is $1.1 million associated with Soak/Start.

Adding these costs results in an estimated cost for durability demonstration of $64.0 million for Soak/Start. Amortizing these costs over 5 years at 7 percent interest gives $15.6 million per year associated with Soak/Start. Dividing these by the estimated sales of 15 million vehicles gives an estimated per vehicle cost of $1.04 associated with Soak/Start.

Under a stand alone approach, because each engine family would be redesigned for Soak/Start, these costs would increase to $63.8 million for mileage accumulation, $3.8 million for emission testing, and $1.2 million for reporting, or $68.8 million total. Amortizing this over 5 years at 7 percent would give an estimated annual cost for durability demonstration associated with Soak/Start of $16.8 million, or $1.12 per vehicle.

4.5. Annual Certification Costs

Annual certification costs are expected to increase due to the increased testing required and resultant increased emission

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[20] An Information Collection Request document has been prepared by EPA (ICR No. 2060-????) and a copy may be obtained from Sandy Farmer, Information Policy Branch; EPA; 401 M St., S.W. (Mail Code 2136); Washington, DC 20460 or by calling (202) 260-2740.

testing costs. The emission test cost is estimated to double, from $1000 per current FTP to $2000 per emission test under the proposed requirements. According to the Office of Mobile Sources most recent ICR update,[21] there are roughly 4500 emission test results reported to EPA every model year. Assuming that roughly 1500 of these tests are associated with durability data vehicles that will remain at the current test cost of $1000, this analysis assumes that 3000 emission tests will be done every year for compliance demonstration at $2000 per test. Assuming 3000 emission tests at a cost increase of $1000 over current costs, the increased testing cost is estimated at $3 million annually.

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 buden is estimated at $2.2 million annually.

Adding these costs results in an estimated increased certification cost of $5.2 million annually. Dividing this by the assumed 15 million vehicle sales results in an estimated increase of $0.35 per vehicle associated with increased certification demonstration.

4.6. Test Facility Costs

The proposed test procedure requirements are expected to result in three types of test facility costs: those for upgrades from existing 2-roll dynamometers to 48" single-roll electric dynamometers; those for construction of completely new exhaust emission test facilities to handle the increased testing demands; and those for construction of temperature control emission test cells for A/C related testing. This analysis assumes that a dynamometer upgrade to a 48" single-roll dynamometer will cost $0.5 million per dynamometer. This analysis also assumes that an entirely new emission test cell, including a 48" single-roll electric dynamomter will cost $2 million per test cell. Consistent with the enhanced evaporative emissions test procedure rulemaking, this analysis assumes that a temperature control

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[21] *ibid.*

emission test cell will cost $0.7 million per test cell.[22]

Using the previously mentioned 4500 emission tests reported to the Agency per model year, and assuming that 4 days in each of 52 weeks in the year provide testing opportunities, but only one-half of those days are used for emission regulatory compliance purposes, ie., 104 days per year, this analysis assumes that EPA regulations impose a need for approximately 22 dynamometers assuming that 2 emission tests can be conducted on each dynamomter per test day (4500/104/2). This analysis assumes that each of these 22 dynamometers will be upgraded to a single-roll 48" electric dynamometer costing $0.5 million each, for an estimated cost of $11 million.

This analysis also assumes that testing requirements will double due to the proposed changes. This will require construction of 22 new exhaust emission test cells with single-roll electric dynamometers costing $2 million per test cell, for an estimated cost of $44 million.

This analysis also assumes that temperature control test cells will have to be built to conduct A/C related testing. The enhanced evaporative emission test procedure rulemaking estimated that 30 such test cells would be required for running loss emission testing.[23] This analysis assumes that 15 additional cells will have to be built, each costing $0.7 million, for an estimated cost of $10.5 million.

Adding these costs results in an estimated cost of $65.5 million associated with test facilities. Amortizing this cost over an assumed 10 year test facility life at 7% intesest results in an estimated annual cost of $9.3 million, or $0.62 per vehicle, wih $0.52 per vehicle associated with exhaust emission test facilities and $0.10 per vehicle associated solely with A/C related test facilities.

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[22] EPA, *Control of Vehicular Evaporative Emissions: Final Regulatory Impact Analysis and Summary and Analysis of Comments*, Air Docket A-89-18, February 1993.

[23] *ibid.*

4.7. Vehicle Hardware Costs

Vehicle hardware costs are those costs for emission control hardware necessary to comply with the proposed regulations. Due to thier nature, vehicle hardware costs are variable costs, ie., they vary with vehicle sales volumes. This analysis assumes a sales volume of 15 million vehicles outside the State of California.

The hardware cost estimates are directly correlated to the engine family redesign costs already discussed. Each of these engine family redesigns has associated with it some hardware cost. For this analysis, the percentage of engine families redesigned is assumed to correspond directly to the percentage of vehicles sold. While this effectively, and inaccurately, assumes that each engine family has equal sales volumes, the nature of the expected redesign efforts does not shed light on the number of vehicles affected (ie., if the expected redesigns included all 4 cylinder engines, the sales volume could be easily estimated from the number of 4 cylinder vehicles sold; however the redesigns are not expected on any separable aspect of the vehicle fleet).

This analysis estimates that 93 percent of engine families will require redesign to comply with the Soak/Start requirements. This 93 percent estimate consists of 31 percent of engine families moving existing catalysts forward (ie., no increased hardware costs), 51 percent of engine families adding catalyst insulation to one catalyst, and 11 percent of engine families insulating two catalysts, and no engine families adding a catalyst for quick light off performance. The hardware cost associated with the addition of a catalyst is estimated at $50 per vehicle, while the addition of catalyst insulation is estimated at $7 per vehicle. Because redesign and other related costs would be roughly equivalent for adding a catalyst versus adding catalyst insulation, catalyst insulation is the assumed method of compliance because of its lower hardware cost and roughly equivalent effectiveness at achieving compliance with the proposed requirements. With the assumption that the percentage of engine families redesigned corresponds directly to the percentage of vehicles redesigned, the increased hardware cost is estimated at $5.11 per vehicle (0.31*$0 + 0.51*$7 + .11*2*$7), or a total of $76.7 million per year associated with Soak/Start.

Under a stand alone test procedure approach, it is assumed that every engine family will require redesign to comply with the Soak/Start requirements. Because compliance can be achieved through catalyst insulation, and because that approach is less costly than adding catalysts, manufacturers would presumably comply by adding catalyst insulation on all their engine families. This analysis assumes that to comply with the stand alone test procedure approach, 85 percent of engine families will require insulation on one catalyst, while 15 percent of engine families will require insulation on two catalysts. Using this assumption, and the assumption that the percentage of engine families redesigned corresponds directly to the percentage of vehicles redesigned, the increased hardware cost associated with Soak/Start would be $8.05 per vehicle (0.85*$7 + 0.15*2*$7), or a total of $121.0 million per year associated with Soak/Start.

Hardware costs associated with compliance with the A/C requirements are assumed to be zero. The A/C requirements are expected to be met through engine control recalibration. Therefore, no redesign efforts are expected and, consequently, no hardware costs are expected for compliance with the A/C requirements.

4.8. Fuel Economy Savings

As previsouly discussed, EPA expects manufacturers to eliminate or greatly reduce the amount of commanded enrichment currently used in order to meet the NMHC and CO standards for the US06 control cycle. This action will result in an improvement in fuel economy due to the lower fuel consumption associated with stoichiometric air/fuel control as compared to commanded enrichment.

EPA used two different methodologies in calculating the fuel economy savings. The first method directly measures the fuel consumption differences for the small subset of vehicles tested by the auto manufacturers in both the production calibration (i.e., commanded enrichment) and the no enrichment (i.e., stoichiometric) calibration. The fuel consumption data, expressed in gallons per mile, were obtained for the aggressive driving cycle (REP05). The difference in the production and stoichiometric tests was weighted by 28 percent to adjust for the fraction of in-use operation represented by the aggressive driving cycle. The result is the fuel consumption benefit, or the gallons of fuel saved per mile of in-use driving which, according to the data, was 0.0006 gallons per mile during typical commanded enrichment modes, or 0.0002 gallons per mile after applying the 28 percent adjustment for aggresive versus normal driving.

Recognizing the limited data used in the above method, EPA also calculated the fuel economy benefit using a second independent approach. The fuel economy benefit was approximated by determining how much extra fuel is used during commanded enrichment operating modes, and the in-use incidence of these commanded enrichment operating modes. Commanded enrichment uses 17 percent more fuel than stoichiometric operation, when the air/fuel ratio is typcially 14.5:1 as compared to a ratio of typcially 12:1 during commanded enrichment. This represents a change of 17 percent. The 6-parameter data from the Baltimore and Spokane in-use driving behavior studies indicated that about 1 percent of vehicle operation time is spent in commanded enrichment mode. However, commanded enrichment events occur while the vehicle is under a high load, which EPA assumes to be three times the normal load. Thus, the 1 percent of operation is multiplied by three to obtain the fraction of load-adjusted, in-use operation subject to commanded enrichment. Multiplying 17 percent by 3 percent load-adjusted operation yields an in-use fuel consumption reduction of 0.51 percent.

Applying this 0.51 percent fuel consumption reduction to the expected weighted Corporate Average Fuel Economy rating of the compliant fleet, adjusted by 85 percent to correlate test data to actual road fuel economy, results in a fuel consumption reduction of 0.0002 gallons per mile. This value agrees favorably with the value calculated by method 1.

Using this fuel consumption reduction and multiplying it, as shown in Appendix B, by the miles driven in a given year, and the appropriate survival rate and discount factor, results in an estimated lifetime fuel economy savings of $16.56, based on a gasoline cost of $0.80 per gallon, excluding state and federal taxes.[24]

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[24] From Cost Projections, FFA, 1992, updated from DOE/EIA Monthly Energy Review, May 1994 and DOT/FHA. According to FHA, average sales-weighted state taxes for gasoline were 18.54¢ in June 1994. Federal tax is 18.4¢.

4.9. Summary of Estimated Costs

Adding the above estimated costs results in an estimated annual cost of $174.5 million associated with the proposed requirements under the composite test procedure approach, or an increase of $11.63 per vehicle. Under the stand alone approach, the estimated annual cost would be $222.1 million, and $14.81 per vehicle, with the increased cost attributed entirely to Soak/Start compliance. Table 4.1 summarizes the estimated costs associated with the composite test procedure approach and the stand alone test procedure approach.

Table 4.1
Regulatory Cost Estimates

	Composite Annual Cost ($ million)	Composite Cost/Vehicle ($)	Stand Alone Annual Cost ($ million)	Stand Alone Cost/Vehicle ($)
Common Costs				
Recalibration	37.3	2.49	37.3	2.49
Test Facilities Dyno Conversions and New Exhaust Emission Test Cells	7.8	0.52	7.8	0.52
Certification	5.2	0.35	5.2	0.35
Common Cost Subtotal	50.4	3.36	50.4	3.36
US06 Costs				
Common Cost Subtotal/3	16.8	1.12	16.8	1.12
US06 Subtotal	16.8	1.12	16.8	1.12
Soak/Start Costs				
Redesign	8.7	0.58	9.3	0.62
Mechanical Integrity Testing	21.7	1.45	23.3	1.56
DDV Testing and Reporting	15.6	1.04	16.8	1.12
Hardware	76.7	5.11	120.8	8.05
Common Cost Subtotal/3	16.8	1.12	16.8	1.12
Soak/Start Subtotal	139.4	9.30	187.0	12.47

A/C Costs				
A/C Test Facilities	1.5	0.10	1.5	0.10
Common Cost Subtotal/3	16.8	1.12	16.8	1.12
A/C Subtotal	18.3	1.22	18.3	1.22
Totals	174.5	11.63	222.1	14.81

5. Cost Effectiveness

The cost effectiveness estimate represents the expected cost per ton of pollutant reduced. The costs developed in Section 5 are not necessarily equally spread among the three pollutant emissions (NMHC, CO, and NOx), nor are they equally spread among the three control areas considered in this analysis (US06, Soak/Start, and A/C). Table 4.1 shows the cost allocation to each of the control areas and pollutants. Those costs designated "Common Costs" in this analysis, which refers to costs for engine control recalibration, exhaust emission test facilities, and certification are allocated equally to each control area and each pollutant emission. Those costs associated with the US06 cycle have been allocated equally to the three pollutant emissions. Those costs associated with Soak/Start requirements are allocated equally to NMHC and NOx because the CO reductions are minimal. Since the requirements associated with A/C are targetted for NOx control, all costs associated with A/C have been allocated to NOx.

Table 5.1 contains the per vehicle cost allocation to each pollutant within each control area for the composite option. Table 5.2 contains the per vehicle cost allocation to each pollutant within each control area for the stand alone option.

Table 5.1
Cost Allocation
Composite Option
($/vehicle)

	NMHC	CO	NOx	Total
US06 Costs	0.37	0.37	0.37	1.12
Soak/Start Costs	4.65	0.00	4.65	9.30
A/C Costs	0.00	0.00	1.22	1.22
Total	5.02	0.37	6.24	11.63

Table 5.2
Cost Allocation
Stand Alone Option
($/vehicle)

	NMHC	CO	NOx	Total
US06 Costs	0.37	0.37	0.37	1.12
Soak/Start Costs	6.23	0.00	6.23	12.47
A/C Costs	0.00	0.00	1.22	1.22
Total	6.61	0.37	7.83	14.81

Dividing the costs shown in Tables 5.1 and 5.2 by the discounted lifetime emission reductions shown in Table 3.2, gives the cost effectiveness estimates shown in Table 5.3.

Table 5.3
Cost Effectiveness Estimates
($/ton)

Control Area	NMHC	CO	NOx
US06	74	2	65
Soak/Start			
Composite	2291	NA	1362
(Stand Alone)	3072	NA	1827
A/C	NA	NA	144
Total			
Composite	707	2	355
(Stand Alone)	930	2	445

Note that the above cost effectiveness estimates do not include the estimated fuel economy savings presented above. The fuel economy savings have not been included here because the Agency believes that the proposed test procedure changes may have some measurable negative impact on the horsepower output of some vehicle engines. This potential lost power will result from the lack of commanded enrichment during some acceleration modes as expected to comply with the US06 cycle. Accompanying this lost power will be the potential for some consumers to consider such affected vehicles as having less value. The Agency does not believe that this lost value will be noticed by most consumers, but acknowledges its potential effect nonetheless. Due to the difficult nature of trying to quantify a cost associated with reduced power output, or reduced 0 to 60 mph acceleration time, etc., the Agency has not attempted to do so, but rather has decided to consider this cost to be negated by the associated savings in fuel expenses.

6. Rationale for Selecting the Proposed Action

The Agency has established a number of emission standards for motor vehicles and engines, designed to control air pollution by reducing in-use emissions of motor vehicles. Compliance with these standards is typically measured using a test procedure that simulates in-use driving, including the driving cycle (speed, time, acceleration, etc.), ambient conditions (such as temperature and humidity), and characteristics of the fuel (such as gasoline volatility). In 1990, Congress amended the Clean Air Act (CAA) and required that EPA review these test procedures and revise them as appropriate to reflect current in-use conditions. The Agency's review focused on the procedures for light-duty motor vehicles, especially the Federal Test Procedure (FTP), the procedure used to measure tailpipe emissions when determining compliance with motor vehicle emission standards.

In response to the review requirement of the CAAA, the Certification Division of EPA's Office of Mobile Sources (OMS) initiated the FTP Review Project (the FTP Review) in November 1990. The first action of the project team was to perform an initial review of existing information to identify elements of the current FTP that might be of concern (justifying additional focus) and others that might not justify concern at this time.

Of immediate concern to EPA at the time was the LA4 cycle[25] representation of one element of in-use driving behavior: aggressive (high-speed and/or high-acceleration) driving. It was clear that the LA4 maximum speed of 57 mph excluded a significant fraction of higher-speed, in-use operation. Similarly, EPA suspected that an important fraction of in-use accelerations were more severe than those found in the LA4. The exclusion of one higher-acceleration driving trace as "unrepresentative" during the LA4 development effort ignored the potential for disproportionate emissions impact of such operation. A 1990 California Air Resources Board (CARB) study found much higher emissions, particularly for CO, during operation at high acceleration rates relative to those seen during FTP-level accelerations. One possible explanation of these emissions

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[25] The LA4 cycle, or CVS-72 cycle, is equivalent to the Urban Dynamometer Driving Schedule (UDDS) as defined in 40 CFR part 86, Appendix I, paragraph (a).

increases is that the engines were not calibrated for emission control during the higher engine loads associated with aggressive driving, as these loads are not encountered during current FTP testing. However, insufficient data existed at the time to quantify the in-use frequency of aggressive driving events or the actual emission impacts. There were also theoretical concerns about other aspects of driving behavior that were not represented in the current test procedures for which no data existed. Thus, the Agency concluded that further information was necessary to properly represent actual driving conditions and began extensive research into driving behavior and conditions and their emission implications.

During the course of the research a number of other concerns with the current FTP were identified, including two additional concerns with the LA4 representation of in-use driving behavior. The first concern was start driving behavior, that is, behavior immediately following vehicle start up and initial idle. Start driving was suspect because truncation of the prototype LA4 trace brought the most aggressive operation close to the beginning of the cycle; driving survey data suggest this is atypical of in-use operation. The second concern was microtransient behavior (short timescale speed fluctuations). In-use driving survey data contain more frequent speed fluctuations than the FTP. The Agency speculated that speed fluctuations on the LA4 may not be representative because the resolution of the chart recorders used to generate the original LA4 traces was insufficient to show the true speed variation.

The Agency identified four suspect elements of the FTP in addition to concerns with the LA4 reflection of driving behavior: the duration of the soaks; the representation of air conditioning load; representation of additional loads on the engine due to factors such as road grade, extra cargo, or trailer towing; and the adequacy of the dynamometer specification for representation of real road load.

With respect to soaks, EPA sought to determine if significant levels of emissions are missed by the current FTP because only very short- and long-duration soaks are reflected in the current structure. One related hypothesis was that differences in the cooling rates of catalysts and engines might lead to excessive emissions during intermediate-duration soaks.

Several aspects of the air conditioning load simulation were problematic. The current FTP adds load as a percentage of the base road-load horsepower curve, which means the FTP air conditioning load decreases with decreasing speed, while real air conditioner system loads relative to road-load horsepower are highest at low speed. Also, vehicles with different base horsepower curves end up with different FTP air conditioning load simulations, even if they have identical air conditioner systems. As in the case of aggressive driving behavior, incorrect representation of air conditioning loads during the FTP risks incorrect simulation of the emissions these loads would generate from an engine in-use.

Road grade, vehicle towing, and cargo also represent a load effect on the engine. The 300 lb passenger-plus-cargo allowance on the FTP is clearly unrepresentative for some driving situations, especially for trucks, and the absence of road grade or vehicle towing simulations on the FTP means these actual in-use loads are not a factor in determining compliance with the emission standards.

Three aspects of the current FTP dynamometer configuration have the potential to misrepresent the actual road load experienced by vehicles in-use. First, the shape of the speed/load curve on current certification dynamometers is fixed and cannot be changed; the magnitude of the speed/load curve is adjusted by periodically calibrating the dynamometer at a single speed (currently, 50 mph). As a consequence, loads at speeds other than the calibration point can be misrepresented. Second, current FTP dynamometers cradle the vehicle drive wheels between two small (8.65-inch) rolls; heating effects and pinching of the tire result in an unrepresentative road "surface." Third, the dynamometer rolls are currently uncoupled and the front roll (which bears the power absorber) spins somewhat more slowly than the rear (which provides the vehicle speed signal); this tends to bias the system towards underloading the vehicle.

While the above discussion highlights areas where EPA sought to focus the FTP Review project, the Agency found three other elements of the FTP where revising the current procedures was unnecessary at this time. The first such area was the altitude of testing. Given that EPA has the authority to perform vehicle testing at any altitude, and it currently exercises that authority, the Agency is not proposing to supplement by further regulation the altitude testing flexibility in current law. While it is possible that driving behavior may differ at high altitudes, EPA believes that any emission controls required for aggressive driving will also be effective during high altitude driving.

A second element which EPA did not pursue beyond the initial evaluation was certification test fuels. In-use fuels have a wide range of properties, yet the average in-use fuel falls within the possible ranges of Federal certification fuel set by current regulations. Significant differences, with potentially large emissions implications, do appear to exist between average in-use fuel and the fuel typically purchased by both EPA and industry for certification testing. After evaluating approaches to addressing this situation, EPA concluded that changes to the regulations are not necessarily required. In addition, various programs to address in-use fuel qualities are still under consideration. If a decision is ultimately made to change the certification fuel regulations, it may be best to do so along with changes to the specifications for in-use fuels.

Finally, EPA determined that it was unnecessary to further address the direct impacts of ambient temperature on FTP tailpipe emissions in this proposal. At the time the Amendments were adopted, the FTP evaluated tailpipe emissions performance in the midrange of temperature (68°F to 86°F), but omitted both cold and hot temperature testing. The emissions concern following cold temperature soaks and during cold temperature operation is increased CO emissions; this concern was addressed through EPA's Cold Temperature CO rulemaking.[26] The direct emissions impact during hot temperature operation is increased fuel evaporation; this concern was addressed through the Agency's Evaporative Emissions rulemaking.[27] Ambient temperature produces indirect emissions effects through increased operation of the vehicle air conditioner; this indirect aspect of temperature was addressed in EPA's detailed review of the FTP and is reflected in proposed revisions to the FTP.

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[26] 17 FR 31888.

[27] 58 FR 16002.

As part of the FTP review, EPA, in conjunction with auto manufacturers and CARB, conducted an extensive review of in-use driving behavior, obtaining a wealth of data on how cars are driven during trips, the length of trips, the length of time between trips, and so on. The Agency then generated representative driving cycles from these data and conducted testing to compare emissions over these cycles with emissions over the LA4 Cycle. The results of these comparisons confirmed that revisions were needed because significant emission levels were observed under conditions not represented by the current FTP.

From these results and other analyses, EPA developed various changes to the FTP, focusing on new driving cycles to add to the current FTP. The Agency also investigated possible control technologies that could be used to control emissions over these new cycles. The proposed revisions to the FTP include these various changes in the test procedure for tailpipe emissions, and the emission standards related to them. The basic approach used is to extend FTP control across all in-use driving behavior and conditions. Additional control is not required because the main focus of the proposed revisions is to change the test procedure, not to re-evaluate the stringency of the existing requirements. Proper incorporation of the full range of in-use driving conditions and behavor will allow future standards to assess feasible increases in stringency.

The proposed test procedure changes rely on a new Supplemental FTP (SFTP) that encompasses areas of the current FTP that inadequately represent the conditions under which vehicles are actually driven and used. The SFTP includes (1) aggressive driving (characterized by high speeds and/or high accelerations); (2) driving immediately following vehicle start-up; and (3) microtransient driving (small timescale speed fluctuations), which occurs across the majority of the normal ranges of operating speeds and accelerations. The proposed SFTP also incorporates conditions during start and moderate driving that are designed to more accurately reflect actual engine load due to A/C operation under typical ozone exceedance conditions. A new intermediate-duration (60-minute) soak period is also included. Also included in the proposal are changes to improve the simulation of actual road load forces across all speed ranges, and revised driver criteria for what constitutes a valid test.

Three of the proposed changes have wider impacts than just the SFTP. The first is to more accurately simulate real on-road loads at the tire/dynamometer interface, which is an element of the proposal that affects dynamometer operation throughout both the FTP and SFTP. The second would remove language specifying "minimal throttle movement" when conducting emission tests and replace it with a specification of maximum speed variation, which also impacts both SFTP and FTP testing. The third would replace existing defeat device language with a requirement for proportional emission control under conditions not directly represented by the FTP and the SFTP, in recognition of the increased flexibility offered by computer controls.

The SFTP includes three single-bag emission test cycles: a hot stabilized 866 Cycle run with a new simulation of in-use A/C operation; a new Soak Control Cycle (SC01), which is run following the new 60-minute soak and with the new simulation of in-use A/C operation; and a new Aggressive Driving Cycle (US06) run in the hot stabilized condition. The cycles of the SFTP can be run as a sequence to save on preconditioning and setup time; however, separate runs of the cycles are permissible with the appropriate soak or preconditioning steps appended. Each of the test cycles is 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. While EPA intends to use a large-diameter single-roll dynamometer with electronic control of power absorption to meet this requirement, any system would be allowed that yields equivalent test results.

Elements of the proposed A/C simulation include a 95°F ± 5°F test cell ambient temperature, A/C set to "maximum A/C" with air recirculation, high interior fan setting, coldest setting on the temperature slide, driver's window down, and front-end supplemental fan cooling. The Agency proposes these conditions as a cost-effective surrogate for testing in a fully controlled environmental chamber set to simulate ozone-exceedance conditions of ambient temperature, humidity, solar load, and pavement temperature, although the use of a fully controlled environmental chamber would also be permitted.

With the exception of changes prompted by use of new dynamometers and an additional driver speed variation tolerance, no changes are proposed for the driving cycle of the conventional FTP. Similarly, EPA proposes to retain unchanged the method of determining compliance with the existing FTP. However, an additional "composite" calculation is proposed that brings 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, summed, and compared to the proposed emission performance standards. For total hydrocarbons (THC), non-methane hydrocarbons (NMHC), organic material hydrocarbon equivalents (OMHCE), organic material non-methane hydrocarbon equivalents (OMNMHCE), and CO, those proposed standards are the same as the standards applicable under the conventional FTP; for NOx, an adjustment factor of 1.15 is applied to that standard to account for the intrinsic emission response of vehicles to the new A/C test conditions. Due to the absence of relevant test data on which to base a decision, no supplemental standards are proposed for diesel particulate.

Included in the composite calculation are a cold start bag (based on Bag 1 of the conventional FTP) and the three bags of the SFTP. The weighting factor for each of the four bags is adjusted as appropriate to reflect the proposed level of control for each type of driving in the SFTP. Because the exhaust constituents respond differently to the loads and speeds of the new SFTP cycles, the proposed levels of control and, thus, the weighting factors of the composite calculation differ somewhat for different pollutants. The proposed weighting factors are:

	HC	CO & NOx
Bag 1 (cold start from FTP)	21%	15%
Bag 4 (866 cycle from SFTP)	24%	37%
Bag 5 (SC01 from SFTP)	27%	20%
Bag 6 (US06 from SFTP)	28%	28%

Flexibilities are proposed to allow manufacturers to reduce their testing burden, particularly during development testing. Manufacturers may forgo hot stabilized testing (Bag 2) on the FTP if they substitute the results from the analogous SFTP hot stabilized 866 cycle ("Bag 4") into the conventional FTP calculation. Similarly, results of the post-soak SFTP test ("Bag 5") may be substituted for the warm soak (Bag 3) FTP results. Criteria are being considered to permit manufacturers to forgo the data submittal requirement for SC01 testing following a 60-minute soak, allowing manufacturers to reduce the SFTP soak duration to 10 minutes.

Appendix A: Vehicle Lifetime Emission Reduction Calculations

NOT AVAILABLE IN THIS ELECTRONIC VERSION

Appendix B: Fleetwide Annual Emission Reductions

NOT AVAILABLE IN THIS ELECTRONIC VERSION

Appendix C: Reduction in Light-Duty Fleet Emission Factors

NOT AVAILABLE IN THIS ELECTRONIC VERSION

Appendix D: Cost Calculations

NOT AVAILABLE IN THIS ELECTRONIC VERSION