Final Regulatory Impact Analysis and Summary and Analysis of Comments

Control of Vehicular Evaporative Emissions

February 1993

U.S. Environmental Protection Agency
Office of Air and Radiation
Office of Mobile Sources
Regulation Development and Support Division
Engine and Vehicle Regulations Branch

Table of Contents

Chapter 1 Introduction

EPA's concern regarding the control of volatile organic compound (VOC) emissions has grown over the years as exceedances of the health-based ozone standard have continued to be a problem in many areas. On hot, sunny days VOC emissions react in the air to form ground-level ozone, which causes respiratory problems and is associated with urban smog. Based on the most recently available information for 1989 to 1991, there are 97 areas that fail to meet the National Ambient Air Quality Standard for ozone (0.12 parts per million).[1] According to ozone monitoring data, based on 1991 only, 70 million people continue to live in U.S. counties exceeding the ozone standard. Evaporative emissions from motor vehicles are a significant source of VOC's and, as a result, EPA has initiated action aimed at reducing these emissions.

In addition, the 1990 amendments to the Clean Air Act direct EPA and the states to carry out new programs to reduce levels of tropospheric ozone, especially in urban areas. With respect to evaporative emissions, the amended Clean Air Act states in §202(k):

> The Administrator shall promulgate (and from time to time revise) regulations applicable to evaporative emissions of hydrocarbons from all gasoline-fueled motor vehicles—
>
> (1) during operation; and
>
> (2) over 2 or more days of nonuse;
>
> under ozone-prone summertime conditions (as determined by regulations of the Administrator). The regulations shall take effect as expeditiously as possible and shall require the greatest degree of emission reduction achievable by means reasonably expected to be available for production during any model year to which the regulations apply, giving appropriate consideration to fuel volatility and to cost, energy and safety factors associated with the application of the appropriate technology.

A. Principles of Evaporative Emission Control

In 1971 EPA began testing motor vehicles for evaporative emissions by subjecting test vehicles to typical drive and park conditions. The evaporative emission test procedure, which has changed little since then, measures diurnal and hot soak emissions. These emission sources, as well as the more recently identified sources of running losses and resting losses, are described in the following paragraphs.

Diurnal emissions occur during periods when a vehicle is not in operation. They result from the heating of a vehicle's fuel tank in response to daily increases in ambient temperature. Emissions result when high ambient temperatures cause a buildup of fuel vapors and eventually cause vapor venting out of the tank. Current vehicles are designed to prevent vapors from reaching the atmosphere by venting them to an evaporative canister. The canister stores the vapors in a bed of activated carbon until the vehicle is driven. At that time the engine draws ambient air through the canister, carrying the stored vapors to the engine to be burned as fuel. If a vehicle has enough storage capacity for fuel vapors generated in use, and can restore that capacity with regular driving, it can maintain control of diurnal emissions.

---

[1] "National Air Quality and Emissions Trends Report, 1991," EPA, October 1992.

Hot soak emissions happen immediately after a vehicle has been driven, due to residual fuel tank heating and the high temperatures of the engine and fuel system. As with diurnal emissions, hot soak emissions are controlled by storing vapors in an evaporative canister and subsequently purging them to the engine.

Running losses are evaporative emissions that occur while a vehicle operates. They represent a greater in-use emission source than previously believed. Running losses are caused by the generation of vapors from the fuel tank as the fuel is heated during driving. This heating comes from several sources, including hot pavement, hot surfaces of the engine and exhaust systems, recirculated fuel that has been heated by the engine, and fuel pumps that are built into fuel tanks. Running losses can be prevented by maintaining enough vapor purge to the engine so the vapors can be consumed before they overfill the canister and reach the atmosphere. Techniques that reduce vapor generation during driving also can contribute to running loss control; for example, insulating or isolating fuel tanks from heat sources, increasing underbody airflow, or using fuel systems that do not return fuel to the tank, can contribute to reduced vapor generation.

A fourth source of evaporative emissions, resting losses, has been more recently identified. Resting losses are composed of fugitive vapors that result from the migration of fuel from the evaporative canister, and permeation through joints, seals, and polymeric components of the fuel system. Resting losses can be controlled by improved design of evaporative canisters and by material selection to prevent fuel permeation.

Control of evaporative emissions is fundamentally different than control of exhaust emissions. Because exhaust emissions from vehicles are largely controlled by engine and fuel management controls and their associated catalytic converters, vehicles tend to provide proportional control of exhaust emissions over a wide variety of conditions. Control is lost abruptly only if a control system component fails (such as the catalyst) or the engine is operating in an override mode (e.g., wide-open throttle). A fully functioning evaporative system in normal operation can experience a loss of control if the canister is simply overfilled with vapor. Also, changes in exhaust emission standards result in incrementally reduced in-use tailpipe emissions. In contrast, the current standard for evaporative emission testing was intended to reflect the expectation that no fuel vapors will be emitted during the test. The nonzero standard for the evaporative emission test was intended as an allowance for small nonfuel hydrocarbon emissions (e.g., from vinyl surfaces, paints, and other polymers) and for test-to-test variability.

Because changing the standard is not an effective means of improving the performance of vehicle evaporative controls, EPA has focused on revising the test procedure to expose the vehicle to more challenging conditions typical of in-use operation, as required by section 202(k) of the Clean Air Act. When vehicles temporarily lose evaporative emission control, emissions can be very high, several grams per mile in some cases. Evaporative emissions come disproportionately from relatively infrequent experiences of temperatures and driving patterns when control is most challenging. Such conditions include high ambient temperatures, a small amount of driving between extended periods of nonuse, or several consecutive days without driving. Thus, increasing the stringency of evaporative emission testing requires changing the test procedure to address these kinds of in-use conditions (see Clean Air Act section 202(k)).

An effective test of evaporative emission control systems needs to include a sequence of three fundamental elements: an initial loading of the evaporative canister, a period of driving for opportunity to purge the canister, followed by a simulation of parking over a series of hot days. Sampling for emissions during the final "day" ensures first that the vehicle can quickly regain storage capacity during driving, and also that the canister's total capacity is sufficient. A rigorous test with this sequence of test segments provides assurance that all sources of evaporative emissions are controlled.

B. Overview of Proposals

EPA initially proposed to change the evaporative emission test in August 1987 by adding a step to load the evaporative canister with vapors at the beginning of the test (52 FR 31274, August 19, 1987). This change was prompted by emission data showing that vehicles passing the current test with an empty canister during certification were often unable to meet the standard with more varied in-use canister conditions. EPA believed that initially loading the canister in the test would ensure that a vehicle could, with limited driving, purge vapors from the canister in preparation for the next loading experience. Vehicles designed to meet those requirements would be expected to maintain their level of control, regardless of how much vapor was in the canister at any time.

Based on subsequent analyses, EPA concluded that this change was insufficient in itself to accomplish the goal of achieving acceptable in-use evaporative emission control. Additional provisions were needed to increase the level of diurnal emission control and to ensure that running losses, which had since been found to be unexpectedly high, would be prevented in use. EPA held a public workshop in June 1988 to discuss new information on these issues and published a new proposal on January 19, 1990 (55 FR 1914).

EPA proposed in the January 1990 Notice of Proposed Rulemaking (NPRM) to keep the canister loading step at the beginning of the test procedure and to add two high-temperature heat builds after the exhaust emission test. Rather than incorporate a running loss test, the January 1990 proposal had provisions that were meant to ensure that running losses would rarely occur. These provisions included the initial canister loading, an engineering design review to ensure that vapors would not be vented to the atmosphere during operation, and a "cap-off" requirement at the beginning of the hot soak test to encourage low-pressure fuel tank designs.

Shortly before EPA published the new proposal, General Motors (GM) proposed a test concept it believed would be an improvement over the proposed test.[2] GM's test differed from that proposed in the NPRM, first by changing the method of conducting diurnal heat builds to a "real time" approach approximating outdoor ambient cycles. Real time diurnal heat builds were to be conducted by exposing the whole vehicle to ambient temperature changes in 24-hour cycles, rather than by the conventional approach of repeatedly heating the freshly fueled tank with a local heating element. Also, the GM proposal added a 70-minute, high-temperature running loss test, placed between the exhaust and diurnal emission tests. Finally, the hot soak test was moved to follow the running loss test.

In the January 1990 NPRM, EPA requested written comments on both EPA's and GM's proposed test procedures. At that time other vehicle manufacturers, citing impacts that such a change would have on facility requirements and the time required for testing, did not support GM's proposed method of testing for diurnal emissions. Nearly all manufacturers, however, supported direct testing for running losses instead of EPA's proposed design review and "cap-off" requirement. Also, a nearly universal request from the vehicle manufacturers was for EPA to work with the California Air Resources Board (CARB), which proposed and

---

[2]GM formalized its proposal in a letter from Lisa M. Fior to Tad Wysor, March 26, 1990 (Docket A-89-18, item IV-D-19).

eventually adopted a test based on GM's proposed test sequence, to adopt a common test procedure.

In response to the comments received following the January 1990 NPRM, EPA published a notice requesting comment on several possible modifications to the proposed test procedure (55 FR 49914, December 3, 1990). In the modified procedure the duration of the diurnal heat builds was extended from one to two hours, and a third diurnal heat build was added. The design review and "cap-off" requirement were replaced with a running loss test, very similar to GM's, which would be conducted after the series of diurnal heat builds. The preconditioning sequence was rearranged so that the evaporative canister would be manually purged and loaded with butane to 1½ times its working capacity just before the exhaust emission test.[3] Finally, a 4-hour period was added to the hot soak test, which was placed after the new running loss test, to measure resting losses. EPA held a public workshop on December 19, 1990 to discuss these changes and accepted written comments until February 22, 1991.

Finally, on December 17, 1991, EPA announced a public workshop to discuss the analysis supporting its position on the previously proposed sequencing of test segments (56 FR 65461). At that time the public also had opportunity to comment on draft regulations containing the entire set of test procedures. The test procedure described in the draft regulations included diurnal emission testing by GM's real time method, but was otherwise consistent with the modified procedure described in the December 1990 notice.

During the development of the final rule, EPA has incorporated most of the substantive revisions to the proposed test suggested by GM and other commenters. Most of the revisions, however, have been made to improve the simulation and repeatability of testing, rather than changing the fundamental test requirements. The expectations for basic hardware and vehicle configurations needed to meet the test requirements have changed little since the January 1990 NPRM. EPA believes the resulting test procedure will ensure that evaporative emission controls will be designed to eliminate evaporative emissions for nearly all in-use events, including those likely to occur under ozone-prone summertime conditions, as required by Clean Air Act section 202(k).

EPA's new test for evaporative emissions is based on the procedures proposed by GM and adopted by CARB. The EPA test also contains a supplemental test requirement, which is necessary to ensure adequate purge capacity, so that in-use evaporative emissions are, in fact, controlled. CARB has similarly interpreted its existing test as requiring a demonstration that control systems have adequate purge capacity to control in-use evaporative emissions. EPA's final evaporative emission test procedure is, therefore, basically an extension of CARB's current test procedure (adopted in August 1990) to the rest of the nation.

Chapter 2 provides a summary and analysis of comments related to the test procedure. Chapter 3 evaluates the technological feasibility of compliance and the schedule for implementation. Chapters 4, 5, and 6 present EPA's detailed analyses of the costs, emission reductions, and cost-effectiveness associated with the new procedure for testing evaporative emissions. A description of a recently developed computer model for evaluating evaporative emissions over a wide range of in-use driving conditions, as well as modeling results relevant to this rulemaking, are included as appendices.

---

[3]For the purposes of the test procedure, the working capacity is the amount of vapor that a canister, starting from a purged condition, would retain in loading to the 2-gram breakthrough point (that is, 2 grams of vapor emitted from the canister).

Chapter 2 Test Procedures and Standard

Pursuing the goal of improved evaporative emission controls has significantly broadened the understanding, both in the Agency and in industry, of the nature of evaporative emissions and the means of their control. The Agency has benefited from extensive public participation in this rulemaking. Many aspects of the rule reflect the input of outside participants. Vehicle manufacturers, individually and in conjunction with the oil industry, have made valuable contributions to the understanding of evaporative emissions.[4] EPA has also worked very closely with CARB, which has concurrently developed and adopted its own revisions to evaporative emission testing requirements.[5]

To better understand EPA's approach to resolving the individual issues raised during the interaction with the public, it is important to identify some fundamental differences between EPA's and GM's approaches to designing an evaporative emission test procedure. The following discussion expands on these basic differences.

First, GM has promoted some of the changes to its proposed test procedure by focusing on how they better represent the experience of an average vehicle in the in-use fleet. The amount of driving before the diurnal emission test is the most important area where GM wanted to maintain a vehicle's "typical" experience in the test. GM wanted to allow as much driving between the initial canister loading and the diurnal emission test as an average car would experience in a full day.

GM's focus on "typical" conditions is not consistent with the statutory mandate, which is to control evaporative emissions to the greatest degree reasonably achievable "under ozone-prone summertime conditions," including two or more days of nonuse. Any test for evaporative emissions must be judged against this standard. EPA's goal in designing a test is therefore not to simulate a single, "representative" in-use condition. Clearly, any specific procedure will only simulate one of a multitude of actual in-use patterns of operation. The broader goal of EPA's test design is to develop a test that will result in good emission performance under nearly all conditions that vehicles will experience in use (see Clean Air Act section 202(k)). Designing the test based on average conditions is inappropriate, because the resulting vehicle designs would be incapable of performing well under the temperature and driving conditions when high evaporative emissions are most likely to occur and control is most needed. For example, EPA's key point of contention with GM's proposed procedure is that the "representative" amount of driving allowed between the initial canister loading and the diurnal emission test, involving about 100 minutes of driving over various patterns, would provide an inadequate purge requirement for many in-use driving scenarios, as discussed below.

Second, GM has emphasized that in several ways its test simulation would more precisely duplicate the physical phenomena that a vehicle experiences in use. GM claimed that these changes to the test would have the effect of improving the accuracy and repeatability of the test results. For example, exposing a whole vehicle to a diurnal heat build

---

[4]The Air Quality Improvement and Research Program, undertaken jointly by the auto and oil industries, has included extensive development of new methods to test evaporative emissions.

[5]In August 1990 CARB adopted revised test regulations for controlling evaporative emissions (Docket A-89-18, item IV-D-83).

would allow the process of vapor generation in the tank and adsorption of those vapors in the evaporative canister to occur at natural rates.

Duplicating as completely as possible the physical phenomena involved in a vehicle's in-use experience is not, in itself, a primary goal in EPA's approach to designing a test procedure. EPA would like to avoid expanding test requirements to improve the test simulation (with consequent administrative burden and straining of Agency resources) if there is no expected positive effect on vehicle design. However, as in the example of the diurnal test method discussed below, other considerations may be involved in EPA's choice of a final test procedure.

In addition to these general issues, participants had specific comments on many aspects of the new test requirements. Following is a summary and analysis of these comments, grouped by major topic area.

A. Sequence of Test Segments

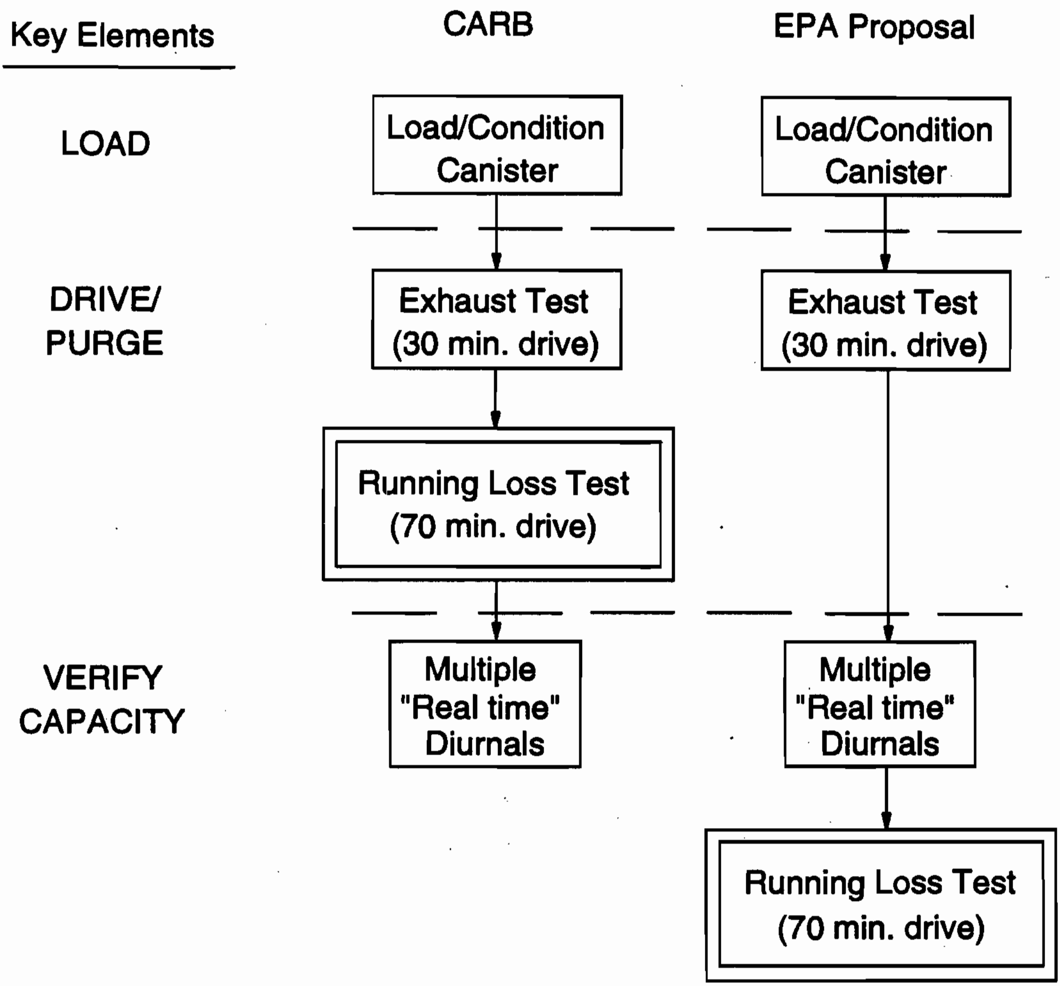
EPA Proposal

The test sequence described in the December 1990 Federal Register notice established the driving time between the canister loading and the diurnal emission test at about 30 minutes, the amount driven during the exhaust emission test (Figure 2-1). This test sequence involved canister loading just before the exhaust emission test, which was in turn followed by the diurnal emission test. A new running loss test was added at the end of the test sequence, not affecting the driving time before the diurnal emission test.

EPA's proposed test sequence was different than that finalized by CARB. CARB's adopted procedure included a 70-minute running loss test between the exhaust and diurnal emission tests, allowing a total of approximately 100 minutes of driving for vehicles to purge their canisters.

Figure 2-1

Basic Elements of CARB and EPA Proposed Sequences



Summary of Comments

Manufacturers objected to EPA's proposal, arguing primarily that the proposed test sequence, compared to in-use driving patterns, represented a rare and rather extreme scenario of vehicle operation. Manufacturers claimed that because the specific drive-park sequence represented in the test would so rarely happen in real driving, EPA's approach was invalid. They reinforced their position with the observation that EPA's MOBILE model estimates that vehicles from the in-use fleet average approximately 30 miles (48 km) of driving per day, much more than the 11 miles (18 km) of driving for the exhaust emission test.[6] Most auto manufacturers recommended that EPA adopt CARB's test procedure.

After considering EPA's technical objections to its procedures, however, CARB acknowledged that its procedure could lead to inadequate purge during short trips. In a March 1992 letter, CARB thus stated,

> As written, the [CARB] procedure may not necessarily ensure adequate purge during short trips, and canister saturation is a possibility. This could occur even on a vehicle which would pass the ARB procedure. ARB and Environmental Protection Agency (EPA) analyses have confirmed significant in-use emissions benefits from requiring adequate purge during the exhaust testing portion of the current test.[7]

To address these concerns, CARB suggested in the same letter adding one of two alternative methods to verify purge during the exhaust emission test. In the first method, purge airflow would be measured and compared with a similar measurement during the running loss test to verify a consistent purge rate. In addition, the change in canister mass during the exhaust emission test would be measured to ensure that approximately 70 percent of the canister's working capacity before breakthrough had been made available. In the second method, CARB would conduct a special test with two diurnal heat builds directly following the exhaust emission test. CARB proposed that these additional test requirements would apply to certification and, potentially, in-use testing. In addition, CARB identified the possibility of adopting EPA's proposed test sequence if its other proposed changes were found not to be viable.

Auto manufacturers had varying responses to CARB's proposed approaches. Some argued that current language in EPA rules that prohibits defeat devices would be effective in ensuring sufficient purge under CARB's adopted test. These manufacturers suggested a requirement to state at certification that they had employed no defeat devices in designing their purge strategy.

Manufacturers opposed CARB's suggestion of weighing canisters during a test run. They commented that such an operation could jeopardize the repeatability, reliability, and validity of test results because of the need to remove and handle components of a vehicle's emission control system.

Commenters who did not object outright to the idea of a purge-verification strategy generally supported the concept of measuring purge airflow. These commenters noted that measuring purge airflow would be the least burdensome strategy, and would give a direct measure of purge behavior. Various formulas for specifying a purge requirement were discussed.

---

[6]The series of MOBILE models is used to characterize the emission behavior of the in-use fleet and to estimate the effectiveness of various control programs.

[7]CARB Mail-Out #92-13, March 6, 1992 (Docket A-89-18, item IV-D-84).

Ford and Chrysler came forward with nearly identical approaches for a potential compromise, consistent with CARB's proposed option for a special two-diurnal test to ensure sufficient purge in short-trip driving patterns.[8,9] Ford and Chrysler recommended that EPA finalize CARB's adopted procedure, with minor modifications, for certification testing. For recall testing, they suggested an abbreviated test, consisting of the preconditioning and exhaust emission test, followed by a moderate-temperature hot soak test, and two diurnal heat builds. Since Ford and Chrysler offered no explanation of the differences for recall and certification testing, EPA understands that they were merely responding to EPA's desire to adopt an enforceable in-use test that would ensure adequate purge rates. The standard for recall testing would be 2.5 grams for vehicles with fuel tank capacity less than 30 gallons (110 liters), and would allow for exclusion of nonfuel emissions. Vehicles with larger fuel tanks would be subject to a 3-gram standard. No explanation of the basis for these relaxed standards was stated.

GM opposed the use of any alternate emission measurement to verify purge.[10] GM claimed that the alternate procedures under consideration would overburden the industry and increase the severity of the full evaporative test procedure. GM claimed, though without explanation, that an alternate emission measurement, with the existing 2-gram standard, would increase the overall purge requirement by 25 percent—with no air quality benefit.

Several commenters recommended a streamlined version of CARB's adopted procedure to facilitate EPA's in-use testing (e.g., see GM's March 23, 1992 letter, page 11). Commenters suggested driving through the running loss test without measuring evaporative emissions to avoid installation of thermocouples and to prevent the need for running loss measurement facilities. Significant fuel heating (and thus vapor generation) would be prevented by holding ambient temperatures at 80° F (26.7° C) and circulating air around the fuel tank.

Analysis of Comments

After considering all of the comments, EPA still believes that CARB's adopted test procedure, by allowing 100 minutes of driving time to purge the evaporative canister, does not ensure effective emission control. Most importantly, the majority of the driving time, and therefore purging time, in CARB's test occurs when there is no measurement of exhaust emissions. Vapors purged from the canister during the running loss test could simply pass unburned out the vehicle's tailpipe as exhaust emissions, without detection. CARB's test sequence thus gives manufacturers an important incentive to minimize the amount of purge during the early part of the test's driving time, when exhaust emissions are measured. An inadequate purge requirement would result in reduced evaporative control effectiveness for vehicles experiencing mostly short trips, and could also cause increased exhaust emissions in use, compared to today's vehicles.

In addition, CARB's adopted procedure would be very difficult to use as the exclusive test for in-use enforcement for three reasons. First, CARB's adopted procedure would require

---

[8]Letter from Gordon E. Allardyce, Chrysler Corporation, to Docket A-89-18, March 23, 1992 (item IV-D-76).

[9]Letter from Donald R. Buist, Ford Motor Company, to Richard D. Wilson, EPA, March 27, 1992 (Docket A-89-18, item IV-D-77).

[10]Letter from Samuel A. Leonard, General Motors, to Richard D. Wilson, EPA, March 23, 1992 (Docket A-89-18, item IV-D-78).

that a full running loss test be conducted before every diurnal emission test. EPA believes that the diurnal emission test is of primary importance in verifying the key parameters of canister purge and storage capacity. EPA expects that the resource-intensive running loss test can be reserved for vehicle designs with higher vapor loads to the engine, such as those with high fuel temperatures during driving. CARB's adopted test would remove this flexibility, and would require a greater investment in running loss facilities, significantly increasing the cost and effort of testing. Second, some of CARB's running loss test specifications are very difficult to maintain, increasing the likelihood of invalid tests. This would also apply to certification confirmatory testing. Third, in-use vehicles would likely need to have fuel tanks removed for installation of thermocouples for the running loss test. Thermocouple installation is a time-consuming procedure, and may call into question the validity of test results if installation affects the integrity of the vehicle's emission control system.

EPA believes that its proposed test, with three diurnal heat builds following the exhaust emission test, is a feasible requirement that would achieve good in-use control. EPA has evaluated the emission benefits of its proposed test sequence relative to CARB's. This evaluation is described in a draft technical report and was the subject of the January 1992 public workshop.[11] The draft report concluded (as noted above) that CARB's test had so much driving time before the diurnal emission test that manufacturers could substantially delay purging. Refinements made to the analysis, described in Appendix A, only reinforce that concern. If vehicles designed for CARB's adopted test delay purging, in-use emissions may actually increase from current levels, contrary to the requirements of Clean Air Act section 202(k) (or section 202(a) for methanol-fueled vehicles). The analysis shows that these vehicles would perform poorly in use, because many in-use driving patterns involve short trips with less driving time than is present in CARB's adopted test procedure. In comparison, the analysis shows that vehicles designed to pass EPA's proposed test sequence with three diurnal heat builds would almost completely control emissions for a wide range of in-use driving patterns.

EPA has, however, made a concerted effort to achieve common test requirements for federal and California-only vehicles, within the constraints of its legal obligation under section 202(k) of the Act. EPA has considered possible modifications to the CARB procedure to ensure effective in-use emission control, while addressing manufacturers' expressed concerns about the relative stringency and associated costs of test options, and the desirability of avoiding the expense and administrative complication of maintaining different federal and California-only tests. The following discussion evaluates the various proposed or suggested modifications to CARB's test.

Merely relying on existing requirements aimed at preventing defeat devices, as suggested by some commenters, is insufficient to ensure adequate emission control. Most participants, including CARB (particularly in its March 6, 1992 letter), have acknowledged that CARB's adopted test sequence allows manufacturers flexibility that could result in poor in-use performance. Defeat device regulations rely on a subjective evaluation of designs to identify possible defeat devices. As much as possible, the test itself should ensure effective in-use performance and so avoid the need for such subjective inquiries. Moreover, this is the Agency's legal mandate under section 202(k).

---

[11]"Emission Evaluation of the GM Real Time Evaporative Test Procedure," draft EPA report by Julie Hayden, September 25, 1991 (Docket A-89-18, item III-B-2).

The various suggested improvements to CARB's adopted test sequence are also not satisfactory. Measuring a change in canister mass during the exhaust emission test is an inappropriate way to verify purge during short trips. Any requirement for a change in canister mass would effectively be a design standard, because it would dictate requirements for certain vehicle components rather than demonstrating the vehicle's performance to an emission standard. EPA strongly prefers performance standards over design standards because design standards can unnecessarily constrain manufacturers' design options, and may not be effective in improving in-use performance in that they may not address possible unforeseen mechanisms by which emissions occur. Also, the removal of a canister to determine its mass change would involve an unnecessary intrusion into the control system, both before and after the exhaust emission test.

Measurement of purge airflow is also an inappropriate way to verify purge. Requiring some specified distribution of purge in different driving conditions would effectively be a design standard, and therefore not a preferred alternative for the reasons just noted. Also, there is an enormous degree of latitude in defining the criterion for acceptable purge distribution, so that setting such a criterion would require a subjective evaluation of what constitutes an optimum strategy, to the exclusion of other reasonable strategies. The nature of design standards virtually ensures that any such criterion would either be ineffective in ensuring in-use emission control, or would unnecessarily restrict manufacturers' flexibility in vehicle design, or both. EPA believes the goals of establishing an effective, yet nonrestrictive purge flow criterion are irreconcilable, as evidenced by the fact that CARB has been unable to reach an agreement with manufacturers. Measurement of purge airflow may also require temporary, intrusive vehicle modifications that could impact vehicle evaporative emissions and call into question the test results.

Manufacturers' suggestions to perform the running loss segment of the test without measuring emissions, in order to increase testing capacity, does not address EPA's primary concern: that manufacturers would minimize purge rates during the exhaust emission test. In fact, removing the vapor generation component from the running loss test by holding the vehicle and its fuel at low nominal temperatures would only increase the incentive for manufacturers to delay substantial purge until the running loss test.

A special test measuring vehicle emissions from two diurnal heat builds immediately after the exhaust emission test is the only suggested modification to CARB's test procedure that addresses EPA's need for assurance of adequate purge. This assurance comes from the fact that such a test measures emissions following a relatively short amount of driving, as is common in use. Measuring emissions is necessary to establish a performance standard, and to prevent the need for any intrusive measurement of secondary variables such as canister mass or purge airflow. A supplemental procedure could verify sufficient purge for short trips without being more stringent overall than the full three-diurnal test. Such a procedure would only change the overall test requirements for vehicles that are indeed insufficiently purging early in the test.

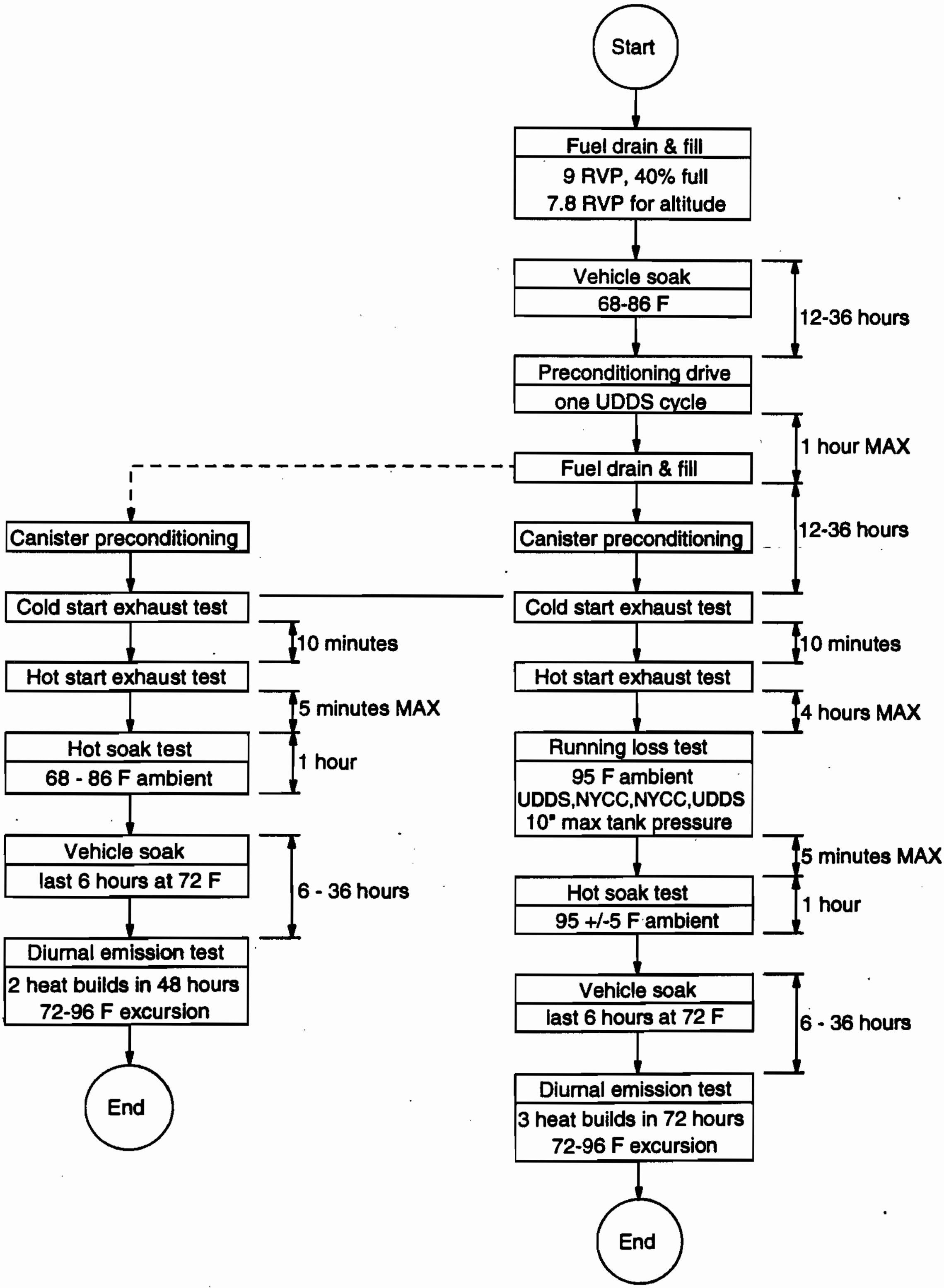
In addition to verifying adequate purge, a supplemental test procedure is also the best way of dealing with EPA's other concerns regarding CARB's test. The simpler supplemental procedure measures the performance of vehicles' evaporative emission controls with much lower resource requirements than the full sequence. Also, the supplemental procedure can prevent the possibility of a significant increase in exhaust emissions by ensuring that exhaust emissions are measured while the canister is being purged.

EPA thus considers the fundamental elements of the alternate procedure suggested by CARB, and developed further in the Ford and Chrysler comments, to be effective and reasonable. The approach taken in defining this procedure helps to ensure that it does not introduce challenges to vehicle designers beyond those already imposed by the three-diurnal test, except for ensuring that vehicles can purge effectively to control evaporative emissions. For example, eliminating a diurnal heat build, initially loading the evaporative canister only to breakthrough, measuring a moderate-temperature hot soak, and increasing the standard from 2 to 2.5 grams all contribute significantly to making the supplemental procedure effective in its limited objective of ensuring proper purge without requiring additional design modifications (such as increased canister size). Figure 2-2 shows EPA's approach to designing an evaporative test based on the Ford and Chrysler comments. Also, EPA believes that the vehicle hardware that would be needed to meet the test requirements proposed in EPA's January 1990 NPRM (e.g., canisters, purge valves) will be sufficient to meet the requirements of the supplemental test.

The supplemental test procedure would not in itself provide assurance that a vehicle could meet all requirements of the longer three-diurnal test. For example, there is no measurement of running losses and the final diurnal heat build is omitted in the supplemental test. Thus, the supplemental procedure is not a replacement for the three-diurnal test. However, the opportunity for EPA to run the longer test, in both confirmatory certification and in-use testing, provides the necessary assurance that vehicle designs will achieve optimum control.

Because neither test sequence is sufficient in itself to demonstrate adequate control of evaporative emissions, manufacturers would have to perform certification testing using both sequences. Reserving the supplemental test only for EPA's testing of in-use vehicles, as suggested by Ford and Chrysler, would therefore be inappropriate. EPA recognizes that this adds some testing burden to the certification process. However, the record established in the docket for this rulemaking makes it amply clear that the industry views consistency with CARB's requirements (with potential implications for vehicle designs and costs) to be of more critical importance than minimizing the test burden for federal testing. A test based on the CARB procedure, with the addition of the supplemental test, deals with manufacturers' concerns and, because it allows EPA to meet statutory requirements, is acceptable to

Figure 2-2
Evaporative Emissions Test



EPA. Moreover, CARB has expressed its willingness to recommend the adoption of this approach to their Air Resources Board following action by EPA.[12]

B. Emission Standards

EPA intends that further emission reductions from improved evaporative emission controls will be prompted by changes in the test procedure itself, rather than by simply reducing the numerical value of the standard, as discussed in Chapter 1. The revisions to the test procedure do cause a change in the effective stringency of the standard, since the test requires the same performance from a more challenging sequence of events, and thus will lead to optimized control of evaporative emissions under the situations contemplated by Clean Air Act section 202(k).

[12]Letter from Thomas Cackette, CARB, to Charles L. Gray, EPA, September 15, 1992 (Docket A-89-18, item IV-D-88).

EPA Proposal

The existing standard is set at 2 grams of hydrocarbons for the combined measurements of diurnal and hot soak emissions. EPA proposed at the January 1992 workshop to adopt the same form of the evaporative standard that CARB adopted. For light-duty vehicles (LDVs) and light-duty trucks (LDTs), this would require the sum of the measured emissions from the diurnal and hot soak tests to be less than 2 grams, and the emissions from the running loss test to be less than 0.05 g/mi (0.03 g/km). Heavy-duty vehicles (HDVs) would be subject to a similar standard based on the existing levels of 3 and 4 grams for light and medium heavy-duty vehicles, respectively, and a running loss standard of 0.05 g/mi (0.03 g/km). Heavy heavy-duty vehicles would continue to be subject to an engineering evaluation to demonstrate compliance with the standards for medium heavy-duty vehicles.

Unlike CARB, EPA proposed to include nonfuel emissions in the standards, not allowing any subtraction or exclusion of nonfuel background from measured emissions. EPA revised the wording of the standard from "fuel evaporative emissions" to "evaporative emissions" to reflect the intent to include all measured emissions to determine compliance with standards. Again, this is in keeping with the mandate of section 202(k) to optimize control of evaporative emissions.

EPA also proposed at the January 1992 workshop to set a standard of 1.0 gram for the spitback test during vehicle refueling.

Summary of Comments

Commenters concentrated on the need to allow subtraction of nonfuel background emissions. Manufacturers argued that they should not be responsible for nonfuel emissions in evaporative testing. This concern was heightened by the proposed change in the sampling period for the diurnal emission test from 1 hour to 24 hours, because nonfuel emissions would accumulate for a much longer time.

For the supplemental procedure, manufacturers requested that the 2-gram standard be relaxed to avoid a net increase in stringency. Manufacturers recommended a 2.5-gram standard for vehicles with fuel tanks smaller than 30 gallons (110 liters), and a 3.0-gram standard for vehicles with larger fuel tanks.

Chrysler suggested introducing somewhat relaxed standards for intermediate useful life testing. Chrysler argued that the lack of experience with the new technologies warranted protection from minor deterioration caused by unexpected problems. For in-use testing, Chrysler proposed relaxing the 2-gram standard to 2.5 grams, and relaxing the 0.05-gram standard for the running loss test to 0.06 grams.

EPA received no other comments related to the running loss test standard or the spitback test standard for light-duty vehicles and light-duty trucks, and received no comments related to any standards for heavy-duty vehicles.

Analysis of Comments

EPA's position on the treatment of nonfuel background emissions was established in the original action to implement the 2-gram standard for evaporative testing (41 FR 35626, August 23, 1976). The Agency stated at that time:

> Providing a factor to account for possible background emissions (e.g., 1 g/test) would thus have the practical effect of easing the intended fuel evaporative emission standard by whatever the background allowance might be, since manufacturers would still be expected to provide test vehicles with minimized background emissions.... If, however, a manufacturer uses paints or plastic materials that will continue for long periods of time to emit significant levels of background emissions, these emissions should properly be charged against the in-use vehicle inasmuch as such emissions are real hydrocarbons that contribute to air pollution.

EPA's position thus has been that the nonzero standard implies an expectation of full control of evaporative emissions, with an allowance to account for nonfuel background emissions and test variability. New understanding of resting losses prompts a small readjustment of this view, since it is now clear that evaporative emissions can be minimized, but not completely eliminated. The revised test and standard, however, maintain the expectation that fuel emissions are near zero, even with the increased performance requirements for control of diurnal, hot soak, running loss, and resting loss emissions.

Including nonfuel background emissions in the reported values should not jeopardize the validity of test results or the feasibility of compliance. EPA and GM test data indicate that nonfuel emissions from stabilized vehicles are typically on the order of 0.1 grams, and occasionally as high as 0.5 grams, in a 24-hour period.[13,14] Even the worst expected background emission is considerably smaller than the 2-gram standard.

Furthermore, as a matter of practice, EPA typically excludes vehicles from recall confirmatory testing for evaporative emissions if there is an indication that nonfuel emissions may be unusually high. For example, if a vehicle had received rust-proofing, body repairs, or modifications to upholstery within the previous three months, it would be excluded from testing. Similarly, if a vehicle had experienced a spill from any container of gasoline or kerosene within the previous three months, it would be excluded from testing.

In response to the comments requesting a relaxed standard for vehicles with large fuel tanks, EPA agrees that this is appropriate for certain vehicles. EPA's approach to setting evaporative emission standards has consistently been that, although a good test procedure is the primary means by which control is assured, setting different diurnal emission standards based roughly on vehicle size is appropriate. This provides recognition of the fact that a larger vehicle, possessing larger fuel system components, is likely to have higher emissions in diurnal testing than a smaller vehicle, even when they are both achieving what would generally be considered an equivalent degree of optimized control. EPA's choice of standards for heavy-duty vehicles in this rule follows this pattern. This is even more important with the introduction of extended-time diurnal emission testing, discussed below. Consistent with this approach, EPA believes that the larger light-duty trucks, those with a gross vehicle weight rating (GVWR) between 6,000 and 8,500 pounds (2,700 to 3,900 kg), which have large fuel tanks (over 30 gallons (110 liters) nominal size) comprise a category of vehicles for which it is appropriate to set a standard of 2.5 grams, halfway between the 2-gram light-duty standard and the 3-gram light heavy-duty standard.

---

[13]"Real Time Nonfuel Background Emissions," Harold Haskew, et al, General Motors, October 1991, SAE 912373.

[14]"Resting Loss and Background Emission Data," EPA note from Alan Stout, to Charles Gray, June 20, 1991 (Docket A-89-18, item IV-B-5).

On the issue of the standard for the supplemental procedure, EPA is increasing the level of the standard by 0.5 grams for all vehicles in order to accommodate manufacturers' concerns. The additional 0.5 grams helps to ensure that the supplemental procedure does not introduce challenges to vehicle designers beyond those already imposed by the three-diurnal test, as described above, and the need to provide assurance that vehicles can purge effectively within a relatively short driving time. The standard for the measured diurnal and hot soak emissions would then be 2.5 grams for light-duty vehicles and light-duty trucks, 3.0 grams for light-duty trucks with GVWR between 6,000 to 8,500 pounds (2,700 to 3,900 kg) that have fuel tanks of nominal size of 30 gallons (110 liters) or more, and 3.5 and 4.5 grams for light and medium heavy-duty vehicles, respectively. The slightly relaxed standard for the supplemental procedure will not compromise in-use control, because the adequacy of control is primarily determined by the test procedure (as explained in Chapter 1), and because manufacturers must also design vehicles to meet the lower standards for the full three-diurnal test. Even with the higher standard, the supplemental procedure, in combination with the rest of the test, will meet the statutory requirement to require the greatest achievable degree of control.

The 0.05 g/mi (0.03 g/km) standard for the running loss test was first proposed by CARB, and was widely supported by the auto industry. The standard allows about 1 gram of emissions during the hour of driving, comparable to current testing for diurnal and hot soak emissions. EPA believes that CARB's adopted standard of 0.05 g/mi (0.03 g/km) will require the greatest achievable degree of control under ozone-prone summertime conditions.

Regarding Chrysler's suggestion for relaxed in-use testing standards, EPA does not believe it necessary to relax these standards. Based on comments, EPA expects that improvements in the evaporative control systems will be fairly straightforward upgrades of existing technologies, as described in Chapter 3. Commenters have provided no clear rationale for a change in technology that would justify a relaxation of the standards for in-use vehicles.

C. Diurnal Emission Test

The generation of vapors from diurnal heating is a straightforward phenomenon that can be simulated in laboratory testing. When a vehicle is not driven but is exposed to outdoor conditions, its fuel temperatures rise and fall in response to cycling ambient temperatures. The increase in fuel temperatures causes evaporation of liquid fuel and expansion of the vapor space so that fuel vapors are driven from the tank. The current method of simulation—rapidly heating the fuel from an initial to a final temperature—is a simple procedure that simulates the actual diurnal heat build. Over the course of the rulemaking EPA has considered various changes that would not only make the test more challenging, but would also increase the accuracy of the simulation.

<u>EPA Proposal</u>—Test Method

At the January 1992 workshop, EPA proposed the new diurnal test method advocated by GM, in which the whole test vehicle would be exposed to ambient temperatures cycled over 24-hour periods. Emissions would be collected in a SHED (Sealed Housing for Evaporative Determination). EPA also requested comment on a simplified method of conducting the diurnal temperature cycling. The test vehicle would be stabilized at the low diurnal temperature, then exposed to the high diurnal temperature with fans positioned to ensure sufficient air circulation around the fuel tank. The air circulation around the fuel tank decreases the time required for the fuel to experience the full temperature excursion. Because this procedure would not be long enough to allow the measurement of resting losses separate from diurnal emissions, a separate test for resting losses would be required.

Summary of Comments

GM championed the concept of extended-time diurnal emission testing; CARB and almost all other manufacturers eventually expressed support for the approach. GM identified several advantages of their method of testing. First, cycling ambient temperatures in 24-hour periods would improve the accuracy and repeatability of the test. Vapor loading rates to the canister would be more representative, the fuel heating would be close to an equilibrium process, as it is in use, and all emission sources would be better measured and controlled.

Second, by allowing the fuel to cool without refueling, the test would automatically account for fuel weathering. Fuel weathering, which occurs as a vehicle is driven or exposed to diurnal heat builds, decreases the volatility of the fuel over time.

Third, GM claimed that the improved simulation of a vehicle's in-use experience would provide incentive for manufacturers to design their emission controls to achieve maximum in-use emission reductions. The lengthy time in the measurement enclosure would account for resting losses, providing an incentive for manufacturers to modify vehicle designs to control these slowly emitted losses. Also, allowing the fuel to cool naturally would encourage manufacturers to design their fuel systems to allow the phenomenon of backpurge. A vehicle that can backpurge draws air and vapors from the evaporative canister into the fuel tank when the liquid fuel cools and causes condensation of fuel tank vapors. Ambient temperature exposure would also give full credit for insulating fuel tanks to minimize fuel temperature excursions (and thus vapor generation).

Several manufacturers opposed the use of the accelerated method to measure diurnal emissions. These manufacturers supported the 24-hour testing method and considered the flexibility provided by an alternate method unnecessary.

Analysis of Comments

While the Agency has no objection to the concept of extended-time testing, it believes that an effective diurnal emission test, with most of the advantages of extended-time testing, can be realized with a much shorter test time. The procedure in the December 1990 workshop notice already took many of these factors into account.

EPA believes that the alternate method for accelerated ambient heating of the vehicle could achieve emission reductions comparable to those achieved by GM's test. Such testing would require only minor modifications to existing equipment and facilities and would greatly reduce the time involved for each test. Nevertheless, because of the broad support for extended-time diurnal emission testing, EPA is finalizing regulations based on this approach. Also, any possible emission sources that may not currently be identified would more likely be measured and controlled with the real time test.

EPA Proposal—Test Severity

In the January 1990 NPRM, EPA proposed to conduct two consecutive diurnal heat builds. EPA proposed to heat the fuel from 72° to 96° F (22.2° to 35.6° C), based on a thorough analysis of summer ambient temperatures across much of the United States. At the December 1990 and January 1992 workshops, EPA proposed the addition of a third diurnal heat build.

As part of the proposal at the January 1992 workshop to adopt GM's method of heating the whole vehicle, EPA included a provision to require an underbody circulation rate of at least 5 miles (8 km) per hour to maintain the transfer of heat into and out of the fuel tank.

Summary of Comments

Manufacturers did not object to the specified temperature range. However, to deal with EPA's concerns for fuel temperatures lagging behind ambient temperatures, manufacturers suggested the possibility of adjusting to an ambient temperature range of 70° to 98° F (21.1° to 36.7° C). In later comments, manufacturers expressed a preference to maintain the 72° to 96° F (22.2° to 35.6° C) ambient temperature range, but to specify a temperature tolerance for the air just below the fuel tank.

Manufacturers questioned the basis for adding the third diurnal heat build, and suggested conducting only two heat builds to save test time and facility costs.

Analysis of Comments

Section 202(k) of the Clean Air Act specifically requires test conditions to reflect "ozone-prone summertime conditions." The temperatures chosen by EPA are based on meteorological data for high ozone days. The high diurnal temperature of 96° F (35.6° C) is the average of the daily high temperatures for the hottest ten percent of the days in this data.[15] Since daily low temperatures in this data subset were, on average, 24° F (4.4° C) less than the associated high temperatures, 72° F (22.2° C) was chosen as the low diurnal temperature. Thus, to meet statutory requirements, EPA is retaining the 72° to 96° F (22.2° to 35.6° C) temperature specification.

Fuel temperatures are expected to experience temperature cycling during the diurnal emission test comparable to what would occur outdoors under ozone-prone summertime conditions. Since test data indicate that peak fuel temperatures are typically at least as high as peak ambient temperatures, EPA would expect fuel temperatures in uninsulated tanks to experience the full temperature cycling from 72° to 96° F.[16] Specifying a minimum 5 mile (8 km) per hour circulation under the vehicle is important in achieving this goal. Testing by EPA shows that, with air circulation around the fuel tank and gradually cycled ambient temperatures, fuel temperatures in uninsulated tanks stay very close to ambient temperatures.[17] Specifying a temperature tolerance for the space below the fuel tank, as suggested by commenters, would be inappropriate, because the temperature gradients involved are very small (especially relative to the ±3° F (±1.7° C) ambient temperature tolerance). Also, even a very thin layer of still air around the fuel tank would be effective in insulating the tank. Because adequate air circulation plays a key role in the diurnal heat transfer process, EPA will retain the opportunity to determine appropriate fan configurations when performing evaporative emission tests.

[15]"Procedure for Determining Daily Maximum and Diurnal Temperatures," EPA memo from Mark Wolcott to John Anderson, September 12, 1988 (Docket A-89-18, item II-B-2).

[16]"Peak Fuel Temperatures in Parked Vehicles," EPA memo from Alan Stout to Joanne I. Goldhand, January 13, 1993 (item IV-B-9).

[17]"Testing in Support of Short Diurnal Test", EPA memo from Bryan Manning to Chester J. France, December 16, 1991, (Docket A-89-18, item IV-B-4).

Moreover, EPA may compare a vehicle's fuel temperatures under outdoor, summertime conditions with test fuel temperatures and take measures to correct any demonstrated discrepancy. EPA recognizes that it is not feasible for a test procedure to ensure a SHED environment that simulates the wide range of environmental factors affecting fuel tank heating in use, particularly those induced by direct solar heating of the vehicle and nearby surfaces. EPA may adjust ambient temperatures as necessary to induce the temperature swing in the fuel representative of in-use conditions. For vehicles with fuel tanks isolated from underbody airflows, by physical barriers or by location, EPA may adjust fans to ensure sufficient air circulation around the fuel tank.

Regarding the comments objecting to the addition of a third diurnal heat build to the test procedure, EPA believes that the third heat build is appropriate. CARB first introduced a third diurnal heat build to evaporative testing, arguing that it would further reduce in-use evaporative emissions. The addition of the third heat build will prompt more effective vehicle designs (in terms of canister capacity and canister purge), which will cause reduced emissions for vehicles that are parked for three consecutive days, as well as other driving scenarios. For example, if a vehicle is driven only a short amount between one-day parking episodes, the additional effectiveness of the canister purge could enable the vehicle to maintain control. In addition, the statute clearly provides discretion to take this action. Section 202(k) states that an evaporative emission standard should provide optimized control "over two or more days of nonuse."

D. Running Loss Test

When federal testing for evaporative emissions was first developed, the possibility of running losses was acknowledged, but the understanding of the phenomenon and the development of test equipment was insufficient at that time to prescribe a test that would prevent running losses under typical summer conditions. The original test for running losses, which involved sampling for emissions with carbon traps during the exhaust emission test, is ineffective because of the low temperatures and the inadequacy of the collection method.

In recent years EPA's understanding of the extent of in-use running losses has grown as testing of in-use vehicles revealed unexpectedly high levels of running losses. EPA therefore included in the proposed revisions to the test procedure a means of ensuring running loss control. Furthermore, the amended Clean Air Act mandates that EPA regulate running losses from in-use vehicles.

The fundamental question in regulating running losses is whether vehicles should be directly tested for emissions during driving, or whether the arrangement of the other test segments—loading the canister, executing a prescribed drive, and conducting consecutive diurnal heat builds—can ensure sufficient running loss control. The following presentation first deals with this fundamental question, then pursues the whole range of issues that arise if a running loss test is required. In the January 1990 NPRM, EPA published GM's running loss test for comment, and proposed a similar test at the December 1990 and January 1992 workshops.

EPA Proposal—Adoption of a Running Loss Test

EPA proposed a set of test provisions in the January 1990 NPRM to prevent the occurrence of in-use running losses. These provisions were intended to guarantee that all fuel vapors generated in the tank would eventually be consumed by the engine. First, the initial loading of the evaporative canister would ensure that sufficient purge occurs during the exhaust emission test so that in-use vehicles would be able to create canister capacity with limited driving. Second, designs of evaporative emission controls would be subject to an engineering review for certification to ensure that all hydrocarbon vapors would be routed to the evaporative canister or directly to the engine. Finally, fuel cap removal at the beginning of the hot soak test (after the exhaust emission test) would encourage the use of low-pressure fuel tank designs during driving. Vehicles with low-pressure designs are preferable, because they are less likely to emit high rates of hydrocarbons if a fuel system loses the ability to hold pressure.

Summary of Comments

Almost all commenters supported adoption of a running loss test and objected to the other provisions that were intended to ensure running loss control. In particular, manufacturers objected to an undefined design review and opposed any limitation of fuel tank pressures. GM and Toyota submitted very similar proposals for conducting a high-temperature running loss test for a long drive. The New York State Department of Conservation supported running loss testing because it included an incentive to minimize vapor generation.

Analysis of Comments

The main factor in controlling running losses is a vehicle's ability to purge vapors to the engine as they are generated. The sequence of events in the test procedure (with or without a running loss test) should generally ensure that vehicles passing the diurnal emission test will have sufficient purge to pass a running loss test. A direct test for running losses, broadly supported by industry, would provide positive assurance that this is the case. EPA has therefore decided to include it as part of the test procedure. A new running loss test would also have the benefit of giving manufacturers the incentive to pursue vehicle designs that reduce fuel temperature increases (and vapor generation) during driving.

EPA is omitting the cap-removal step from the hot soak test. EPA is instead adopting CARB's requirement to prevent fuel tank pressures higher than 10 inches of water (2.5 kPa), unless the vapors, other than refueling emissions, are vented to the evaporative canister when the fuel cap is removed. EPA is adopting this requirement to maintain consistency with CARB's test requirements wherever this can be done without sacrificing emission control benefits. Although EPA does not believe that this requirement will fully prevent high fuel tank pressures, because of the vent-to-canister provision, CARB's requirement should be effective in preventing gasoline emissions whenever fuel caps are removed after a pressure buildup in the fuel tank. In the future EPA expects to pursue other regulatory action as necessary to deal with the problems associated with fuel systems that fail to hold pressure.

EPA is omitting the design review as a routine part of the certification process, but is including in the regulations the requirement to route all vapors to the engine or the evaporative canister. This provides the manufacturers with a straightforward requirement aimed at ensuring that vehicles do not routinely lose control. There is no justification for maintaining a valve that would release vapors under expected driving conditions. The regulations allow for an exception in emergency situations and are not intended to include refueling emissions.

EPA Proposal—Test Parameters

EPA proposed that a vehicle be exposed to 95° F (35° C) ambient conditions with humidity held at 100 grains per pound (14.3 grams per kilogram) of dry air during the running loss test.

EPA also recommended that the driving cycle consist of one Urban Dynamometer Driving Schedule (UDDS), two New York City Cycles (NYCC), and another UDDS. After the first UDDS and the second NYCC the vehicle would experience a two-minute idle. The two NYCCs of this driving cycle were a revision to GM's proposed driving cycle of three UDDSs, which CARB adopted.

EPA specified a vehicle refueling event before the running loss test to prevent excessive weathering of the test fuel. EPA also specified an overall air circulation requirement of 5.5±0.5 cfm per cubic foot (ℓpm per liter) of enclosure volume.

Summary of Comments

Manufacturers endorsed the 95° F (35° C) ambient temperature specification.

Most manufacturers preferred a driving schedule with three UDDS cycles, but they acknowledged that either driving schedule would be acceptable, especially if it would be adopted by both EPA and CARB. Most commenters did not expect the different driving schedules to result in product differences or different in-use control of running losses. The New York City Department of Environmental Protection emphasized that vehicles should be tested with low-speed driving and short trip cycles, such as is reflected in the NYCC, to ensure control in these conditions.

Manufacturers requested lowering or removing the humidity specification to avoid uncomfortable conditions for the test drivers, adding that the humidity specification is not a significant test requirement.

Manufacturers requested that the refueling event before the running loss test be omitted, to avoid having to test to an unlikely in-use scenario and to prevent unnecessary test effort.

Honda asked that EPA change the air circulation requirement, because of the large volume of their enclosure, and because of CARB's different specification for a high-volume road-speed modulated fan.

Analysis of Comments

The selection of 95° F (35° C) as the ambient temperature for the running loss test is based on the control scenario of a vehicle starting a long trip near the point of its maximum fuel temperature during the day, clearly a reasonable possibility. With no comments to the contrary, EPA is adopting this specification.

EPA analysis supports the driving schedule proposed at the December 1990 workshop. EPA analysis of test data indicates that the New York City Cycle, representative of approximately 15 percent of urban driving, can increase the effectiveness of the running loss test.[18] The analysis showed that vehicles with adequate purge for higher-speed UDDS driving can have inadequate purge at lower speeds.

[18] "Running Loss Emission Control: LA-4 vs. NYCC Test," EPA memo from Rick Rykowski to Charles Gray, April 17, 1990 (Docket A-89-18, item IV-B-6).

Controlling the humidity of the test environment is desirable, because humidity has some effect on the vehicle's ability to purge its canister.[19] The proposed humidity specification of 100 grains per pound (14.3 grams per kilogram) of dry air, equivalent to a dew point of 67° F (19.4° C) and a relative humidity of 40 percent at 95° F (35° C), represents typical summer conditions in the United States. EPA acknowledges, however, that driver discomfort at the high temperatures is a reasonable concern. Given the concern for driver discomfort, the proposed humidity specification, as a test parameter of secondary importance, has not been retained.

EPA has revised the specified circulation to a minimum 2 cfm per cubic foot (ℓpm per liter) of enclosure volume. This minimum overall circulation rate is expected to be sufficient to prevent temperature and hydrocarbon stratification in the enclosure. Omitting the maximum circulation rate allows full use of a fan that varies with dynamometer roll speed.

<u>EPA Proposal</u>—Fuel Temperature Profile

EPA proposed that the manufacturer establish fuel tank liquid temperature profiles for driving in summer conditions. The fuel temperature profile would be used as a target during the running loss test to simulate the heating of the vehicle's fuel tank during driving. EPA proposed to limit testing to certain ambient conditions, including steady or increasing ambient temperatures over 80° F (26.7° C), a sustained wind speed under 10 miles (16 km) per hour, and a road surface temperature at least 30° F (16.7° C) above ambient temperature, on average, during the test. Manufacturers would generate the profile by obtaining a trace of fuel temperature versus time while driving the vehicle over the established driving schedule.

The measured temperature profile would be adjusted to an initial temperature of 95° F (35° C). Fuel temperatures during the running loss test would be controlled to match the profile temperature within 3° F (1.7° C); this tolerance would be reduced to 2° F (1.1° C) during the last two minutes of the test.

<u>Summary of Comments</u>

CARB adopted a procedure with different requirements for developing fuel temperature profiles. CARB specified ambient temperatures at least 95° F (35° C), wind speeds under 15 miles (24 km) per hour, road surface temperature at least 20° F (11.1° C) above ambient temperature, and a maximum cloud cover of 25 percent.

Commenters acknowledged the need to develop fuel temperature profiles in summer conditions. Manufacturers recommended that EPA and CARB adopt the same ambient condition requirements to avoid the need for two profiles. GM and Ford proposed ambient temperature specifications of 87° to 100° F (30.6° to 37.8° C) and 90° to 100° F (32.2° to 37.8° C), respectively. Honda recommended specifying an ambient temperature of at least 95° F (35° C), a sustained wind speed of less than 10 mph (16 km/hr), and road surface temperatures at least 20° F (11.1° C) above the ambient temperature, measured at the beginning and end of the drive. Toyota commented that the proposed ambient requirements would seriously limit the ability of Japanese and European manufacturers to establish their fuel temperature profiles.

---

[19] "Effect of Humid Purge Air on the Performance of Commercial Activated Carbons Used for Evaporative Emission Control," J. Urbanic, et al, September 1989, SAE 892039.

Honda requested that EPA allow manufacturers to adjust the measured fuel temperature profiles to an initial temperature less than 95° F (35° C). The lower initial temperature would be based on a demonstration that there is adequate insulation of the fuel system to ensure lower-than-ambient fuel temperatures at the beginning of any drive.

Honda also requested that EPA add a requirement to control the vapor temperatures in the fuel tank during the running loss test. Manufacturers would generate a vapor temperature profile for the last two minutes of the driving cycle; vapor temperatures during the last two minutes of the running loss test would be required to match this profile to within 3° F (1.7° C).

Analysis of Comments

Through the development of fuel temperature profiles for in-use vehicles, EPA has learned much about the factors that affect the heat transfer to the fuel tank during vehicle operation. The temperature of the pavement relative to ambient temperature correlates most strongly with fuel temperatures. Test data shows that pavement temperatures are often 30° F (16.7° C) and sometimes 40° F (22.2° C) or more above ambient temperatures.[20] EPA is therefore specifying a minimum temperature difference of 30° F (16.7° C) to provide adequate assurance of conditions representative of ozone-prone summertime conditions.

EPA is requiring measurement of pavement temperatures throughout the drive. Pavement temperature is very sensitive to instantaneous solar loading. Pavement temperatures measured only at the beginning and end of the drive could, therefore, give a poor indication of conditions on a partly cloudy day.

EPA does not believe that very high ambient temperatures are needed to develop fuel temperature profiles. As long as pavement temperatures are high enough above ambient temperatures, fuel temperature behavior should be representative of high-temperature conditions. In fact, with all other conditions constant, higher ambient temperatures should coincide somewhat with lower fuel temperature increases. This relationship can be explained by the dependence of heat transfer on temperature gradients. When the fuel in the tank starts at a lower temperature, there is a greater temperature gradient relative to the underbody air heated by the engine, and also a greater temperature difference between the recirculated fuel and the fuel in the tank. However, this effect does not appear to be primary, and, considering manufacturers' desire for consistency with CARB's requirements, EPA is specifying a minimum ambient temperature of 95° F (35° C), with no maximum temperature.

Because pavement temperature serves as a good indicator of the degree of solar loading, and is fundamental in affecting fuel temperatures, EPA believes that an extra specification for maximum cloud cover is not necessary. However, to be consistent with CARB's requirements, EPA is including CARB's specified maximum cloud cover of 25 percent. Considering the subjectivity involved in cloud cover assessments and ambient temperature measurements, EPA is also requiring submission of meteorological data from the nearest weather station. EPA expects manufacturers to justify any significant discrepancy between the reported figures.

---

[20] "Determination of Tank Fuel Temperature Excursions", Final Report by ATL, Inc. (EPA contract 68-C9-0027, Work assignment 2-1), November 19, 1991 (Docket A-89-18, item IV-A-4).

EPA is not allowing manufacturers to use lower initial temperatures for the running loss test for several reasons. First, in the common in-use occurrence in which a vehicle parks for a short time between trips, fuel temperatures at the beginning of the second trip could be much higher than the ambient temperature because of the previous drive. In such a scenario, tank insulation would actually increase the likelihood of higher fuel temperatures. Second, EPA test data indicate that peak fuel temperatures are typically at least as high as peak ambient temperatures, and sometimes as much as 5° or 6° F above peak ambient temperatures.[21] Third, 95° F (35° C) is not intended to be a maximum possible ambient temperature. Therefore, even with substantial insulation of the fuel tank, fuel temperatures could easily reach 95° F (35° C) on a warmer day. Finally, specifying different temperatures for fuel and ambient at the beginning of the test introduces a technical difficulty. Because dissimilar temperatures in the lab are inherently unstable, maintaining different temperatures until the start of the test, as well as controlling the fuel temperatures during the early stages of the profile, would be difficult.

EPA strongly opposes the use of vapor temperature profiles for the running loss test. If the vapor temperature during testing were to begin to depart from the profile, technicians, using airflow to control liquid fuel temperatures, would have no additional control variable to independently manage vapor temperature. The dual temperature requirements would greatly increase the difficulty of successfully completing a running loss test. In addition, because the fuel temperature is the key parameter linking the running loss test with on-road summertime driving, matching an additional parameter may result in running loss tests that simulate an overly narrow range of in-use conditions.

<u>EPA Proposal</u>—Testing Method

EPA believes that vehicles should be subject to running loss testing either in a sealed enclosure or by the point-source method, in which emissions are sampled from the several expected sources on the vehicle. The opportunity to test in a sealed enclosure would ensure that emissions from unexpected sources would be accounted for.

<u>Summary of Comments</u>

Auto manufacturers opposed the testing for running losses by the enclosure method. First, manufacturers wanted to be responsible for passing only a single test for all enforcement testing. Manufacturers claimed that having two alternative test methods would make them subject to dual test requirements. Because they would have to pass a test by either method, they would have to develop facilities and operations to demonstrate compliance with both methods. Furthermore, manufacturers believed that emissions from unexpected sources would be detected in the diurnal or the hot soak tests.

Second, commenters were concerned about the repeatability, accuracy, and technological feasibility of the enclosure method. GM questioned the mass resolution and hydrocarbon retention capabilities of the larger SHED with the higher air circulation, and expected the vehicle's demand for engine and supplemental air to distort measurements. In comparison, GM claimed much better than 0.1-gram precision and over 98 percent propane recovery for the point-source method. Manufacturers claimed that nonfuel emissions in an enclosure would pose an unmanageable problem. Manufacturers questioned the feasibility

---

[21] "Peak Fuel Temperatures in Parked Vehicles," EPA memo from Alan Stout to Joanne I. Goldhand, January 13, 1993 (item IV-B-9).

of maintaining the specified ambient temperatures in an enclosure and of routing air to the induction system and from the tailpipe.

Third, manufacturers claimed that an enclosed dynamometer would be too costly to justify. GM stated that the enclosure facility cost would be at least ten times the cost of the point-source sampling system, since the point-source test would utilize existing equipment configurations. Similarly, Nissan claimed that the enclosure method would cost from $459,000-$473,000 per enclosure, compared to $87,000 per cell for point-source testing. Ford suggested that the enclosure test may require robotic control, which could cost an additional $250,000 per unit.

Finally, manufacturers urged EPA to eliminate the enclosure method for safety reasons. Manufacturers claimed that driving the vehicle in the enclosure was unacceptable because of the potentially high rates of vapor generation and the presence of high-pressure fuel-injection systems without ventilation in the enclosure. These conditions could result in high levels of hydrocarbons or other gases in the enclosure, which could place the driver at risk of high exposure or fire if he or she had difficulty escaping the enclosure.

The Auto/Oil Air Quality Improvement Research Program also indicated a preference for point-source testing, based on a much higher observed frequency of void tests with the enclosure method. The joint test effort involved difficulties primarily in maintaining control of fuel and ambient temperatures during running loss tests. The difficulties were presumably caused by retaining the mass of air in the enclosure, and by the limited access of technicians to make adjustments to fans and other equipment.

Analysis of Comments

As in-use vehicles age, they can emit running losses from many unpredictable sources. Testing by the point-source method would therefore be appropriate only for vehicles having readily identifiable and measurable sources of emissions. Therefore, if a running loss test is to be effective in achieving the emission reductions mandated by the Clean Air Act, the Agency believes it must be able to test for running losses in a sealed enclosure.

Enclosure testing for running losses is technically feasible. A standard of 0.05 grams per mile (0.03 g/km) for the running loss test would translate to 0.9 grams of hydrocarbons or, for a 4000 ft^3 (113 m^3) enclosure, about 12 ppm carbon. Such concentrations are well within the measurement range of existing equipment. The large running loss enclosure should present no new problems of hydrocarbon retention, even with the higher air circulation. Since air is routed from outside the enclosure directly to the engine's air intake, EPA does not expect the vehicle's air consumption to distort test results. EPA's experience with running loss testing has clearly demonstrated the feasibility of supplying engine air in an enclosure and of controlling ambient and fuel temperatures.

Nonfuel emissions should not compromise test results. New dynamometers are designed to emit no hydrocarbons at test temperatures, and the rate of nonfuel emissions from the vehicle should be comparable to that during the diurnal emission test (much less than 0.1 gram per hour).

Retaining the option to test for running losses in a sealed enclosure should pose no new safety problems for testing. First, EPA believes there is no technical difference in test safety between enclosure and point-source testing, or between running loss testing and conventional testing for exhaust emissions. In each type of testing, the vehicle is run on a dynamometer in a closed room with air supplied to the engine and exhaust gases routed out; sensors are in place to detect for unsafe conditions; and a door is accessible for personnel to exit. Second, to prevent badly emitting vehicles from producing dangerous hydrocarbon levels, a test may be terminated at the point of failure and remain valid. For those manufacturers that do not want to invest in the enclosure method, contract testing facilities should be available to perform any desired enclosure testing.

The experience gained from the Auto/Oil testing does not warrant a conclusion that the point-source method is superior to the enclosure method. Maintaining fuel temperatures within the prescribed tolerance should not be significantly more difficult in a sealed enclosure. EPA expects that fuel temperature control will require some learning, but that technicians will be able to meet test tolerances equally with either method. As indicated in the comments, programmable automatic controls may be able to eliminate void tests caused by fuel temperature control problems. Maintaining ambient temperatures within test tolerances is a matter of correctly sizing, configuring, and operating the heating, ventilating and air conditioning system and is not expected to be problematic, either for point-source or enclosure testing.

In summary, EPA continues to believe it necessary to retain the option to conduct running loss testing in a SHED. Manufacturers clearly want to retain the option to conduct their own routine testing using the point-source method, and EPA has no objection to this method. Furthermore, CARB also allows testing by either the point-source or the enclosure method. Finally, manufacturers may choose to rely solely on the point-source method; manufacturers would have to gain enough confidence that testing by the point-source method would be adequate to ensure compliance with running loss testing by the enclosure method. EPA is therefore retaining both methods in its test procedure. Thus, the rule makes clear that EPA may conduct testing using the enclosure method; manufacturers using the point-source method would have to design vehicles able to pass EPA's enclosure testing to be in compliance.

E. Preconditioning

The preconditioning of the vehicle includes all parts of the test from the beginning of the test sequence up to the beginning of the exhaust emission test. Though no sampling or testing occurs during the preconditioning period, this portion of the test is important in stabilizing the test vehicle to a known initial condition and preparing it for the series of test segments that follow.

<u>EPA Proposal</u>—Method of Canister Loading

In the January 1990 NPRM, EPA proposed to change the existing procedure by adding a step initially to load the evaporative canister to breakthrough. The evaporative canister would be loaded beginning from its as-received condition by placing the vehicle in a SHED and repeatedly heating the fuel tank until 2 grams of vapor was detected in the SHED. In the December 1990 workshop notice, EPA revised its proposal to allow as an option CARB's more convenient method to load the evaporative canister. In that option the canister would be manually purged and then loaded by sending to the canister an amount of butane equivalent to 1½ times the canister's working capacity at a rate of 15 grams butane per hour. Of course, since this would involve loading the canister past breakthrough, not all of this butane would be retained. In the December 1991 workshop notice, EPA proposed to load canisters, without purging, to 2-gram breakthrough using a mixture of butane and nitrogen at a rate of 40 grams butane per hour.

Summary of Comments

After the December 1990 workshop, auto manufacturers contested the severity of the revised canister loading procedure. Since vehicles could pass the test only by keeping the canister from reaching breakthrough, commenters felt that any load beyond breakthrough was unjustified. Several recommended that canisters be loaded with an amount of butane equivalent to the 2-gram breakthrough point. However, following the January 1992 workshop, auto manufacturers generally recommended adopting CARB's procedure, including the canister preconditioning.

Auto manufacturers agreed with the specification to load canisters with butane instead of with gasoline, but most commenters objected to the specification of loading with pure butane. They claimed that the butane should be mixed with equal parts of nitrogen to better approximate the mixture of gasoline and air generated from the fuel tank. Manufacturers' data indicated that canisters loaded to breakthrough with pure butane contained 10 to 60 percent more butane than canisters loaded with a mixture of butane and nitrogen.[22,23]

The American Petroleum Institute (API) pointed out that changes to in-use fuel volatilities continue to decrease the amount of butane in summer gasolines. API advocated a vapor composition for canister loading that includes pentane and hexane, as well as butane.

Manufacturers requested that the procedure include an initial purge of the vehicle's evaporative canister to eliminate the variability involved in testing as-received vehicles. CARB preferred to purge canisters because it enabled them to specify a fixed quantity for subsequent vapor loading, which reduces the labor requirement for monitoring the procedure.

EPA received several suggestions for canister loading rates. Toyota and Ford recommended 30 and 50 grams per hour, respectively, to avoid a prolonged canister loading procedure. CARB specified a rate of 15 grams per hour for their test. GM suggested loading canisters at whatever rate would result in about a 6-hour loading period, since in-use canisters of various sizes experience different loading rates over a constant time period.

Analysis of Comments

The Agency believes that initially loading to the 2-gram breakthrough point represents a sufficient amount of vapor to test vehicle purge rates. Loading the evaporative canister to less than breakthrough would not require emission control throughout the range of expected evaporative system behavior. A load represented by 1½ times the working capacity of the canister is expected by EPA to be a very unusual in-use occurrence, because properly functioning vehicles that can meet the new test requirements should rarely experience canister loading beyond breakthrough in use. However, to be consistent with CARB's test requirements for the three-diurnal test sequence (as supported by the manufacturers), EPA would find it acceptable to load the canister with an amount of vapor equal to 1½ times its working capacity. This degree of preconditioning will contribute to optimized control of evaporative emissions by ensuring control even under the relatively extreme conditions simulated by loading the canister beyond breakthrough.

---

[22]Letter from Satoshi Nishibori, Nissan, to Docket A-89-18, February 22, 1991 (Docket A-89-18, item IV-D-42).

[23]Letter from Samuel A. Leonard, GM, to Richard D. Wilson, EPA February 22, 1991 (docket A-89-18, item IV-D-45).

For the supplemental two-diurnal test sequence, initially loading beyond breakthrough would be excessive, because of the short amount of driving before the diurnal emission test. EPA is therefore specifying an initial canister load to 2-gram breakthrough for the two-diurnal test.

Data submitted by manufacturers show that, for loading evaporative canisters, butane is a reasonable substitute for gasoline. The data indicate that canister behavior is nearly the same when loaded with the two different types of vapors.[24] This is not surprising, since butane comprises about half of the fuel vapor over a typical fuel with Reid vapor pressure (RVP) equal to 9 psi (62 kPa); the rest of the vapor is approximately 30 percent pentane, 10 percent hexane, and 10 percent heavier hydrocarbons.[25] The use of butane would greatly simplify the loading procedure by reducing the time required and making possible the use of less expensive, more readily available equipment.

At the time of the December 1990 workshop there had been no technical justification for the added test complexity of adding nitrogen to butane for loading the evaporative canister. However, manufacturers' data submitted since, while widely varying, clearly indicate that the presence of nitrogen in the loading stream decreases the amount of hydrocarbon retained by the canister. Moreover, a review of the literature revealed a potential theoretical basis for the claimed effect. The amount of vapor that can be adsorbed onto activated carbon increases as the partial pressure of the vapor increases. Increasing the concentration of butane in the vapor stream from 50 to 100 percent doubles the partial pressure of butane and seems to change the adsorption from a single-layer to a multiple-layer phenomenon.[26] This would explain the more effective retention of pure butane in the canister. Because of this new data, and the recognition that nitrogen is a major component of fuel tank vapors, EPA considers this suggested change to be justified.[27]

In spite of the advantages of loading canisters with butane, EPA believes it is important to retain the option of better simulating a canister's in-use experience. The two-diurnal test therefore allows, as an alternate procedure, canister loading with fuel tank vapors. Maintaining such an alternate procedure would avoid the complication of routinely adding pentane and hexane to butane for canister loading.

To better simulate vehicles' in-use experience, EPA is also specifying no canister purging prior to loading to breakthrough for the supplemental two-diurnal test. Initially purging a canister from an in-use vehicle would remove the system from its as-received condition, which may cause a subsequent test to underestimate that vehicle's actual emission potential. Removing initially resident vapors from the canister, and replacing them with butane or other gasoline vapors, may be detrimental for several reasons. First, as vehicles

---

[24]Letter from Noboru Fujii, Nissan, to Alan Stout, EPA, June 21, 1990 (Docket A-89-18, item IV-D-13a).

[25]"Composition of Vapor Emitted From a Vehicle Gasoline Tank During Refueling," Robert L. Furey and Bernard E. Nagel, GM, February 1986, SAE 860086.

[26]*Hydrogenous Catalysis in Practice*, C.N. Satterfield, McGraw Hill Co. 1980, p. 28.

[27]For example, with a fuel vapor pressure of 9 psi (62 kPa) (e.g. 9 psi (62 kPa) RVP fuel at 100° F (38° C)) and a barometric pressure of 14.7 psi (101 kPa), the vapor space would be composed of approximately 60 percent fuel vapors and 40 percent air (which is primarily nitrogen).

age, their canisters gradually lose capacity as larger molecules occupy available sites; these harder-to-purge molecules should not be removed from the canister for the sake of test convenience, or for the sake of getting the vehicle into a repeatable condition. Second, if in-use vehicles have overloaded canisters, then EPA would want to test them in that condition. Third, butane has not been demonstrated as a good substitute for either oxygenated fuels or methanol. On the contrary, manufacturers have acknowledged that, for existing canister designs, purging methanol vapors is more difficult than purging gasoline or butane vapors. Furthermore, the initial 23-minute preconditioning drive should enable a properly functioning vehicle to almost completely purge its evaporative canister. In that case, an additional purge would be redundant, and would require unnecessary handling of the evaporative control system. A test would more easily identify inadequate and malfunctioning systems, on the other hand, by initially loading the canisters from the as-received (unpurged) condition.

Regarding the rate of vapor loading, it is not possible simply to set the loading rate to simulate in-use experience. Test data from Automotive Testing Laboratories (ATL) indicate that loading rates can vary from 2 grams per hour for a moderate diurnal heat build to 300 grams per hour or more for a long, high-temperature drive.[28] Also, as GM pointed out, vehicles with larger fuel tanks and canisters generally experience higher vapor loading rates. For its test, CARB specified a loading rate of 15 grams butane per hour. EPA agrees that this specification is a fair representation of a canister's in-use experience, and is also specifying 15 grams butane per hour to load canisters in the three-diurnal procedure. Because the canister is loaded with a known quantity of vapor at a low, constant rate, the process is slow, but requires a technician only to set up the equipment and then turn it off after a certain amount of elapsed time.

In contrast, for canister loading in the two-diurnal procedure, the apparatus must be monitored continuously until breakthrough is observed. It is therefore advantageous to accelerate the canister loading rate and minimize the total loading time. As the loading rate is increased, however, the canister becomes less able to retain the hydrocarbon vapors, reducing the canister load at the point of breakthrough. EPA testing indicates that a loading rate of 40 grams butane per hour is the best balance between these opposing factors.[29] The data show that purged canisters, loaded at a rate of 40 grams butane per hour to breakthrough, may hold 10 to 20 percent less vapors than the same canisters loaded at 5 grams butane per hour. The data also shows that canisters are much less effective at storing vapors at higher rates. EPA is therefore specifying a loading rate of 40 grams butane per hour to load canisters for the two-diurnal procedure.

EPA recognizes GM's concern for avoiding a prolonged canister loading step for larger vehicles. If the above specifications require canister loading for longer than 12 hours (the minimum soak time), manufacturers may submit data supporting a faster rate. The faster rate would be based on completing the canister loading procedure in 12 hours.

---

[28]All test data generated by ATL for EPA is stored in publicly available files in a Micro database (account name "SMAJ") on the Michigan Terminal System (MTS) at Wayne State University.

[29]"Effect of Load Rate on Canister Load at Two Gram Breakthrough," EPA memo from Dan Barba to Joanne I. Goldhand, December 10, 1992 (Docket A-89-18, item IV-B-10).

Summary of Comments—Miscellaneous Issues

Manufacturers suggested various means for detecting breakthrough with the butane-loading apparatus, including use of a trap canister that would indicate attainment of the 2-gram breakthrough point when its mass had increased by 2 grams, or use of a mini-SHED to contain emitted vapors.

Mercedes Benz and Ford requested that they be allowed to remove canisters and replace them with stock canisters already loaded according to specifications.

Manufacturers requested that the initial preconditioning drive be initiated as a cold start for purposes of adaptive memory. GM added that an oil sump temperature could be specified to ensure that the test vehicle would experience a cold start for the initial drive.

Analysis of Comments

EPA believes that there is more than one acceptable detection method to accomplish loading to the 2-gram breakthrough point. The baseline method of detecting this is to place the vehicle in a SHED to load the canister(s) until 2 grams of hydrocarbons are measured in the SHED. An auxiliary evaporative canister may also be used to collect emitted vapors from the vehicle's canister(s); vapors would be loaded until the mass of the auxiliary canister increases by 2 grams.

Evaporative canisters may not be removed from test vehicles. A vapor hose will typically have to be disconnected to load the canister, but EPA wants to avoid unnecessary handling of vehicle components. Such temporary, intrusive vehicle modifications may call into question the validity of test results if they affect the integrity of the vehicle emission control system. As a result, canisters cannot be loaded with butane separately in a mini-SHED, and loaded stock canisters cannot be used to substitute for a vehicle's existing canister.

The test vehicle soaks for a minimum of 12 hours (6 hours at EPA's option) before the preconditioning drive to ensure that the vehicle is stabilized at the test temperature. EPA believes this stabilization period is sufficient to ensure that all vehicles will have a cold start for the initial preconditioning drive.

F. Hot Soak Test

EPA Proposal

EPA proposed at the December 1990 workshop to conduct the hot soak test for one hour at 95° F (35° C) ambient following the running loss test. Based on current regulations, seven minutes would be allowed between completion of the running loss test and the start of the hot soak test; EPA proposed to decrease that time to five minutes. EPA proposed an overall air circulation requirement of 0.4±0.2 cfm per cubic foot (ℓpm per liter) of enclosure volume.

Summary of Comments

Honda requested that EPA allow the full seven minutes to transition from the running loss test to the beginning of the hot soak test. Commenters also requested that the air circulation requirement be changed to 0.6±0.2 cfm per cubic foot (ℓpm per liter) of enclosure volume to match the specification of the diurnal emission test.

Analysis of Comments

Because the hot soak emission rate is highest shortly after a drive, it is critical for the hot soak measurement to make the transition as quickly as possible. EPA expects five minutes to be enough time to move the vehicle from the driving cell for the running loss test to the hot soak enclosure. EPA agrees that the specified circulation rate should match that of the diurnal emission test.

G. Exhaust Emission Test

EPA Proposal

EPA proposed at the December 1990 workshop to match fuel temperatures during the exhaust emission test to a target profile that the manufacturer would develop on the road for the same driving cycle and roughly the same conditions. Current practice frequently allows the addition of a supplemental fan that directs air at the fuel tank, ostensibly to simulate underbody airflow, but often resulting in overcooling of the fuel. This unrepresentative situation prevents the expected heating of, and vapor generation from, the fuel tank during the exhaust emission test, so vehicles that have supplemental cooling during the test may not be able to maintain control of exhaust emissions when vapors are generated in use.

Summary of Comments

CARB joined the auto manufacturers in questioning the benefits of requiring fuel temperature control during the exhaust emission test, especially considering the costs involved in the generation of the target profiles and the task of controlling fuel temperatures during the test.

Analysis of Comments

EPA agrees that the burden involved in requiring manufacturers to generate fuel temperature profiles, and to control fuel temperatures according to that profile, is too great compared to the modest benefits of that improvement to the test. EPA is therefore not requiring fuel temperature control during the exhaust emission test as part of this rulemaking.

The Agency may later evaluate the need to revise the current procedure for justifying supplemental cooling in an effort to improve the exhaust emission test. Revisions in this area may include new requirements for more rigorous justification for additional cooling, as well as changes to the method of supplying cooling during the test.

H. Heavy-Duty Vehicles and Engines

EPA Proposal

EPA proposed in the August 1987 NPRM to revise the test procedure for heavy-duty engines to require that the engine start the exhaust emission test with a loaded canister. This change would ensure that engines could purge hydrocarbons from the evaporative canister without causing an increase in exhaust emissions.

The Agency proposed in the January 1990 NPRM to make changes to the evaporative emission test for heavy-duty gasoline- and methanol-fueled vehicles similar to the changes to the test for light-duty vehicles, i.e., initially loading the evaporative canister with vapor, and conducting consecutive diurnal heat builds after the dynamometer run.

Summary of Comments

Ford and Chrysler had serious reservations about the feasibility of passing the proposed heavy-duty test, because of the magnitude of vapor generated from the fuel tank and purged from the evaporative canister. They pointed out that heavy-duty vehicles have larger fuel tanks and different driving patterns that make it difficult to purge the evaporative canister.

Analysis of Comments

Manufacturers have provided insufficient basis to warrant any change in the Agency's position. Although larger fuel tanks result in a need for a larger canister capacity, the proportionately greater fuel consumption of these engines allows for the purging of the additional stored vapor. EPA believes that compliance will be possible through proper selection of existing hardware and technology.[30] The different driving patterns for heavy-duty vehicles are already reflected in the specified driving cycle for those vehicles. EPA acknowledges that the test specifications for temperatures, fill level, and driving schedule may be especially challenging for heavy-duty vehicles; however, the fact that these challenging specifications represent real conditions reinforces the importance of finalizing the proposed changes to the test procedure.

I. Fuel Spitback

This rulemaking includes provisions to prevent fuel spitback during refueling. Fuel spitback can be a problem when the design of the fuel filler neck is inadequate to accommodate in-use fuel fill rates. The result can be fuel spillage, which is both an environmental and a safety hazard.

EPA Proposal

EPA proposed in 1987 and again in the January 1990 NPRM to limit commercial dispensing rates to 10 gallons (37.9 liters) per minute in an attempt to prevent spitback during refueling events. At the January 1992 workshop, EPA proposed also to test vehicles for spitback by collecting liquid fuel emissions during a refueling event, either by collecting emissions in a bag, or by a visual observation of spitback.

Summary of Comments

Auto manufacturers acknowledged spitback as a legitimate emission source that warrants control, but expressed concern about the ability of the proposed test to measure spitback accurately, to distinguish between vapor and liquid emissions, and to distinguish between spitback and dragout losses (fuel dripping from nozzle after dispensing). Manufacturers were opposed to the proposed reliance on visual observation of spitback. Manufacturers wanted either to treat spitback as a customer satisfaction issue, or to deal with it outside the scope of this rulemaking. Commenters suggested that the issues be resolved

[30]"Onboard and Evaporative Control System Cost Estimates for the SNPRM," EPA memo from Jean Schwendeman, to the Record, December 22, 1988 (Docket A-89-18, item II-B-6).

either in a future workshop or by the involvement of the Society of Automotive Engineers (SAE).

The oil industry argued that spitback is independent of fill rate, that auto manufacturers should bear the responsibility to design their vehicles to prevent spitback, and that current dispensing rates have increased and are significantly higher than the proposed limit. They also argued that any limitation on dispensing rates should include an exemption for fuel pumps devoted to refueling heavy-duty vehicles, which have much larger fuel tanks.

Analysis of Comments

EPA is taking action to limit spitback during fuel dispensing, since spitback is a known contributor to air pollution that may endanger public health and welfare within the meaning of section 202(a) of the Clean Air Act. EPA has conservatively estimated a fleet average value of 0.15 grams per gallon (0.04 g/liter) for spitback emissions.[31] Nationwide, spitback emissions were projected to be nearly 4 million gallons (15 million liters) per year. Reducing spitback emissions would thus result in an air quality benefit, a substantial fuel savings, and health and safety benefits for in-use refueling events.

Rather than relying only on a limitation of fuel dispensing rates, EPA is depending on direct testing of vehicles to prevent spitback. Because the underlying goal is to prevent in-use emissions, the Agency is implementing a test that simulates the experience of concern.

The spitback test thus consists of draining the vehicle's fuel tank, filling the tank to 10 percent of its nominal capacity, operating the vehicle over one UDDS, then promptly refueling the vehicle with at least 85 percent of the tank's nominal capacity at 10 gallons (37.9 liters) per minute. Compliance would be determined by catching liquid emissions in a plastic bag secured around the dispensing nozzle and then weighing the collected fuel.

Heavy-duty vehicles over 14,000 pounds (6,400 kg) GVWR will not be tested for spitback. These vehicles are typically designed with filler necks so short that fuel can be dispensed directly into the fuel tank. These vehicles would therefore not be expected to experience spitback. A small number of these heavy-duty vehicles may have filler necks long enough to make spitback possible; however, the overall air quality benefit of extending the spitback test to these vehicles is negligible.

EPA has modified the proposed spitback test to accommodate manufacturers' concerns. First, the test now clarifies that the vapor in the spitback collection bag must be expelled before weighing. Second, the test specifies a means of handling the nozzle to prevent any dragout losses from affecting measured spitback emissions. Also, the final rule establishes a standard of 1 gram per test to ensure that the accuracy of the procedure was sufficient to determine compliance. Finally, the test specifies the use of a commercially available dispensing nozzle. Any issues of nozzle/filler neck compatibility are beyond the scope of this test procedure.

EPA conducted testing to develop the spitback collection procedure. Emissions were collected in a rectangular tedlar bag, approximately 15" x 20", with two small openings on opposite ends of the bag to allow passage of the dispensing nozzle. Each opening was fitted

---

[31] "Investigation of the Need for In-Use Dispensing Rate Limits and Fuel Nozzle Geometry Standardization," EPA Technical Report, May 1987 (Docket A-89-18, item IV-A-2).

with a tedlar insert for the bag to be clamped onto the filler pipe and the dispensing nozzle, ensuring that liquid emissions are trapped in the bag. One side of the bag was left open to allow displaced fuel vapors to escape easily. Upon completion of the dispensing operation, the nozzle was removed from the vehicle and the bag, with the opening of the nozzle held up to prevent any dripping into the bag. Then the bag was folded several times to retain the trapped liquid fuel, to eliminate any vapor space, and to facilitate weighing the bag. Because the procedure was effective in collecting all (and only) liquid fuel emissions, it served as the basis for drafting the regulatory language for the spitback test.

In addition, the final rule limits in-use dispensing rates to 10 gallons (37.9 liters) per minute. With a vehicle test for spitback in place, the limitation on in-use dispensing rates ensures that the test specifications will reflect actual dispensing conditions. Because of the minimal cost of complying with the rate limitation, as described in Chapter 4, EPA does not believe that a trend toward higher in-use dispensing rates, if it exists, would be an obstacle to meeting the new requirements.

Insufficient basis was provided for the comment that spitback is independent of fill rate. EPA test data indicate that higher flow rates are associated with a more frequent occurrence of spitback.[32] Furthermore, a consideration of the mechanics involved in the spitback phenomenon indicates that, although the configuration of the filler neck/nozzle interface plays a major role, it would be difficult to envision a situation in which the rate of fuel crossing the interface is not also important.

EPA agrees that the limitation on dispensing rates should not extend to pumps that service only heavy-duty vehicles. Such dedicated pumps would be expected to service primarily the heavy-duty vehicles that are exempt from spitback test requirements, as described above. All other gasoline- or methanol-dispensing pumps belonging to retailers or wholesale purchaser-consumers are subject to the 10 gal/min (37.9 liters/min) limit.

J. Methanol-Fueled Vehicles

EPA Proposal

EPA proposed that the regulations apply to both gasoline- and methanol-fueled vehicles.

Summary of Comments

For flexible-fueled vehicles, auto manufacturers objected to the use of low-level blends of methanol for testing. A mixture of 10 percent methanol in gasoline has a volatility of about 12.5 psi (86.2 kPa) RVP, which causes a much greater amount of vapor generation than most other compositions of methanol and gasoline. Manufacturers requested a different fuel composition for flexible-fueled vehicles, or at least an extended time before requiring use of the worst-case fuel.

Several manufacturers requested additional lead time to comply with the new test requirements for flexible-fueled vehicles. The purge requirements at slow speeds for varying

[32] "Application of Onboard Refueling Emission Control System to a 1988 Ford Taurus Vehicle," EPA technical report, EPA-AA-SDSB-91-06, page 36 ff. (Docket A-89-18, item IV-A-6).

fuel vapor composition, and the need to prevent permeation were cited as the most challenging aspects of the proposed test that warranted additional time for development.

Manufacturers identified the need for flexible-fueled vehicles to have additional preconditioning whenever the test fuel would be changed to prevent a test run from being affected by previously used fuels.

Analysis of Comments

In a separate rulemaking, EPA set out the requirements for composition of test fuels for flexible-fueled vehicles (54 FR 14426, April 11, 1989). EPA concluded at that time that, to maintain control in all expected in-use conditions, vehicles should be tested with the worst-case fuel mixture. EPA therefore specified a test fuel mixture of 90 percent gasoline and 10 percent methanol (M10) for evaporative testing.

As described in Chapter 3, EPA expects that flexible-fueled vehicles will not need to be designed to meet the new evaporative emission test requirements until the last year of the phase-in schedule. The approximately 6½ years between promulgation of EPA's final rule and the first sales of flexible-fueled vehicles subject to the new evaporative test requirements provides much more lead time than provided by past EPA actions. Moreover, manufacturers were aware of CARB's similar requirements adopted in August 1990 and so have had some time to prepare. Concerning permeation, the industry is currently making great progress in improving the permeation-resistance of materials. Since even gasoline-fueled vehicles need to be able to prevent permeation of methanol and other oxygenated compounds, much of the materials development and selection for flexible-fueled vehicles is well underway. EPA therefore believes that the specified lead time is sufficient to design vehicles to meet test requirements, within the meaning of section 202(a)(2) of the Act.

Testing with different fuel mixtures does require additional preconditioning when the test fuel is changed. EPA has drafted a procedure of repeated drives and refuelings, based on the procedures of the Auto/Oil research effort, for inclusion in the final regulations.[33] The procedure consists of purging and reloading the evaporative canister, draining and refilling the fuel tank, starting the vehicle several times, and driving through one UDDS.

K. Other Issues

In addition to the areas covered above, comments were received on a number of other issues. These comments are discussed below.

EPA proposed various methods to minimize the impact of invalid tests. These included an accelerated procedure to bypass a portion of the test that had been successfully completed before a test error, and a means of accepting test data after a test error, depending on how the error affected the test results. Manufacturers objected, arguing that the proposed provisions might modify test requirements, and would encourage sloppy testing. In response, EPA does not intend to pursue these methods to deal with invalid tests. Instead, EPA has attempted to minimize the potential for test errors in the development of the test procedure.

Some commenters requested that EPA change some of the tolerances for test parameters. Commenters wanted to change the tolerance on the ambient temperature of the

[33]Telefax from Dave Brooks, Auto/Oil Air Quality Improvement Research Program, March 17, 1992 (Docket A-89-18, item IV-D-81).

diurnal emission test from ±1° to ±3° F (0.6° to 1.7° C). Commenters also wanted to relax the proposed specification to maintain enclosure pressures within 0.2 inches (0.5 cm) of water of barometric pressure, allowing a difference of up to 2 inches (5 cm) of water. EPA agrees that both of these specifications should be changed to make the test procedure easier to execute. To avoid too much variability in diurnal emission test, EPA is retaining the specification that, on average for the whole test, ambient temperatures need to be within 2° F of the target profile. Neither of these changes should affect test stringency.

Honda requested that EPA change its specification for the volatility of test fuel from 9 to 7.8 psi (62 to 53.8 kPa) RVP for all testing, because new volatility requirements specify 7.8 psi (53.8 kPa) RVP for nonattainment areas. However, EPA is retaining the specification of 9 psi (62 kPa) RVP test fuel. Decreasing the volatility of test fuel is inappropriate because 9 psi (62 kPa) RVP fuel will still be widely available in much of the country. EPA's volatility requirements limit summer fuel volatilities throughout the continental U.S. to a maximum of 9 psi (62 kPa) RVP; nonattainment areas in some warm climates or at high altitudes have a maximum fuel volatility of 7.8 psi (53.8 kPa) RVP (55 FR 23658, June 11, 1990). States with the lower volatility requirement may, however, justify changing to a maximum of 9 psi (62 kPa) RVP. Because 9 psi (62 kPa) RVP fuel will be widely available in the U.S. for the foreseeable future, EPA is requiring manufacturers to demonstrate sufficient control on that fuel.

API requested that EPA specify 10.5 psi (72.4 kPa) RVP test fuel to allow for a higher in-use fuel volatility without foregoing emission control. Increasing the volatility of the test fuel is also inappropriate; EPA's rulemaking to establish maximum volatility levels demonstrated that it was cost-effective to reduce in-use volatilities to the current levels. Moreover, the Clean Air Act forbids the sale of any summer fuel with a volatility higher than 9 psi (62 kPa) (section 211(h)).

Manufacturers requested specification of 7.8 psi (53.8 kPa) RVP test fuel for high-altitude testing, and wanted confirmation that EPA would not change its policies by requiring vehicle testing for high-altitude. EPA agrees that 7.8 psi (53.8 kPa) RVP fuel is appropriate for high-altitude testing, since EPA's regulations limiting summer fuel volatilities establish 7.8 psi (53.8 kPa) RVP as the maximum volatility level for high-altitude areas (55 FR 23658, June 11, 1990). For this rulemaking, EPA is not changing its policy on the need for high-altitude testing for certification. Manufacturers may continue to submit test data indicating compliance with standards, or, in lieu of testing, may submit a statement that they can meet the test requirements, based on sound engineering judgment. EPA may in the future require high-altitude testing if there is an indication that testing is needed to improve emission control in these areas.

GM objected to EPA's proposed regulatory text that required all fuel vapors to be routed to the evaporative canister or to the engine. GM claimed that the requirement was not clear, and that EPA had communicated no plan to enforce the provision. EPA believes that the provision is straightforward and involves no ambiguities that unduly jeopardize a manufacturer's certification. Enforcement would be based on an engineering evaluation of the fuel system for each vehicle design submitted for certification. EPA would expect vapors to be routed to the evaporative canister without any restriction or release valve that could cause vapor venting under normal operating conditions, other than vehicle refueling. This would be similar to EPA's successfully implemented requirement for eliminating engine crankcase emissions.

Ford requested that EPA not require the new test procedures for Selective Enforcement Audits (SEAs) at assembly facilities. Ford wanted to avoid evaporative testing on newly assembled vehicles because of the lack of measurement facilities and the concern for high levels of nonfuel emissions from new polymeric components. Ford also wanted to avoid the canister preconditioning for exhaust-only testing, because of the facility requirements, and because of the time constraints in the assembly process. EPA will continue the practice of omitting evaporative testing from the SEA process because of the concern for high nonfuel emissions from newly assembled vehicles. EPA may, however, conduct the new canister preconditioning for SEA exhaust testing. Purging canisters, and then loading them with butane and nitrogen, requires very little equipment and adds little time to the procedure to test for exhaust emissions. Moreover, the ability to control exhaust emissions while purging a loaded canister is central to any new requirements for evaporative emission control.

GM requested that EPA hold a public workshop after it publishes the final rule to discuss detailed improvements to the test procedure. GM expected the industry to gain experience in the early stages of complying with test requirements, making possible a set of improvements to the test that would make it easier to run. EPA is resolving as many technical issues as possible before publishing this final rule. After publication, EPA expects to work with manufacturers in setting up test facilities and initiating testing. EPA will consider the need for any amendments as part of that process.

L. Comparison to CARB's Adopted Test

In addition to the differences in test fuel RVP and diurnal/running loss temperatures, and the inclusion of the supplemental two-diurnal test, the test procedure being adopted by EPA differs from the one adopted by CARB on a number of lesser points. These are listed below. Many of these differences are also discussed in the previous sections of this chapter but are repeated here in order to present a complete comparison. Because of the expressed desire of many commenters for maximum consistency between the EPA and CARB procedures, the reasons for the differences are also provided. Note that some of these deviations from the CARB procedure are desired by manufacturers.

Running loss test

- Delete requirement for vapor temperature control; instead specify narrowed fuel temperature tolerance at the end of the running loss test
  - Vapor temperatures are very difficult to control independent of liquid fuel temperatures, considering that a single control mechanism, ambient heating of the vehicle, is used. To better control the vapor generation during the running loss test, the temperature tolerance for the liquid fuel is instead narrowed from ±3° F (1.6° C) to ±2° F (1.1° C) for the last two minutes.

- Delete requirement for proportional-speed fan for vehicle's full frontal area
  - EPA believes that specifying a proportional-speed fan for the vehicle's radiator provides very little improvement to the test simulation; the large expense for the fan is therefore not justified. EPA is maintaining the current specification for radiator cooling during the exhaust emission test (40 CFR 86.135-90(b)). Also, EPA is adapting specifications for underbody circulation, and direct blowing on the fuel tank, to provide adequate fuel temperature control.

- Replace the second UDDS in the driving cycle with two NYCCs
  - This provides a broader range of driving patterns, including more low-speed and idle operation, thus ensuring a more robust running loss test, as described in Chapter 2.

- o Delete allowance for initial fuel temperature below 95° F (35° C)
  - Two-temperature systems, such as would be required at the start of the test under this provision, are inherently unstable, thus making the test prone to voiding. Furthermore, lower temperatures are unwarranted, since they would less accurately reflect ozone-prone summertime conditions, as required by statute.

- o Allow driver to put car in neutral between cycles
  - This change allows the driver to rest or stand twice for up to two minutes during the drive. This should make it easier for the driver to continue accurate driving through the whole 70-minute drive. No effect on the vehicle's emission performance is expected.

- o Increase initial stabilization period from one to four hours maximum
  - EPA and manufacturers believe that, in some cases, more time is needed to stabilize fuel temperatures to 95° F (35° C) to start the running loss test.

- o Specify maximum fuel tank pressure allowance of 10 inches of water (2.5 kPa) for both SHED and point-source methods
  - Maintain consistency between optional test methods.

- o Define provision to deal with high coolant temperatures
  - The CARB test monitors coolant temperatures but provides for no action based on this information. EPA clarifies the meaning by specifying that a dashboard warning of high engine temperatures should prompt the termination of the test run.

- o Add provision to allow continuous sampling
  - With either the point-source or the enclosure method, emissions could be measured continuously by a flame ionization detector, or collected in bags for subsequent measurement.

- o Add minimum overall circulation requirement (1.0 cfm/ft^3) (ℓpm/liter) for the enclosure method
  - CARB's specification of fans for the vehicle's radiator, underbody, and fuel tank provide no specification to prevent temperature or hydrocarbon stratification in the enclosure.

- o Delete allowance to correct suspected equipment errors
  - This provision leaves unwarranted discretion to testing personnel. Clearly, if equipment is shown to be in error, test results may be invalidated.

- o Clarify that cap removal is not allowed during the test
  - Modify language to avoid the possible interpretation of the provision limiting pressures to allow cap removal during the running loss test.

- o Change test speed resolution during the running loss test to ±0.1 mph (0.16 km/hr), once per second
  - Speed measurement frequency reflects current test specifications. Resolution is relaxed somewhat from current EPA specifications, because fuel temperatures, and thus emissions, are not sensitive to small variations in vehicle speed.

- Lower minimum surface temperature for running loss test from 70° to 40° F (21° to 4.4° C)
  - Specifying 70° F (21° C) as a minimum surface temperature makes it very difficult to maintain ambient temperatures within EPA's specified range of 95±5° F (35.0±2.8° C). Allowing surface temperatures as low as 40° F (4.4° C) does not affect the accuracy of testing.

Diurnal test

- Do not allow subtraction of nonfuel background emissions
  - EPA applies the evaporative standards to measured fuel and nonfuel emissions.

- Set underbody circulation to 5 mph (8 km/hr); add discretion to ensure temperature swing representative of that experienced in use
  - Circulation is required to ensure that fuel in an uninsulated fuel tank experiences appropriate heating; discretion is required to ensure that airflow is not defeated by vehicle designs that provide more effective insulation during the test than actually occurs in use.

- Define average tolerance (±2° F (1.6° C)) for cycled temperatures
  - Average tolerance is defined as the average of the absolute values of the differences between measured and target temperatures. Not considering absolute values would allow a significantly smaller temperature range.

- Allow 6 to 36 hours between the hot soak test and the diurnal emission test, with the last 6 hours held at the initial ambient temperature for the diurnal emission test
  - The stabilization of the test vehicle at the initial test temperature makes it easier to start the diurnal emission test.

Preconditioning

- Define working capacity in terms of 2-gram breakthrough
  - Working capacity has various definitions in industry, and CARB left the term undefined. EPA chose the 2-gram breakthrough point to be consistent with its own procedures, and with the understanding of most participants, including CARB.

- Add option to conduct additional preconditioning driving on a dynamometer (not just outdoors); delete 20-mile (32 km) minimum for extra driving.
  - EPA does not drive test vehicles outdoors, but would like to maintain the flexibility of additional vehicle operation to prepare vehicles for testing.

- Allow canister loading in three-diurnal test at faster rates if more than 12 hours is required
  - EPA believes that testing personnel should be able to start the exhaust emission test within 12 hours after the end of the preconditioning drive. For some very large vehicles, canister capacity may require more than 12 hours of canister loading at the specified rate of 15 grams butane per hour. For those vehicles, manufacturers may alter loading rates and times to accomplish the full canister loading in a 12-hour period. Allowing the accelerated 12-hour loading time is consistent with the experience of a parked vehicle undergoing a diurnal heat build.

- o Specify a maximum period of one hour to refuel the test vehicle after the preconditioning drive
  - CARB's test specified no time requirement for the refueling event

- o Change humidity specification during canister purge to 50±25 grains per pound (7.1±3.6 grams per kilogram) of dry air
  - Lowering the humidity specification and widening the tolerance will make testing easier, with no loss in the effectiveness of the test.

<u>Hot soak test</u>

- o Specify ambient temperatures: 95±10° F (35.0±5.6° C) for first five minutes, 95±5° F (35.0±2.8° C) for remainder of hot soak test
  - CARB's regulations included inconsistent specifications, requiring either 55 or 60 minutes of temperature control during the hot soak test. EPA believes that the temperature tolerance should be relaxed for the first five minutes of the test, because of the difficulty of sufficiently cooling the SHED at the beginning of the hot soak test. This is consistent with the vehicle's experience outdoors, since a newly parked vehicle cools gradually, rather than being exposed to high rates of circulation with cool air.

- o Require the hot soak test to start no more than five minutes after completion of the running loss test, and no more than two minutes after engine shutdown
  - Most of the vapor generation (and thus emissions) from the hot soak test come in the first few minutes of the test period. It is therefore important to minimize the time between the running loss test and the beginning of the hot soak test. EPA's testing experience indicates that five minutes is a sufficient allowance. The 2-minute specification is consistent with established test practices.

- o The initial hydrocarbon measurement is taken before the vehicle enters the enclosure
  - With this change from current practice, the test would account for all hot soak emissions from the instant the enclosure is sealed.

<u>Fuel temperature profile</u>

- o Change "representative" profile to "highest expected" profile
  - Evaporative families, based on vehicle characteristics such as canister capacity and tank size, include no means of grouping vehicle models by their fuel temperature increase during driving. Nevertheless fuel temperatures are the most basic variable involved in conducting the running loss test. Therefore, only a test vehicle with the highest fuel temperatures would ensure adequate control for all the vehicles it represents. Manufacturers are allowed to develop fuel temperature profiles for subsets of an evaporative family (e.g., for an engine family, or for an individual model), at their discretion.

- o Require use of any vehicle options that limit underbody airflow
  - Because features such as air dams and running boards can dramatically influence fuel temperatures during driving, they must be in place during development of a vehicle's fuel temperature profile. Not requiring these optional features would allow many in-use vehicles to routinely experience conditions more severe than test conditions.

- o Relax driving tolerances to ±4 mph (6.4 km/hr)

- EPA's experience with fuel temperature profiles indicates that fuel temperatures are not sensitive to small variations in vehicle speed. Relaxing the driving tolerance would make it easier to complete test runs without sacrificing the accuracy of the data collection.

o Allow temporary deviation from the driving schedule—up to three times for a maximum of 15 seconds each
  - Outdoor driving according to a prescribed schedule poses some risk of collisions with other vehicles. Departing from the driving schedule for up to 45 seconds during the 70-minute drive should minimize that risk without affecting the validity of the data.

o Increase the required pavement temperature to 30° F above ambient, measured throughout the drive
  - The higher pavement temperatures are critical in developing fuel temperature profiles that represent the vehicle's behavior in ozone-prone summertime conditions. In addition, because pavement temperatures are very sensitive to instantaneous solar loading, temperatures must be measured throughout the driving period, rather than only at the beginning and end of the drive.

o Measure ambient temperature and wind speed throughout the drive
  - Measurement of ambient conditions throughout the drive ensures that the desired conditions are met during the whole drive and minimizes the potential for measurements that are not characteristic of the drive period.

o Specify standard procedure for measuring ambient temperature and wind speed, and require submission of weather station data
  - EPA has observed that temperatures reported by testing personnel are sometimes much different than those reported by local airports. To resolve differences in these measurements, EPA has incorporated requirements to meet federal standards for making ambient measurements. These procedures should make the test requirements clear, objective, and uniform for all involved. Obtaining data from the nearest weather station provides a valuable but inexpensive check on the data collected at the test site, particularly for the very subjective cloud cover assessment.

o Require pavement temperature measurement to be made on a surface representative of the driving surface
  - Measurement on a surface with a different color, texture, or composition could cause erroneous results.

o Calculate fuel profile independent of ambient temperatures
  - CARB's procedure unnecessarily ties fuel temperatures to measured ambient temperatures. With EPA's approach, fuel temperatures must be reported as a relative profile (e.g., a 25° F (13.9° C) temperature rise), independent of ambient temperatures. The relative profile is then adjusted to the initial fuel temperature of 95° F (35° C) to establish the absolute profile for the running loss test.

o Require submission of results from all valid tests and create a composite profile
  - Consistent with data submission requirements for manufacturers' emission testing, EPA is requiring the submission of all test data for fuel temperature profiles. Because fuel temperature profiles can vary significantly, even under

constant ambient conditions, manufacturers must create (based on simple averaging) a composite fuel temperature profile from all valid tests for a vehicle model. This composite profile is to be used in running loss testing.

Equipment

- o Define the nominal volume of variable-volume SHED based on mid-temperature of diurnal range
  - Because the volume in a variable-volume SHED depends on the temperature, an average temperature must be used to determine SHED volume.

- o Delete maximum surface temperatures in running loss enclosures
  - EPA does not believe that this provision is necessary. Furthermore, engine and exhaust surface temperatures, as well as the specified upper tolerance for tank temperature control, can easily exceed the "global" maximum temperature specified in the CARB procedure.

- o Increase diurnal test and hot soak test air circulation to 0.8±0.2 cfm/ft^3 (ℓpm/liter)
  - CARB's specification of 0.3 to 0.6 cfm/ft^3 (ℓpm/liter) is increased to provide additional circulation for adequate heating and cooling during the diurnal emission test. The circulation rates for the hot soak test match those for the diurnal emission test.

- o Specify enclosure ambient pressure of 0 to -2 inches of water (0 to -0.5 kPa) for fixed-volume enclosures
  - Maintaining a slight negative pressure would simplify the needed controls, without affecting the integrity of the enclosure or the test results.

- o Adapt the enclosure calibrations to EPA's test specifications
  - Ambient temperatures and other detailed specifications have been changed to adapt to EPA's test requirements. If manufacturers request that EPA accept a demonstration of calibration according to CARB's procedures, EPA would consider such a request under the provisions for alternate equipment configurations (40 CFR 86.106-90(a)).

Heavy-duty

- o Require canister loading for heavy-duty engine exhaust tests
  - Engine testing for exhaust emissions should be consistent with test requirements for the full vehicle.

- o Include heavy-duty vehicle testing for 8,500 to 14,000 pound (3,900 to 6,300 kg) GVWR complete vehicles
  - EPA has consistently proposed to include these vehicles in the scope of its new evaporative emission control requirements. CARB's justification for leaving them out is not clear.

Flexible-fueled vehicles

- o Delete specification of M35 for flexible-fueled vehicles
  - EPA has separately established M10 as the appropriate fuel for testing flexible-fueled vehicles (54 FR 14426, April 11, 1989).

Miscellaneous

- o Omit specified procedures for generating deterioration factors
  - Because there were no proposed changes to the requirements for manufacturers to submit durability data, EPA will not change its current policy of allowing manufacturers discretion in establishing evaporative deterioration factors.

- o Revise format, adjust constants for evaporative calculations
  - Changes are necessary to maintain consistency with existing language in the Code of Federal Regulations.

- o Add language for testing with methanol, as appropriate

M. Adjustments to Test Tolerances for EPA Testing

EPA has identified the following specifications from CARB's test that can be relaxed, without increasing the stringency of the test, to minimize the number of invalid tests and avoid unnecessary facility modifications. In order to maximize consistency with the CARB procedure, EPA will retain the CARB specifications in its regulations (that is, without these adjustments) and add provisions for conducting testing with each of these adjustments at EPA's option.

Running loss test

- o Delete need for heated pumps and sample lines (point-source)
  - EPA believes that heated pumps and sample lines are not necessary to prevent condensation of collected emissions during running loss testing by the point-source method. The relatively low concentrations of hydrocarbon or methanol vapors in the dilution stream ensure that the dew point of the vapor at any time during the test stays well below 95° F (35° C). Furthermore, any error caused by such condensation would directionally decrease the stringency of the test.

- o Omit measurement of fuel tank pressure
  - Omitting the pressure measurement will clearly not affect test stringency. EPA may choose not to measure fuel tank pressures in order to simplify testing.

Preconditioning

- o Change initial cold soak to 6 hour minimum (from 12 hours)
  - EPA believes that 6 hours is adequate to stabilize the vehicle prior to the preconditioning drive. Since no evaporative measurement is involved in this portion of the procedure, the shorter soak time should have no effect on any subsequent evaporative measurement.

Chapter 3 Technological Feasibility and Lead Time

A. Technological Feasibility

Because the new evaporative test procedure implements a performance-based standard, manufacturers have substantial flexibility in deciding how to upgrade vehicle designs in response. However, several likely modifications are evident from comments and discussions with industry: larger canisters, better canister purge, permeation-resistant fuel and vapor lines, anti-spitback features, and some means of limiting fuel tank temperatures. It is not expected that all of these changes would be required on all models.

No manufacturer has indicated that the new test procedures represent requirements that are technologically infeasible. Even for EPA's last proposed test sequence, manufacturers challenged the cost-effectiveness, but not the feasibility, of compliance. Industry commenters almost universally requested that EPA finalize a test procedure based on CARB's adopted procedure. Therefore, because the test procedure being finalized is based on CARB's procedure, there is even less uncertainty concerning technological feasibility. Because manufacturers have been aware of CARB's test requirements for over two years, and must soon certify vehicles with it, EPA believes that industry support of CARB's procedure implies manufacturer acknowledgement of the technological feasibility of the test.

Larger canisters involve no major technological challenges. The required size increase is modest, a liter or two for light-duty vehicles. Furthermore, more efficient carbon media are available that would minimize the size increase, if vehicle designers desired to do so. A straightforward redesign of the internal structure of the canister may be necessary to ensure a good distribution of airflow as well. Chapter 4 provides additional discussion on the likely hardware changes involved in producing larger canisters.

The primary need for demonstration of feasibility in the revised test procedure relates to the requirement of purging a loaded evaporative canister during the exhaust emission test. There are two related requirements: the vehicle must be able to purge enough vapor from its canister to create capacity for the subsequent diurnal heat builds, and the vapors must be purged from the canister without simply being passed unburned through the engine as exhaust emissions.

Manufacturers have various means to create sufficient vapor storage capacity. First, increasing the rate of purge would cause the vehicle to more quickly remove vapors from the canister. Since the existing evaporative emission test has very little purge requirement, the purge design of current vehicles varies greatly. For example, GM has quoted 1½-13 ft^3/LA-4 (42-368 liters/LA-4) as the range for purge volume for their current vehicles.[34,35] EPA believes that increased purge rates will be one of the most important results of revising the test procedure. Second, manufacturers could incorporate methods to reduce the magnitude of vapor generation, thereby reducing the amount of vapor that would have to be removed from the canister to create the needed storage capacity. Finally, if the canister volume is insufficient, in spite of aggressive purging, to create the required capacity, a larger canister

[34]The rate of purge is quantified in terms of volume of ambient air (in ft^3) that is drawn across the evaporative canister during the UDDS (or LA-4) driving cycle.

[35]Transcript from January 28, 1992 public workshop, p. 102 (Docket A-89-18, item IV-F-4).

would make it possible to remove enough vapor with lower purge rates. Different combinations of canister size and purge capability could achieve the same performance.

GM, in modeling for CARB's adopted test procedure, assumed a purge rate of 10 ft^3/LA-4 (283 liters/LA-4) for a vehicle with a 20-gallon (76-liter) fuel tank.[36] This falls within the range of values EPA would expect from vehicles designed to meet the new test requirements. GM estimated further that passing a supplemental two-diurnal test would require a 25 percent increase in purge rates. EPA believes that the test parameters of its supplemental two-diurnal procedure have been relaxed enough that the additional test requirements verify sufficient purge, without increasing test stringency. Nevertheless, GM's estimates make clear that the purge rates required by EPA's test are within the range of current technology, and are therefore feasible for all vehicles.

Test data indicate that some recent-model vehicles are already capable or nearly capable of managing the required amount of vapor without exceeding exhaust emission standards. During the exhaust emission test, a typical vehicle would have to consume about 75 grams of vapor, roughly six percent of the vehicle's total fuel requirement, to restore canister storage capacity for two diurnal heat builds.[37] Methods to reduce vapor generation from the fuel tank would reduce this amount and make it easier to meet the performance requirements of the test, as described above. Testing by Ford showed that a current model vehicle was able to purge up to at least 116 grams during an exhaust emission test with no more than a ten percent increase in exhaust hydrocarbons.[38] Testing by CARB on 1990 and 1991 Buick LeSabres showed a negligible effect of increased purge vapors on exhaust emissions, even when the vehicles were re-equipped with large, heavily loaded canisters.[39] Based on this information, EPA believes that the technology already exists for vehicles to meet the purge requirements of the revised test procedure, and to achieve all other emission standards as well.

The current evaporative test procedure provides little or no control of resting losses. The new evaporative test procedure measures emissions in a SHED over long periods of time and will, therefore, control resting losses. One technology that may be employed in response to this requirement is the use of permeation-resistant fuel lines and fuel vapor lines. Steel lines provide good permeation resistance and are already in use in these applications. Although the use of steel lines could be maximized, it is expected that the need for some flexible segments will remain. Newly developed teflon-coated nylon tubing provides very good

---

[36]Letter from Samuel A. Leonard, GM, to Richard D. Wilson, EPA, March 23, 1992 (Docket A-89-18, item IV-D-78).

[37]With a fuel economy of 25 mpg (9.5 ℓ/100 km) and a fuel with specific gravity of 0.74, a vehicle would need 1,246 grams of fuel to drive 11.1 miles.

[38]"EPA Meeting with Ford," EPA memo from Alan Stout to Docket A-89-18, July 17, 1991 (item IV-E-13).

[39]"Effects of Vapor Purging on Exhaust Emissions," CARB memo from Michael Carter to Bob Cross, February 4, 1992 (Docket A-89-18, item IV-D-82).

permeation resistance and could be used in these applications.[40] Chapter 4 provides additional discussion of the costs associated with these design changes.

Plastic fuel tanks, by being more susceptible to permeation, also face a new challenge in limiting resting losses. One manufacturer, however, by developing a technology to limit permeation, has committed to supplying plastic fuel tanks that emit less than 0.1 gram in 24 hours.[41] EPA expects that auto manufacturers can initially, or in the near future, meet test requirements with plastic fuel tanks.

Anti-spitback valves are already used in some vehicles. EPA test data show that some vehicle designs are capable of meeting the spitback requirements at a dispensing rate of 10 gallons (37.9 liters) per minute. There are no technological barriers to more widespread use of these valves if manufacturers determine that the valves are needed to comply with the anti-spitback test requirements.

To control running losses, manufacturers are expected to manage fuel temperatures to ensure that fuel boiling does not occur during the running loss test. This can be accomplished by several methods, including rerouting fuel lines, adding insulation or heat shields, and locating fuel pumps outside of fuel tanks (described in more detail in Chapter 4). None of these methods of control pose any technological difficulties. EPA expects such methods to be adequate to meet requirements for running loss control.

The limit of 10 gallons (37.9 liters) per minute on fuel dispensing rates poses no new technological challenge. Fuel nozzles that can accomplish this purpose are already in use in the U.S., at little or no additional cost, as discussed further in Chapter 4. The limited flow rate is achieved with a simple spring-loaded device installed in the fuel nozzle.

B. Lead Time

EPA Proposal

The implementation date originally proposed in August 1987 was the 1990 model year. Most recently, however, EPA proposed at the January 1992 workshop to adopt the following phase-in schedule, which was also adopted by CARB:

Model Year	Percent of Production
1995	10
1996	30
1997	50
1998	100

---

[40]For example, Pilot Industries has available its "P-CAP" line of permeation-resistant fuel lines and fuel vapor lines. Letter from Edward K. Krause, Pilot Industries, Inc., to Alan Stout, EPA, August 25, 1992 (Docket A-89-18, item IV-D-92).

[41]Letter from Norman W. Johnston, Solvay Automotive, to Richard D. Wilson, EPA, February 3, 1992 (Docket A-89-18, item IV-D-67).

At the January 1992 workshop, EPA proposed to implement the 10 gallon (37.9 liter) per minute dispensing limit June 1, 1993.

Summary of Comments

After the January 1992 workshop, auto manufacturers agreed with the proposed phase-in schedule, provided there were no substantial differences between CARB's and EPA's test procedures, and provided that the rulemaking was concluded promptly. In September 1992 EPA released draft regulations for the final test procedure.[42] In response, manufacturers indicated that EPA's final rule had been delayed enough that compliance in the 1995 model year was no longer possible, since there was insufficient time to make significant design changes or to complete federal certification testing for 1995 model year vehicles.[43]

There were additional requests for delayed implementation for various special concerns, including small manufacturers, and manufacturers of methanol-fueled and heavy-duty vehicles. Daihatsu requested that the new test be implemented for all vehicles in the 1997 model year, arguing that it would be most difficult for manufacturers with only a small number of families to meet test requirements.

EPA received no comments regarding the lead time for the limit on in-use fuel dispensing rates.

Analysis of Comments

Three different sections of the Clean Air Act provide guidance for determining lead time for test requirements. These are sections 202(k), 202(a)(2), and 202(a)(3)(C).

Section 202(k)

Section 202(k), in directing EPA to promulgate new regulations to control evaporative emissions from all gasoline-fueled motor vehicles, provides that "the regulations shall take effect as expeditiously as possible." This applies to the evaporative emission test requirements for gasoline-fueled light-duty vehicles, light-duty trucks, and heavy-duty vehicles.

EPA now believes that maintaining a phased approach as proposed, but reducing manufacturers' compliance requirements by ten percent each year, is the most expeditious implementation schedule that is realistically feasible. This schedule effectively delays the start of the phase-in until model year 1996, according to the following schedule:

[42]Docket A-89-18, item IV-C-10.

[43]See, for example, Letter from Kelly M. Brown, Ford Motor Company, to EPA Air Docket, November 5, 1992 (Docket A-89-18, item IV-D-90).

Model Year	Percent of Production
1996	20
1997	40
1998	90
1999	100

This schedule, which decreases manufacturers' compliance requirements by ten percent each year, is designed to respond to manufacturers' concerns while maintaining consistency with the proposed implementation schedule. EPA acknowledges that manufacturers can no longer be expected to make changes and complete certification for the 1995 model year on a national scale due to the date of promulgation of this rule.

The revised implementation schedule, while responding to the manufacturers concerns, reduces the phase-in requirement by only ten percent in each year of the phase-in, and so minimizes the effect on the air quality benefit provided by improved evaporative emission controls. Furthermore, in California (and in any states adopting the California evaporative standards), a larger percentage of vehicles will be sold in these model years, and in the 1995 model year, with greatly improved evaporative emission controls compared to current controls. Some of these additional vehicles may be sold in states that have not adopted California standards as well, if manufacturers choose not to market separate California and non-California versions of certain models. Thus, the effect of the revised schedule on the air quality benefit will be minimized.

The phased in approach to implementation, starting as it does with a modest 20 percent requirement, recognizes that current vehicle designs vary with respect to degree of modification needed to comply with the new requirements. The phase-in allows earlier implementation of the easier-to-fix designs in a large manufacturer's model line, while allowing additional lead time for more challenging redesigns.

For heavy-duty vehicles and engines, manufacturers presented no evidence that an additional delay in the implementation schedule was necessary, and EPA knows of none; therefore, gasoline-fueled heavy-duty vehicles and heavy-duty engines are subject to the same implementation schedule as for light-duty vehicles.

It is reasonable to expect manufacturers designated as small entities to comply only with the 1999 model year requirement, primarily because of the large impact the revised test will have on capital requirements for facility modification and construction. Also, the advantage of a phased in implementation schedule is clearly reduced where a manufacturer's domestic offering is limited.

Section 202(a)(2)

Requirements finalized pursuant to section 202(a)(1) of the Act are to be implemented according to the provisions of section 202(a)(2). This includes the new evaporative test procedure for methanol-fueled light-duty vehicles and light-duty trucks, the fuel spitback test, and the dispensing limit for fuel pumps. The 202(k) provision for implementation "as expeditiously as possible" therefore does not apply. Section 202(a)(2) states:

> Any regulation prescribed under paragraph (1) of this subsection (and any revision thereof) shall take effect after such period as the Administrator finds

> necessary to permit the development and application of the requisite technology, giving appropriate consideration to the cost of compliance within such period.

Although the requirement for implementation "as expeditiously as possible" does not apply to methanol-fueled light-duty vehicles and light-duty trucks, EPA believes that the same phase-in schedule for gasoline-fueled vehicles should apply to these vehicles. EPA does not expect methanol-fueled vehicles, including flexible-fueled vehicles, to represent a large percentage of any manufacturer's sales volume in the early years of the phase-in. Therefore, manufacturers will be able to delay certifying these vehicles to the new requirements until later in the phase-in schedule, if desired, without incurring undue costs of compliance.

EPA is phasing in the fuel spitback test with the new evaporative test requirements. As described in Chapter 4, the requisite technology already exists for preventing fuel spitback during refueling. Since designs for spitback control may be affected by a manufacturer's approach to meeting the new evaporative test requirements, implementing the fuel spitback test on a different schedule may cause an unnecessary increase in the cost of compliance.

The limitation on fuel dispensing rates will be delayed until January 1, 1996 for large fuel handlers. The technology for compliance is currently being used by a portion of the industry. Implementing the dispensing limit in January 1996 provides ample time for the replacement of the remaining dispensing nozzles and will ensure that the first vehicles subject to fuel spitback control will generally be fueled at pumps subject to the dispensing limit. Moreover, EPA intends to minimize the cost of compliance by allowing industry to meet the requirements through the natural turnover of equipment, rather than requiring retrofit or replacement of equipment to meet test requirements. Therefore, entities that handle less than 10,000 gallons (38,000 liters) per month are allowed an additional two years to meet the limitation on dispensing rates.

<u>Section 202(a)(3)(C)</u>

Clean Air Act section 202(a)(3)(C) applies to heavy-duty methanol-fueled vehicles. That provision states:

> Any standard promulgated or revised under this paragraph and applicable to classes or categories of heavy-duty vehicles or engines shall apply for a period of no less than 3 model years beginning no earlier than the model year commencing 4 years after such revised standard is promulgated.

To comply with the requirements of section 202(a)(3)(C), implementation of the new requirements for methanol-fueled heavy-duty vehicles and engines should begin in model year 1998. Implementation for these vehicles is then phased in on the same schedule as for other vehicles, namely 90 percent in model year 1998 and 100 percent in following years.

Chapter 4 Economic Impact

The revised evaporative test procedure will result in costs for various components on the vehicle, as well as costs for new facilities and the effort spent for research and testing.

The January 1990 NPRM depended on a detailed assessment of the technology and costs that would be necessary to meet test requirements.[44] The expected changes included larger evaporative canisters and vapor lines, more sophisticated purge valves, and new rollover valves. EPA estimated at that time a retail price equivalent (RPE) total cost of $9.65, $13.40, and $11.25 for light-duty vehicles, light-duty trucks, and heavy-duty vehicles, respectively.

In response to the January 1990 NPRM, several commenters claimed that EPA underestimated vehicles costs. EPA received cost estimates ranging from $30 to $110. However, no commenter responded to any of the individual assumptions comprising EPA's cost analysis, and no commenter attempted to justify any of the new estimates.

At the January 1992 public workshop, GM offered new cost figures. GM estimated a total cost of $100 to meet the requirements of the CARB procedure, and a total of $200 to meet the requirements of the procedure discussed at EPA's January 1992 workshop. For the CARB procedure, GM identified the need for "a larger canister, running loss control by thermal management techniques, and a 'smart purge' system."[45] For EPA's proposed procedure, GM said it would need, in addition, a hydrocarbon sensor to maintain control of exhaust emissions, and a heated canister system to more rapidly remove vapors from the canister.

Industry's cost estimates have been insufficiently supported for EPA to change its analysis. Commenters have identified no hardware that EPA's analysis had not accounted for, and have provided no direct challenge to the assumptions that went into EPA's cost estimate. Moreover, CARB estimated the cost of compliance for its evaporative test procedure to be $18 per vehicle, very close to EPA's estimate.[46] CARB's estimate assumed the evaporative control system would be composed of a 5-liter canister, some additional vapor lines, and a fuel cooling system.

The highest figure, GM's $200 estimate, was associated with EPA's older proposed test requirements, which are not being finalized. The test requirements that EPA is finalizing are based on the CARB test procedure, to which GM applied its $100 cost estimate. Nevertheless, GM's $200 estimate, involving the hydrocarbon sensor and heated canister, was not substantiated with cost information. EPA is unconvinced that manufacturers could not meet the EPA's proposed test requirements by increasing the size of the evaporative canister and improving the aggressiveness and control of the purge system. Also, the technology for

---

[44] "Onboard and Evaporative Control System Cost Estimates for the Supplemental Notice of Proposed Rulemaking," EPA memo from Jean Schwendeman to the Record, December 22, 1988 (Docket A-89-18, item II-B-6).

[45] Letter from Samuel A. Leonard, General Motors, to Richard D. Wilson, EPA, March 23, 1992 (Docket A-89-18, item IV-D-78).

[46] "Technical Support Document for a Proposal to Amend Regulations Regarding Evaporative Emissions Standards, Test Procedures, and Durability Requirements...," California Air Resources Board, August 9, 1990 (Docket A-89-18, item IV-D-87).

hydrocarbon sensors seems to be unavailable in the near term. Moreover, GM relied on a complex and expensive method of heating canisters externally, ignoring evidence in the technical literature that canisters could be most effectively, and very cheaply, heated by purging with heated air.[47]

EPA has revised its cost estimates, depending largely on the assumptions used in the NPRM. Updated cost estimates are described below. Unless otherwise indicated, all prices in the following discussion represent the original equipment manufacturer (OEM) cost that auto manufacturers pay, in 1992 dollars. Cost estimates are rounded to the nearest $0.05 in intermediate calculations. Previously published costs expressed in 1988 dollars, where used as a basis for the present calculations, are increased by 15 percent to account for inflation.

A. Vehicle Hardware Costs

The following paragraphs detail EPA's revised cost estimates associated with vehicle changes expected to result from the new test procedures. The estimates are summarized in Table 4-1.

Table 4-1
Hardware Cost Estimates

Cost Item	Light-Duty Vehicles	Light-Duty Trucks	Heavy-Duty Vehicles
Canister	3.50	6.05	2.95
Purge valve	1.10	1.10	1.10
Fuel and vapor line	0.80	1.10	1.45
Fuel temperature management	0.30	0.00	0.00
Spitback valve	0.30	0.35	0.35
Total Cost	6.00	8.60	5.85

1. <u>Evaporative Canisters</u>

Evaporative canisters are expected to increase in size to accommodate the need to store larger quantities of fuel vapor. The NPRM cost analysis, using an estimated volume increase from 1.3 to 2.7 liters for light-duty vehicles, relied on an established, detailed methodology to estimate the increased canister cost. EPA received no comments on the methodology of estimating canister cost.

Current modeling efforts indicate the need for canisters of approximately the same size as used in the NPRM analysis. GM has indicated that it expects to meet CARB's requirements with a 2-liter canister, indicating that the NPRM estimate may be conservative. As a result, EPA has revised its cost estimate for evaporative canisters only to account for

[47]"Vapor Canister Heater for Evaporative Emissions Systems," Robert P. Bishop and Peter G. Berg, February 1987, SAE 870123.

inflation, resulting in an increased cost of $3.50. Similarly, light-duty trucks and heavy-duty vehicles are expected to incur increased costs of $6.05 and $2.95, respectively.

2. Purge Valves

Purge valves are among the most important components to be improved as a result of the revised evaporative test requirements. EPA expects purge valves to be upgraded to manage higher vapor flow rates and maintain improved control of low flow rates. This would involve changes to the valve assembly, as well as the electronic control of the valve.

The NPRM cost analysis characterized various in-use designs for purge valves and calculated a cost increase for a frequency-modulated solenoid valve. EPA received no comments on the methodology of estimating the cost of purge valves. EPA therefore maintains the earlier estimate for a fleet-average increased cost, adjusted for inflation, of $1.10 per vehicle. The same cost was assumed for light-duty trucks and heavy-duty vehicles.

Additional costs will be incurred in the programming of the electronics that control the valve. The programming is considered to be part of the effort for research and development, described below.

3. Rollover Valves

In the NPRM cost analysis, EPA recognized the fact that many vehicles already had some form of vapor vent or rollover valve, but conservatively estimated that all vehicles would need a new rollover valve to allow full venting of fuel vapors from the tank to the canister, without allowing liquid fuel to enter the vapor line. Rollover valves are now installed on all vehicles to meet safety requirements preventing liquid fuel leaks in an accident.

EPA expects the new test requirements to require no change in size or function for existing rollover valves. The diurnal emission test involves more vapor generation, but with the very gradual heating in 24-hour cycles, vapor flow rates through the rollover valve during the test will decrease. The test procedure also does not increase vapor flow rates during driving. For example, manufacturers are not required to avoid a reliance on pressurized systems to reduce vapor generation. Also, EPA expects that fuel temperatures during driving, and therefore vapor generation, will decrease for many vehicles, as described below.

EPA therefore expects no cost for new or improved rollover valves.

4. Vapor Lines

The NPRM cost analysis allocated a cost for vapor lines, assuming that increased vapor flow rates would require larger tubes to route vapor from the fuel tank to the canister. This assumption is no longer valid, because the test procedure no longer involves an increased vapor flow rate, as described above.

Manufacturers commented that both fuel and vapor lines were suspected sources of emissions from permeation of fuel. Comments fell short of stating a need to change materials, and included no estimate of any cost. For this analysis, EPA conservatively assumes that fuel and vapor lines, currently composed of steel and nylon tubes, will have to be modified to reduce fuel permeation.

EPA assumes that manufacturers will maximize the use of impermeable steel in fuel and vapor lines, leaving several short sections that require a somewhat flexible material. A new technology, in which nylon tubes are lined with a teflon material, seems to provide adequate resistance to permeation. The teflon-coated nylon tubes cost roughly $0.30 per foot ($0.98 per meter), for either fuel or vapor lines, compared to a cost of about $0.14 per foot ($0.46 per meter) for either steel of plain nylon tubes.[48] EPA estimates that a total of 5, 7, and 9 feet (1.5, 2.1, 2.7 meters) of the new nylon tubes will be required for the whole set of fuel and vapor lines on light-duty vehicles, light-duty trucks, and heavy-duty vehicles, respectively, resulting in per-vehicle cost increases of $0.80, $1.10, and $1.45.

EPA understands that concerns for chemical resistance and electrostatic dissipation are prompting some changes in materials selection. EPA has not considered the possible positive or negative effects of such changes in estimating the cost of meeting evaporative requirements.

5. Fuel Temperature Management

Auto manufacturers are expected to design vehicles with lower fuel tank temperatures during driving to avoid fuel boiling during the running loss test. As described in Chapter 5, EPA estimates that a total of 58 percent of light-duty vehicles will need moderate design changes to avoid fuel overheating. However, EPA has confirmed that the two percent of vehicles with the highest fuel temperatures are scheduled to go out of production before implementation of the new evaporative test requirements. EPA estimates that the remaining 56 percent of light-duty vehicles would need to reduce fuel temperature profiles by as much as 15° F.

Manufacturers have several possible options for reducing fuel temperatures during driving. For example, fuel lines are often exposed to very hot engine surfaces, allowing the recirculated fuel to be heated before it returns to the fuel tank. Isolating the fuel lines, either with a simple heat shield, or through more careful routing, would greatly decrease the amount of heat absorbed by the fuel. Similarly, hot exhaust pipes are sometimes located very close to fuel tank surfaces, resulting in localized heating of the fuel in the tank; a heat shield or other insulation, or more careful routing, would again greatly reduce fuel heating. Adding heat shields or rerouting lines should involve a very small amount of additional parts and material. EPA estimates an average cost of $0.50 for the vehicles that need any of these changes. The cost of $0.50 per vehicle, spread over 56 percent of the fleet, results in an average cost of $0.30 for each light-duty vehicle.

More expensive means are available to deal with high fuel temperatures, but manufacturers have not indicated that they intend to change to the more expensive methods. For example, installation of a variable-flow fuel pump would eliminate the recirculation of fuel, eliminating the heating involved as the unused fuel goes past the engine and back to the fuel tank. The variable-flow fuel pump, installed inside the fuel tank, would also deliver much less fuel and give off much less heat. Also, some vehicles are currently designed to route the recirculating fuel past air conditioning components to prevent the fuel from heating. The current use of such a system supports EPA's expectation that limiting heat transfer to the fuel line is effective in limiting fuel temperatures in the fuel tank.

In the future manufacturers can probably design new models to sufficiently limit fuel temperatures with no direct costs. Factoring fuel temperatures into early engineering efforts could prevent the need for additional hardware or other features to ensure adequately low fuel

---

[48]Letter from Edward K. Krause, Pilot Industries, Inc., to Alan Stout, EPA, August 25, 1992 (Docket A-89-18, item IV-D-92).

temperatures. For example, the fuel lines could be routed to minimize exposure to hot surfaces. The fuel tank could be isolated from the exhaust system and from hot underbody air. The fuel pump could be located outside the fuel tank. Total airflow underneath the vehicle could be increased as necessary. These design changes would involve significant costs for existing models, but should be fully available at very little or no cost for future models.

Light-duty trucks and heavy-duty vehicles are designed differently than light-duty vehicles in ways that prevent overly high fuel temperatures. For example, light-duty trucks and heavy-duty vehicles typically have relatively high underbody clearance, resulting in a greater cooling effect from underbody airflow. Because there is more space underneath the vehicle, fuel tanks can also be isolated from exhaust systems. In addition, light-duty trucks and especially heavy-duty vehicles are more likely to have carbureted fuel systems, which do not circulate hot fuel back to the fuel tank. EPA therefore expects that light-duty trucks and heavy-duty vehicles do not need to be modified to reduce fuel temperatures in order to meet new test requirements.

6. Anti-spitback valve

Manufacturers may need a valve installed in the vehicle's filler neck to prevent spitback during refueling. The NPRM cost analysis quoted a vendor's estimated cost of $0.25 for the valve. Manufacturers provided no comment on the need for or the cost of an anti-spitback valve. Some current vehicles are already designed with the valves, but EPA conservatively assumes that all vehicles need the valve, adjusted for inflation to a current price of $0.30. Light-duty trucks and heavy-duty vehicles have a slightly higher estimated cost to account for vehicles with multiple tanks.

7. Seals

Kautex of Canada was the only participant to comment on the need for a change in seals, such as O-rings and gaskets. Kautex claimed that current seals would be inadequate to pass EPA's proposed 4-hour resting loss test, but gave no indication that the proposed 24-hour diurnal testing would require new seal materials. Because EPA is adopting only the 24-hour diurnal emission test, no cost was estimated for more expensive seals.

B. Development and Production Costs

The following paragraphs describe EPA's revised estimates of the overall costs associated with the new test procedures. The estimates are summarized in Table 4-2.

Table 4-2
Total Vehicle Cost Estimates

Cost Item	Light-Duty Vehicles	Light-Duty Trucks	Heavy-Duty Vehicles
Vehicle Components	6.00	8.60	5.85
Packaging	0.75	0.90	1.00
RD&T	0.20	0.35	0.90
Certification	0.15	0.15	0.15
Facilities	0.60	0.60	0.60
Total OEM Cost	7.70	10.60	8.50
Markup (26 %)	2.00	2.75	2.20
Total RPE Cost	9.70	13.35	10.70

1. Packaging

The NPRM cost analysis included estimated costs of $0.75, $0.90, and $1.00 associated with the need to accommodate the larger evaporative canister for light-duty vehicles, light-duty trucks, and heavy-duty vehicles, respectively. EPA demonstrated in its 1987 Draft Regulatory Impact Analysis ("1987 DRIA") that such modifications can almost always be avoided.[49] EPA found that most vehicles at that time could easily accommodate the expected increase in canister volume. If a vehicle cannot accommodate the anticipated larger canister, other design options would be available. A higher grade of activated carbon would reduce canister volume with little or no increase in total cost. Also, converting from cylindrical to rectangular or other shapes could allow more efficient packaging of the canister. EPA expects a negligible cost for vehicle body modifications to accommodate larger evaporative canisters. However, EPA will maintain its conservative estimate from the NPRM cost analysis.

2. Research, Development, and Testing

EPA's estimate of the cost for research, development, and testing is documented in the 1987 DRIA. EPA's cost estimate, which received no comment, factored in engineering time, technician time and the cost of testing for each evaporative family. The new cost estimate, therefore, is based on the 1987 estimate adjusted only for inflation, and is $0.20, $0.35, and $0.90 for light-duty vehicles, light-duty trucks, and heavy-duty vehicles, respectively.

3. Certification

The NPRM cost analysis estimated a cost of $0.05 per vehicle for the effort involved in certifying vehicles to the new test procedures. While receiving no comments on this estimate, EPA believes that the previous estimate should be adjusted to reflect changes to the test

[49]"Draft Regulatory Impact Analysis, Control of Gasoline Volatility and Evaporative Hydrocarbon Emissions from New Motor Vehicles," EPA, pp. 4-34 ff., July 1987 (Docket A-85-21, item II-A-45).

procedure that increase the burden of the certification process. The method of cycling temperatures in 24-hour periods is the primary test change that increases the certification burden. Estimating a per-vehicle cost for certification testing is difficult; EPA therefore makes a simple estimate of a tripled overall cost for certification testing, to $0.15 per vehicle.

4. Facilities

GM has estimated that the automotive industry will need 72 variable-temperature enclosures to comply with CARB's test procedure requirements.[50] EPA has not conducted an independent assessment, but this estimate appears to be reasonable based on recent information obtained from GM, and based on the number of manufacturers that currently perform their own certification testing.[51] EPA assumes that manufacturers performing their own certification tests will need to build one running loss test site as well. Thus, EPA estimates that the industry will require 72 variable-temperature enclosures and 30 running loss sites for the new evaporative test procedure.

Based on GM's comments and EPA's investigation of facility costs, the cost of each variable-temperature enclosure and running loss site is estimated to be $225,000 and $700,000, respectively. The estimated cost to the industry for these enclosures is then 37.2 million dollars (Table 4-3). Amortizing this cost over ten years at ten percent per year, and conservatively assuming an annual production of approximately ten million vehicles per year, results in a per-vehicle cost of $0.60.

Table 4-3
Facility Costs for Automotive Industry

Equipment Requirements	Number	Unit Cost	Cost
Variable-Temperature SHED	72	$225,000	$16,200,000
Running Loss SHED	30	$700,000	$21,000,000
Total			$37,200,000

C. Overall Vehicle Lifetime Costs

1. Fuel Savings

The vehicle costs discussed above are offset by a savings in fuel consumption over the life of the vehicle. This is due to the capture of fuel vapors that would have otherwise been lost to the atmosphere, and the subsequent burning of these vapors in the engine. Two factors affect the determination of the fuel savings.

First, a cost element is added to reflect the additional fuel consumption caused by the extra weight of the improved evaporative control system. In 1988 EPA prepared a detailed analysis to quantify the effect of the added weight, concluding that light-duty vehicles would

---

[50]Letter from Samuel A. Leonard, GM, to Richard D. Wilson, June 5, 1990, page 39 (Docket A-89-18, item IV-D-30).

[51]"Telephone Conversation with General Motors Staff," EPA memo from Dan Barba to Docket A-89-18, October 19, 1992 (item IV-E-24).

add a discounted lifetime cost of approximately $0.50.[52] The analysis assumed, among other things, a 1.8 pound (0.8 kg) increase in weight for canister, vapor line and valve changes, and a crude oil price of $20 per barrel. Although adjustments to some of the assumptions could be made to reflect updated information, such modifications would be minor and would not significantly affect the $0.50 estimate. Similarly, weight penalties of $1.15 and $0.60 were calculated for light-duty trucks and heavy-duty vehicles, respectively.

Second, a cost savings is credited to account for the retention and combustion of fuel vapors that would otherwise be lost to the atmosphere. To estimate the benefit of burning the vapors, EPA assumes that all the vapor is butane, and that all the vapor purged from the canister is burned in the engine to power the vehicle. The heat of combustion (BTU/pound) of butane is six percent higher than that of 9 psi (62 kPa) RVP gasoline, so a pound (kg) of butane is considered equivalent to 1.06 pounds (kg) of gasoline. With a gasoline density of 6.18 pounds per gallon (0.74 kg/liter), and a conservatively assumed cost of $1 per gallon ($0.26 per liter), the resulting cost credit is $0.38 per kilogram of butane.

The amount of butane recovered over the lifetime of the vehicle can be estimated by applying per-vehicle emission reductions (in g/mi) over the vehicle's life. Vehicle life is assumed to be ten years and 100,000 miles for all vehicle classifications in order to simplify the analysis. This results in an estimated fuel recovery of 40, 25, and 105 kg for each light-duty vehicle, light-duty truck, and heavy-duty vehicle, respectively. The associated cost credits, discounted at a rate of ten percent per year over ten years, are $9.35, $5.85, and $24.20 for each light-duty vehicle, light-duty truck, and heavy-duty vehicle, respectively. Combining these credits with the offsetting weight penalties and rounding to the nearest whole dollar yields net fuel savings of approximately $9, $5, and $24 for each light-duty vehicle, light-duty truck, and heavy-duty vehicle, respectively.

2. Overall Vehicle Costs

Overall, OEM costs for light-duty vehicles are estimated to increase by $7.70. A 26 percent markup results in a RPE cost of $9.70. However, this initial cost for purchasing a vehicle is offset over the life of the vehicle by the net fuel savings. A summary of costs for each type of vehicle is provided in Table 4-4.

Assuming that 10 to 15 million vehicles requiring improved evaporative controls are sold per year, and conservatively using the light-duty truck costs of $13 per vehicle without considering the net fuel savings, EPA estimates an annual cost of $130 to 200 million. This cost would be largely or completely offset by the associated fuel savings.

[52] "Onboard and Evaporative Control System Cost Estimates for the Supplemental Notice of Proposed Rulemaking," EPA memo from Jean Schwendeman to the Record, December 22, 1988 (Docket A-89-18, item II-B-6).

Table 4-4
Cost Summary

	LDV	LDT	HDV
Cost to manufacturer	$8	$11	$9
Cost to consumer	$10	$13	$11
Net Fuel savings	$9	$5	$24
Net cost to consumer	$1	$8	-$13

D. Fuel Dispensing Nozzles

Fuel dispensing nozzles must be designed to limit fuel flow to a maximum rate of 10 gallons (37.9 liters) per minute. Husky Corporation, representing approximately 30 percent of the market, already installs a simple flow-limiting device in all its nozzles at no cost to the purchaser.[53] EPA therefore assumes that the cost of such a device is negligible if a nozzle needs to be replaced before the effective date of the dispensing rate limitation. Nozzle turnover rates vary widely, but on average nozzles are estimated to last from one to three years.[54] That replacement rate is expected to increase because of new safety requirements for fuel dispensing equipment.[55] Moreover, stations that must install stage II vapor recovery systems are already required to limit fuel flow to 10 gallons (37.9 liters) per minute (57 FR 13498, April 16, 1992). With a lead time of three years for large stations and five years for small stations, EPA expects that the cost of implementation of this requirement will be negligible.

[53]"Phone Contact with Husky Corporation," EPA memo from Alan Stout to Docket A-89-18, November 2, 1992 (item IV-E-27).

[54]"Investigation of the Need for In-Use Dispensing Rate Limits and Fuel Nozzle Geometry Standardization," EPA technical report prepared by the Standards Development and Support Branch, May 1987 (Docket A-89-18, item IV-A-2).

[55]For example, the National Fire Protection Association set a standard for fuel dispensing nozzles to prevent the possibility of an operator returning a nozzle to its stored position without first deactivating the fuel flow (ANSI NFPA 30-A, effective August 17, 1990).

Chapter 5 Environmental Impact

A. Methodology

Emission reductions resulting from the improved evaporative test procedure are estimated using EPA's MOBILE emission factor model, version 5.0 (MOBILE5). MOBILE5 is EPA's model for calculating fleet average motor vehicle emission factors. Each evaporative emission factor (diurnal, hot soak, running loss, and resting loss) calculated by MOBILE5 is a composite of emission factors from vehicles with properly functioning emission controls and vehicles with failed controls.[56]

The projections used here are made for the year 2020 in order to provide benefit predictions for a fully turned-over fleet and to factor in other known trends, such as the effects of other new Clean Air Act programs. Emission inventory reductions are estimated by determining the difference between post-control emissions (2020 projection with the new evaporative test procedure in place) and baseline emissions (2020 projection without the new procedure). Post-control emission factors are calculated in MOBILE5 using the percent reduction factors discussed in Section C below. To simplify the discussion, this chapter focuses the methodology description on light-duty vehicles. The calculations for light-duty trucks and heavy-duty vehicles use essentially the same approach.

EPA has developed a supplemental evaporative emissions model, separate from MOBILE5, to evaluate the expected reductions in VOC emissions associated with the improved evaporative emission test procedure. The supplemental model, described in Appendix A, calculates canister emissions during diurnal, hot soak, and driving episodes and makes use of actual in-use trip patterns to track canister condition. Results of this modeling effort are presented in Appendix A and summarized in this chapter.

B. Baseline Emissions

A summary of the MOBILE5 input parameters used to determine the baseline emissions is provided in Appendix B, along with the MOBILE5 output files. The primary inputs include the use of 9 psi (62 kPa) RVP gasoline, a daily diurnal temperature swing of 72° to 96° F (22.2° to 35.6° C), full implementation of EPA's high-technology inspection and maintenance (I/M) program, and the implementation of a reformulated gasoline program as required in the Clean Air Act. The RVP was chosen to represent designated Class C areas in Phase II of EPA's volatility controls (55 FR 23658, June 11, 1990). The temperature swing is based on meteorological data from these Class C areas, as discussed in Section C of Chapter 2.

The inspection and maintenance program reflects EPA's proposed rule requiring high-technology I/M programs in serious, severe and extreme nonattainment areas (57 FR 52950, November 5, 1992). To simplify the estimate of emissions, EPA conservatively assumed that vehicles in areas not covered under the high-technology I/M program will experience the same emission reductions due to the improved evaporative test procedure as vehicles in high-technology I/M areas. In fact, emission reductions resulting from the improved evaporative test procedure will be somewhat greater in areas not covered under the I/M program.

---

[56]These vehicle categories are described in "Draft MOBILE5 Hot Soak and Diurnal Emissions," handout from EPA MOBILE5 Workshop, July 8, 1992 (Docket A-89-18, item IV-B-8).

However, the effect of I/M on emission reduction estimates for the new test procedure is small, because the I/M program reduces evaporative emissions primarily from failing vehicles, whereas the improved evaporative test procedure reduces emissions primarily from properly functioning vehicles.

The use of reformulated gasoline in certain areas, as required in the Clean Air Act, will also have some effect on the MOBILE5 predictions. Although the details of the reformulated gasoline program have not yet been finalized, MOBILE5 is capable of modeling the effects of the program, assuming a 25 percent overall VOC emission reduction standard. Unlike the I/M program, the use of reformulated gasoline is expected to significantly reduce evaporative emissions from properly functioning vehicles. Thus, in the areas of the country using reformulated gasoline, baseline evaporative emissions would be lower, resulting in correspondingly smaller emission reductions from the improved evaporative test procedure.

To account for the use of reformulated gasoline in affected areas, emission factors are calculated using MOBILE5 for vehicles operating with and without reformulated gasoline. The two emission factors are then weighted, based on the expected use of reformulated gasoline across the nation, to produce an overall nationwide emission factor. Currently, it is anticipated that reformulated gasoline will be used in the nine cities specified in the Clean Air Act, all of California, several areas that are likely to opt in to the Clean Air Act program, and some additional areas that will be included due to the effects of fuel distribution system spillover. Based on this, it is estimated that about 40 percent of the nation would use reformulated gasoline.[57]

Table 5-1 presents the projected baseline evaporative emissions calculated using MOBILE5 and weighted to account for the expected use of reformulated gasoline in 40 percent of the nation. Appendix B contains the MOBILE5 input and output files used in this analysis.

Table 5-1
Baseline LDV Emission Levels
for Calendar Year 2020 in g/mi (g/km)

Category	Problem-free	Purge-fail	Pressure-fail	Composite
Running loss	0.32 (0.20)	2.76 (1.72)	2.76 (1.72)	0.39 (0.24)
Hot soak	0.05 (0.03)	0.68 (0.42)	0.69 (0.43)	0.06 (0.04)
Diurnal	0.10 (0.06)	0.18 (0.11)	0.42 (0.26)	0.11 (0.07)
Resting loss	0.07 (0.04)	0.07 (0.04)	0.07 (0.04)	0.07 (0.04)
TOTAL	0.54 (0.34)	3.69 (2.35)	3.94 (2.45)	0.63 (0.39)

C. Emission Reductions

Percent reductions resulting from improved evaporative emission controls are estimated for each of the four categories of evaporative emissions: diurnal, hot soak, running losses, and resting losses. Percent reduction factors are then input into MOBILE5 to estimate per-vehicle reductions in g/mi and total VOC inventory reductions in metric tons. The new

[57]"Evaluation of the Use of Ethanol and MTBE in Reformulated Gasoline," prepared by Sobotka & Co, Inc. for the U.S. EPA, September 30, 1992 (Docket A-89-18, item IV-A-5).

evaporative test procedure's effect on emissions from vehicles with inoperative evaporative control systems (referred to as failed vehicles) will be much different than its effect on emissions from properly functioning vehicles (pass vehicles). Therefore, failed vehicle percent reductions are discussed separately near the end of this section.

Diurnal Emissions

Diurnal emissions are classified in MOBILE5 as partial, full, or multiple-day events. A partial diurnal occurs when a diurnal is interrupted by a trip during the period in the day when ambient temperatures are rising. Multiple-day diurnals occur when a vehicle has not been driven for two or more consecutive days.

Vehicles designed to the existing evaporative test procedure, which simulates a 1-day diurnal event, control a large percentage of partial and full-day diurnal emissions. It is expected that vehicles designed to the new test procedure will further reduce emissions from partial and full-day diurnals, for several reasons. First, current vehicles are designed to pass the test based on a 60° to 84° F (15.6° to 28.9° C) diurnal heat build. The improved evaporative test procedure will require control during a higher temperature heat build of 72° to 96° F (22.2° to 35.6° C). Based on vapor generation estimates using the Wade Model, modified based on work by Reddy, the higher temperature diurnal results in almost twice the vapor generation.[58,59] Thus, the higher temperature diurnal requirement will result in larger canisters capable of controlling emissions on these hotter days.

Second, the improved evaporative test procedure will require control of three consecutive diurnals rather than only one under the current evaporative test procedure. The increased canister capacity required for the extra diurnals in the test procedure provides added assurance that a single full-day diurnal will be controlled.

Furthermore, the improved evaporative test procedure is expected to result in higher canister purge rates. The improved test procedure will require vehicles to be capable of purging a loaded canister during the exhaust emission test in preparation for a multiple-day diurnal heat build. This provides an advantage for partial and full-day diurnal control because the rapid purge helps to ensure that storage capacity is restored, even after the short drives typical of many in-use driving patterns.

However, available data show that in-use vehicles with properly functioning evaporative systems consistently emit a small quantity of hydrocarbons during a diurnal heat build, even with a well purged canister. Figure 5-1 shows a distribution of diurnal emission data collected from EPA's emission factor program.[60] The data exclude failed and tampered vehicles and is limited to fuel-injected vehicles tested according to the existing test procedure. The data show that vehicles most frequently emit around 0.5 to 0.6 grams during a 60° to 84° F (15.6° to 28.9° C) temperature diurnal and that a majority of vehicles emit less than 1.8

[58]"Factors Influencing Vehicle Evaporative Emissions," D.T. Wade, January 1967, SAE 670126.

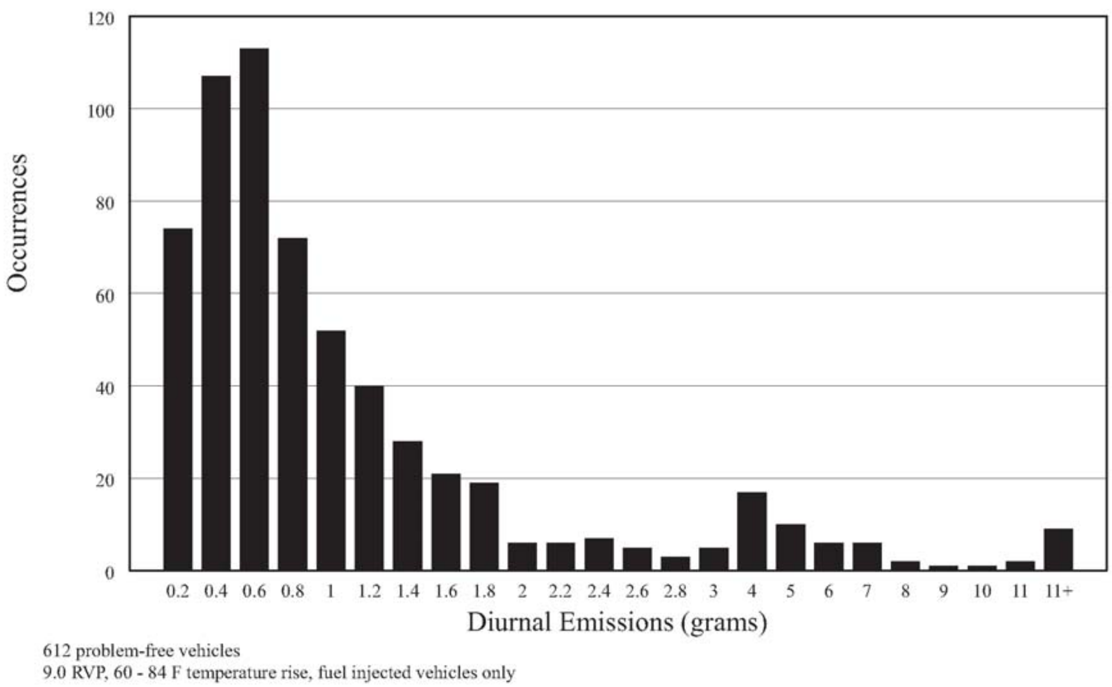
[59]EPA applied a correction factor of 0.78 to Wade Model predictions based on the work of S.R. Reddy, "Prediction of Fuel Vapor Generation From a Vehicle Fuel Tank as a Function of Fuel RVP and Temperature," September 1989, SAE 892089.

[60]"I/M Costs, Benefits, and Impacts," EPA, November 1992, Appendix A, pages 32 & 33 (Docket A-91-75, item V-B).

grams per test. EPA conservatively assumes that these emissions will continue to exist even with the new test procedure in place and that as a result, the improved evaporative test procedure will control only some fraction of current full-day diurnal emissions.

A conservative method of estimating the emission reduction is to assume that all vehicles in the test data base that emit more than 1.8 grams would be brought below this level via increased canister capacity and better purge. Vehicles emitting more than 1.8 grams are assumed to be experiencing the canister breakthrough phenomenon associated with insufficient canister capacity, which the new test procedure is specifically intended to address. As mentioned above, vehicles emitting at lower levels are conservatively assumed to be unaffected by the new procedure in this analysis. The average diurnal emissions in this data set (Figure 5-1), weighted according to fuel system type using MOBILE5 parameters, is 1.31 grams per test.

Figure 5-1.
Distribution of Diurnal Emissions Data



Eliminating the emissions greater than 1.8 grams per test from the data set (thus effectively assuming that the vehicles emitting at these higher levels are redesigned to emit at the weighted average emission level for vehicles in the data base that emit at below 1.8 grams per test) results in an average emission level for the full data set of 0.65 grams per test. Thus, a 50 percent reduction in full-day diurnal emissions is a reasonable, albeit conservative, estimate of the effect of the improved test procedure.

This estimate should also reasonably approximate the percent reduction in partial diurnal emissions, due to the similarity between partial diurnals and full diurnals in terms of the degree of control provided by the current and new procedures. Thus, a reduction of 50 percent is expected to occur in both partial and full-day diurnal situations as a result of the improved evaporative test procedure. Reductions in multiple-day diurnal emissions are expected to be somewhat higher than for partial and full-day diurnals. Because EPA's existing evaporative test procedure does not address multiple-day diurnal events, unlike the one-day diurnal scenario examined above, larger reductions are possible in multiple-diurnal emissions than in one-day diurnal emissions.

EPA emission factor data also provides some basis for estimating the reduction in two- and three-day diurnal emissions. The data identifies how well in-use evaporative systems controlled diurnals as a result of the existing test procedure requirements. It is expected that future reductions in second- and third-day diurnal emissions will be similar to the reductions in full-day diurnal emissions that resulted from adoption of the current evaporative test procedure. Based on the EPA-modified Wade Model, EPA estimates that, without evaporative controls, vehicles would emit roughly 17 grams during a 60° to 84° F (15.6° to 28.9° C) diurnal, assuming a 16-gallon (61-liter) tank, 9.0 psi (62 kPa) RVP fuel, 40 percent tank fill level, and a permanent fuel tank vapor space of 2.4 gallons (9 liters). Considering the average 1.31 grams per test for controlled diurnal emissions discussed above, a reduction of over 90 percent results.

However, due to the uncertainty associated with the various temperature conditions and driving patterns surrounding multiple-day diurnal events, EPA believes that a more conservative estimate is appropriate for two- and three-day diurnal emission reductions. Therefore, EPA estimates that adoption of the new evaporative test procedure will result in a reduction in second- and third-day diurnal emissions of 75 percent.

Though not specifically addressed by the new test procedure, some control of emissions on the fourth day of an extended multiple-day diurnal episode is expected. This control is due to the ability of the canister to collect some vapor even after the canister has been loaded beyond its normal working capacity. Consistent with past EPA analysis of this phenomena, it is expected that roughly half of the emissions on the fourth day of a multiple-diurnal event would be captured by a canister sized to control emissions from three diurnals.[61] The same canister would also control some smaller fraction of diurnal emissions from a fifth day, probably around 25 percent. Due to the occurrence of backpurge between successive diurnal events, EPA estimates that the evaporative system will continue to control roughly 25 percent of all multiple-day diurnal emissions beyond five days.

Due to the infrequency of diurnal events lasting four or more days, MOBILE5 calculations are simplified by applying a single reduction factor for these events. In this case, the 50 percent figure for fourth-day control was adjusted downward to reflect the smaller benefits expected in multiple-diurnal episodes of five days or more. Based on the fraction of the fleet experiencing multiple day diurnals of four days or more, EPA estimates a 40 percent reduction in emissions during diurnal events lasting four or more days.[62]

---

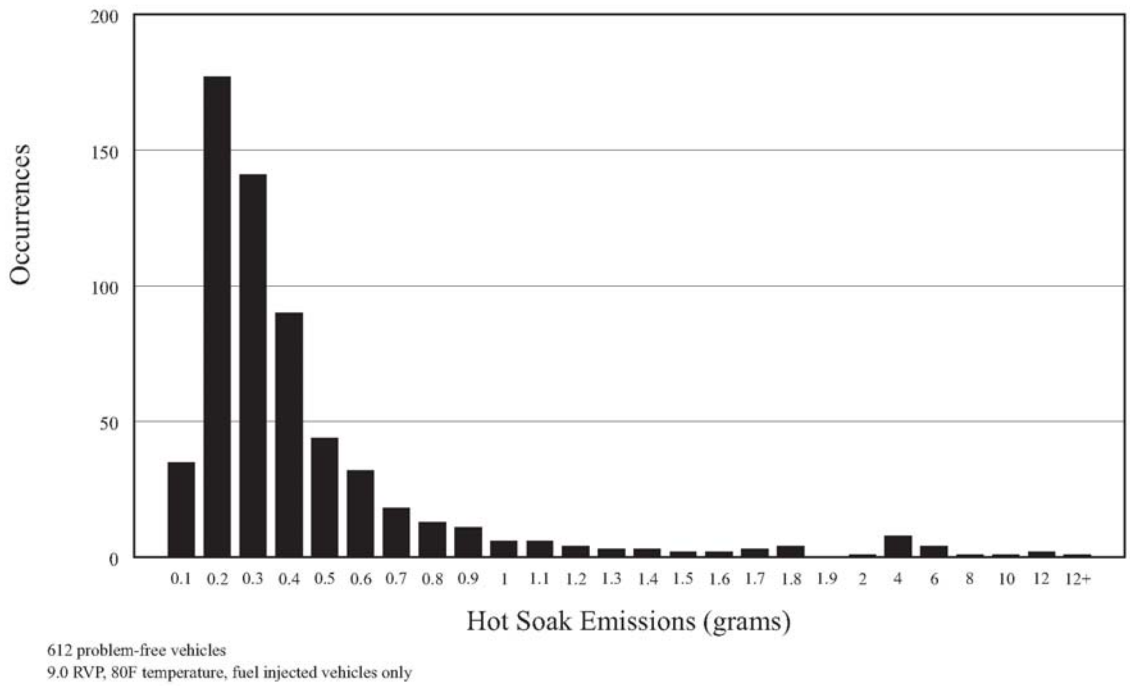
[61]"Multiple Diurnal Emissions," EPA memo from David Bartus to Celia Shih, December 19, 1989 (Docket A-89-18, item II-B-4).

[62]"Reductions in Evaporative Emissions and Running Losses from Enhanced Vehicle-Based Control," EPA memo from Alan Stout to Charles Gray, December 19, 1989 (Docket A-89-18, item II-B-5).

Hot Soak Emissions

Faster purge and larger canisters will ensure that canisters also have capacity at the end of a drive to collect generated hot soak vapors. An estimate of the reduction in hot soak emissions can be derived from the data collected in EPA's emission factor testing.[63] The distribution of the hot soak data from EPA testing is shown in Figure 5-2.

Figure 5-2.
Distribution of Hot Soak Emissions Data



The average hot soak emissions in the data set, weighted according to fuel system type using MOBILE4.1 parameters, is 0.48 g/test. Using an approach similar to the one taken in the above discussion on diurnal emissions, it is assumed that the new test procedure will produce little
incentive to eliminate the small hot soak emissions evident in the test results for a large number of vehicles. These small emissions (most often in the 0.2 to 0.3 gram range) can be expected to continue to occur in future vehicles designed to meet the improved evaporative test procedure.

[63]"I/M Costs, Benefits, and Impacts," EPA, November 1992, Appendix A, pages 32 & 33 (Docket A-91-75, item V-B).

In the hot soak data, most of the vehicles emit less than 0.7 grams per test. Eliminating all hot soak emissions above 0.7 grams per test from the distribution (thus effectively assuming that vehicles emitting at these higher levels are redesigned to emit at the weighted average emission level for vehicles in the data base that emit at below 0.7 grams per test) results in an average hot soak emission value of 0.25 g/test. Thus, it is estimated that hot soak emissions will be reduced by approximately 50 percent (0.48 to 0.25 g/test, on average) as a result of the improved evaporative test procedure.

Running Losses

Because the scope of in-use running losses has been identified only fairly recently, it is difficult to estimate the reductions in running losses that are likely to result from the new evaporative test procedure. However, a reasonable estimate can be produced using running loss emission data contained in MOBILE5.

MOBILE5 estimates that the running losses from current problem-free vehicles average 0.32 g/mi (0.20 g/km). EPA sees no reason to expect that the new procedure will not reduce these emissions to a level near the standard of 0.05 g/mi (0.03 g/km), a reduction of 84 percent. However, considering the uncertainties in these estimates and the fact that extreme in-use conditions may result in some loss of control, it is reasonable to decrease the full assumed benefit somewhat to a percent reduction level of 80 percent.

Resting Losses

Reductions in resting losses can be estimated by comparing resting losses from current vehicles to an estimate of the control level required to pass the improved evaporative test procedure. Because resting losses are measured concurrently with diurnal emissions, a separate standard has not been specified for resting losses in the new test procedure. However, an upper limit for resting losses expected, following implementation of the improved test procedure, can be estimated by subtracting the emissions expected from the hot soak and diurnal portions of the test from the 2 gram per test overall evaporative standard.

Manufacturers will be required to design a system that emits no more than 2 grams during the hot soak test and the highest-emitting 24-hour cycle of the diurnal emission test (which includes resting losses). Based on data from EPA's emission factor testing as discussed above, it is estimated that diurnal emissions normally contribute approximately 0.5 to 0.6 grams per test and that a hot soak can be expected to add another 0.2 to 0.3 g/test. Providing a 0.4 g/test margin of safety to pass the test, 0.7 to 0.9 grams per 24-hour period (or about 0.03 g/hr) appears to be a reasonable estimate of the upper limit for future resting losses. This estimate is consistent with GM's testimony at the January 1992 workshop that its vehicles would need to control resting losses to levels under 0.7 g per 24 hours to comply with test requirements.

Resting loss emission data contained in MOBILE4.1 indicate that current vehicles emit an average of 0.11 grams of hydrocarbons per hour. Comparing this value to the expected post-control resting loss rate of approximately 0.03 g/hr results in approximately a 75 percent reduction in resting losses due to the new evaporative test procedure.

Failed Vehicles

EPA expects that some vehicle designs will need to be revised to ensure lower fuel temperatures during driving in order to prevent fuel boiling during the running loss test. Lower fuel tank temperatures during driving would result in reduced emissions, even for vehicles having inoperative evaporative controls, because of the reductions in vapor generation rates at the lower fuel temperatures. EPA analyzed ATL's running loss data on a representative sample of failed vehicles to estimate the effect of the new test for running losses on in-use emission levels.[64] The 85 light-duty vehicles tested all had fuel systems that did not hold pressure. Testing was conducted at 5 different combinations of ambient temperature and fuel volatility.

EPA expects manufacturers to design vehicles that limit fuel temperature rises to 29° F (16.1° C) during the running loss test. This is based on the expectation that vehicles designed to pass the running loss test (which begins with fuel temperatures at 95° F (35° C)) would limit maximum fuel temperatures to no higher than 124° F (51° C), in order to provide an 8° F (4.4° C) margin of safety below the boiling point of certification fuel. Table 5-2 shows a breakdown of the fuel temperature profiles for the test vehicles. The data indicate that 41 percent of the vehicles require no change to prevent fuel boiling during the running loss test; 56 percent of the vehicles require a reduction in fuel temperatures of up to 15° F (8° C); 2 percent of the vehicles need more than a 15° F (8° C) reduction.

Table 5-2
Distribution of Fuel Temperature Profiles

Percent of Vehicles	Range of Current Profiles °F (°C)	Expected Reduction °F (°C)
41	0-29 (0-16.1)	0 (0)
28	30-34 (16.7-18.9)	1-5 (0.6-2.8)
20	35-39 (19.4-21.7)	6-10 (3.3-5.6)
8	40-44 (22.2-24.4)	11-15 (6.1-8.3)
0	45-49 (25.0-27.2)	16-20 (8.9-11.1)
2	50-54 (27.8-30.0)	21-24 (11.7-13.3)

To estimate emission reductions, EPA assumed that vehicle families represented by ATL test vehicles with fuel temperature profiles greater than 29° F (16.1° C) would be redesigned such that their distribution of fuel temperatures match that of the lower-temperature vehicles in the ATL data. It is possible that some of these vehicle designs may be modified only to the point of achieving the 29° F (16.1° C) profile; however, EPA expects that the incentive to reduce the magnitude of vapor generation during driving will prompt manufacturers to reduce fuel temperatures beyond the minimum required to avoid fuel boiling. Thus the distribution of ATL running loss test data for vehicles that maintained fuel at 29° F (16.1° C) or lower is assumed to be the distribution for all vehicles meeting the new evaporative emission test requirements. The estimated emission reductions are then the calculated differences between the average running loss emissions (measured by ATL) for the distribution of all tested vehicles and the modified distribution.

[64]"MOBILE5 Inputs for Evaporative Emission Reductions from Fail Vehicles," EPA memo from Alan Stout to Joanne I. Goldhand, January 5, 1993 (Docket A-89-18, item IV-B-11).

The calculated emission reductions for each test condition are presented in Table 5-3. The data indicate a reduction of approximately 30 percent for ambient temperatures of at least 95° F (35° C). The testing at 80° F (27° C) involved only 19 vehicles, but clearly indicated less of an effect, with a 17.8 percent reduction. At lower ambient temperatures, fuel boiling is less likely, even for vehicles with large fuel temperature increases during driving. The data do not indicate any dependence of emission reductions on fuel volatility. EPA therefore estimates that failed vehicle running loss reductions resulting from the new evaporative emission control requirements will be as indicated in Table 5-4. Reductions for intermediate temperatures are calculated in MOBILE5 by linear interpolation.

Table 5-3
Emission Reduction Results from Testing of Failed Vehicles

Ambient Temperature	Fuel Volatility (RVP)		
	7.0	9.0	10.4
80° F (27° C)	-	-	17.8%
95° F (35° C)	28.6%	29.6%	-
105° F (41° C)	27.0%	28.7%	-

EPA believes that these reductions are appropriate for hot soak emissions as well, due to the dependence of hot soak emissions on fuel heating at the end of vehicle operation. EPA expects no reduction in diurnal emissions for failed vehicles, because diurnal vapor generation is a function of ambient temperatures rather than heat produced by vehicle operation.

Table 5-4
Running Loss and Hot Soak Emissions:
Percent Reductions for Failed Vehicles

Temperature	Reduction
65° F (18° C)	0%
80° F (27° C)	15%
95° F (35° C)	30%
105° F (41° C)	30%

For resting losses, EPA expects that failed vehicles will reduce resting losses as effectively as pass vehicles (75 percent reduction). Because resting losses are controlled primarily by material selection, resting losses should be unaffected by a vehicle's ability to purge or hold pressure.

EPA has not quantified any expected change in the frequency of failing evaporative systems attributable to the new evaporative test procedure. Manufacturers have argued that the test procedure will cause a revamping of fuel system designs, which will improve system durability. It is possible that changes to reduce permeation will result in more durable components. However, the new test procedure does not require the use of more durable systems, which makes it difficult to estimate the degree of improvement in durability.

Therefore, EPA is unable to quantify this effect at this time. It should be noted that the MOBILE5 analysis accounts for the effects of the enhanced I/M and onboard diagnostics programs in determining the number of failed vehicles in the fleet.

<u>Other Reductions</u>

The calculated reduction in VOC emissions also includes a substantial reduction in benzene, a known carcinogen. Benzene reductions will have an important societal benefit. EPA has, however, not factored benzene reductions into the calculation of benefits, because they are difficult to quantify in cost terms, and because the new test procedure is clearly justified without this additional calculation.

Table 5-5 summarizes EPA's estimate of the percent reductions resulting from the improved evaporative test procedure. The percent reduction factors are applied to MOBILE5 to estimate fleet-average emission reductions and final emission levels, in grams per mile, resulting from the improved evaporative test procedure.

Table 5-5
Percent Reductions in Emissions

Category	Problem-free Reduction	Pressure-fail Reduction	Purge-fail Reduction
Running loss	80%	≤30%*	≤30%*
Hot soak	50%	≤30%*	≤30%*
Diurnal:			
Partial	50%	0	0
Full	50%	0	0
2-3 Days	75%	0	0
4+ Days	40%	0	0
Resting Loss	75%	75%	75%

* See Table 5-4.

D. Projected Emission Factors

The emission reduction factors discussed in Section C above are based on light-duty vehicle technology, but also apply to light-duty trucks and heavy-duty vehicles. It is considered appropriate to make this simplifying assumption for the light-duty truck classification because light-duty trucks resemble light-duty vehicles in terms of both vehicle technology and in-use driving patterns. The technology used to control evaporative emissions from heavy-duty vehicles may be somewhat different than that used for light-duty vehicles, potentially affecting emission reductions. However, because gasoline-fueled heavy-duty vehicles do not make up a large percentage of total vehicle miles traveled, assuming the same level of control for heavy-duty vehicles should not significantly affect overall emission estimates.

Table 5-6 summarizes the predicted post-control evaporative emission levels by applying the percent reduction factors summarized in Tables 5-4 and 5-5 to baseline emission levels from MOBILE5. Table 5-7 summarizes the corresponding emission reductions for light-duty vehicles. The MOBILE5 projection for evaporative emissions for light-duty vehicles designed to meet the new evaporative control requirements is 0.23 g/mi (0.14 g/km), a reduction of 0.40 g/mi (0.25 g/km).

Table 5-6
Post-Control LDV Emission Levels for Calendar Year 2020
in g/mi (g/km)

Category	Problem-free	Purge-fail	Pressure-fail	Composite
Running loss	0.06 (0.04)	2.01 (1.25)	2.01 (1.25)	0.12 (0.07)
Hot soak	0.02 (0.01)	0.50 (0.31)	0.51 (0.32)	0.04 (0.02)
Diurnal	0.04 (0.02)	0.19 (0.12)	0.42 (0.26)	0.05 (0.03)
Resting loss	0.02 (0.01)	0.02 (0.01)	0.02 (0.01)	0.02 (0.01)
TOTAL	0.14 (0.09)	2.72 (1.69)	2.96 (1.84)	0.23 (0.14)

Table 5-7
Summary of LDV Emission Reductions for Calendar Year 2020
in g/mi (g/km)

Category	Baseline	Post-control	Reduction
Running loss	0.39 (0.24)	0.12 (0.07)	0.27 (0.17)
Hot soak	0.06 (0.04)	0.04 (0.02)	0.02 (0.01)
Diurnal	0.11 (0.07)	0.05 (0.03)	0.06 (0.04)
Resting loss	0.07 (0.04)	0.02 (0.01)	0.05 (0.03)
TOTAL	0.63 (0.39)	0.23 (0.14)	0.40 (0.25)

The supplemental modeling discussed in Appendix A, which uses a very different approach than MOBILE5 to determine emission factors, predicts similar emission reductions resulting from the new evaporative test procedure. The results of this modeling support EPA's position that vehicles designed to CARB's adopted test could have very high in-use emissions if manufacturers substantially delayed canister purging at the beginning of a trip. The current results reinforce the findings of the modeling presented at the January 1992 workshop. The modeling indicates that the addition of the supplemental test sequence provides assurance that vehicles will be designed to perform well under in-use driving conditions. In fact, the results show that the test procedure being finalized, by protecting against excessive purge delays, will provide air quality benefits very near those sought in the last EPA proposal.

Applying the percent reduction factors in Tables 5-4 and 5-5 to baseline emissions for light-duty trucks, MOBILE5 estimates that emissions will drop from 0.45 to 0.20 g/mi (0.28 to 0.12 g/km) as a result of the improved evaporative test procedure, a reduction of 0.25 g/mi (0.16 g/km). For heavy-duty vehicles, MOBILE5 estimates that emissions will drop from 2.98 to 1.94 g/mi (1.85 to 1.21 g/km), a reduction of 1.04 g/mi (0.65 g/km). Appendix B contains the MOBILE5 output files from which these numbers were calculated. Baseline and post-control emission factors from the MOBILE5 output files were weighted to account for the use of reformulated gasoline in 40 percent of the country. Overall, MOBILE5 estimates that total motor vehicle VOC emissions will be reduced from 1.67 g/mi to 1.32 g/mi (1.04 to 0.82 g/km) as a result of the new evaporative test procedure, a reduction of 20 percent.

E. Total Nationwide VOC Emission Reductions

EPA estimates nationwide evaporative emission reductions by applying the MOBILE5 gram/mile emission reduction estimates to projections of future VMT (vehicle miles traveled). The year 2020 was selected for this purpose in order to remain consistent with the environmental benefits analysis discussed above.

Based on EPA's Fuel Consumption Model, VMT projections for light-duty vehicles, light-duty trucks and heavy-duty vehicles for the year 2020 are projected to be 1780, 970, and 160 billion miles (2860, 1560, and 260 billion km), respectively.[65] Applying these VMT projections, the total VOC reductions in the year 2020 resulting from the improved evaporative test procedure for light-duty vehicles, light-duty trucks, and heavy-duty vehicles are projected to be 710,000, 240,000, and 170,000 metric tons of VOC, respectively; this is a total of 1,120,000 metric tons annually. As discussed in the previous section, this results in a total motor vehicle VOC inventory reduction of 20 percent.

[65] "Draft MOBILE4 Fuel Consumption Model," U.S. EPA and Computer Sciences Corporation, April 1991 (Docket A-89-18, item IV-A-3).

Chapter 6 Cost-effectiveness

Comparing benefits and costs makes possible an estimate of the cost-effectiveness of emission reductions for the new test requirements. The estimated per-vehicle emission reductions (in g/mi) discussed in Chapter 5 are projected over the vehicle's life, then discounted to quantify the vehicle's lifetime reductions in present terms. Vehicle life is assumed to be ten years and 100,000 miles for all vehicle classifications in order to simplify the analysis. The analysis uses a ten percent discounting rate. This is the rate commonly used by EPA in performing cost-effectiveness analyses.

The resulting discounted lifetime total emission reductions are 26, 16, and 68 kg for light-duty vehicles, light-duty trucks, and heavy-duty vehicles, respectively. Dividing the costs discussed in Chapter 4 by benefits gives cost-effectiveness figures of $380, $810, and $160 per metric ton for light-duty vehicles, light-duty trucks, and heavy-duty vehicles, respectively, and a weighted average cost-effectiveness (based on projected vehicle registrations in the year 2020) of $500 per metric ton.[66] Table 6-1 summarizes the cost-effectiveness results.

Although these cost-effectiveness calculations have used a ten percent discount factor, EPA believes that three percent may be a more realistic rate.[67] Using this rate, the resulting cost-effectiveness figures would be $290, $620, and $130 per metric ton for light-duty vehicles, light-duty trucks, and heavy-duty vehicles, respectively, and $380 per metric ton overall.

These figures are conservative in that they do not factor in the cost savings over the lifetime of the vehicle caused by improved fuel economy. Applying these fuel consumption credits (Table 4-5) results in an overall cost-effectiveness of $170 per metric ton.

Even considering GM's cost estimate of $100 per vehicle, which was insufficiently substantiated, the cost-effectiveness would be $3800 per metric ton for light-duty vehicles.

Table 6-1
Cost-Effectiveness
of Improved Evaporative Emission Control

	Light-Duty Vehicles	Light-Duty Trucks	Heavy-Duty Vehicles
Emission reduction	0.40 g/mi (0.25 g/km)	0.25 g/mi (0.16 g/km)	1.04 g/mi (0.65 g/km)
Discounted lifetime total	26 kg	16 kg	68 kg
Vehicle cost	$10	$13	$11
Discounted cost per metric ton	$380	$810	$160

[66] "Draft MOBILE4 Fuel Consumption Model," U.S. EPA and Computer Sciences Corporation, April 1991 (Docket A-89-18, item IV-A-3).

[67] "Supplemental Guidelines on Discounting in the Preparation of Regulatory Impact Analysis," U.S. EPA, Office of Policy, Planning, and Evaluation, 1989.

Appendix A

Evaporative Modeling with In-Use Driving Patterns

A. Overview

In September 1991, EPA completed a draft report describing an analysis that compared the effects of using various evaporative emission test procedures for vehicle certification.[1] This analysis concluded that the proposed EPA test provided the best assurance for control of evaporative emissions. An opportunity to critique the analysis was given in the January 1992 workshop. The analysis at that time used a model that was designed to predict how often a vehicle's canister would be loaded past breakthrough based on the vapor generation from diurnal heat builds and canister purge during driving. Since the January 1992 workshop, EPA has considered comments on the original model and has developed an upgraded model that better simulates real world evaporative emissions.

The objective of the upgraded evaporative emission model is to calculate canister emissions during diurnal, hot soak, and driving episodes by maintaining a continuous accounting of canister condition (storage capacity). This is achieved by calculating the mass of hydrocarbons (HC) going to the canister due to (1) ambient heating, (2) hot soak following drives, and (3) heating of the fuel in the fuel tank when the vehicle is driven. Also, the model calculates the mass of HC purged from the canister during vehicle operation and backpurge as a result of ambient cooling. Resting losses are not modeled. The model simulates vehicle driving patterns by tracking the start and end times of each drive and park event and the distance traveled in each drive event. These driving patterns were taken from a database developed for General Motors by National Purchasing Diary (NPD) as described below.[2]

B. NPD Details

The vehicle drive characteristics in the September 1991 analysis and in this model are based on an automotive usage database developed for General Motors in 1979 by NPD. This database spanned one week and included 2,870 vehicles. Participants in the NPD survey were asked to keep a travel diary for each of their vehicles for one week. Entries into the diary included: number of trips per day, distance traveled per trip, and time of the beginning and end of every trip taken. A trip was defined as the time between engine start-up and engine shut-down.

For the model, the trip data were screened in order to identify and remove any obviously mistaken trip entries. After the screening process, 1,787 vehicles remained. Because the canister condition and evaporative control of a given vehicle depends on each trip, vehicles with trips having any of the following characteristics were completely removed from the database:

1. longer than 1440 minutes (24 hours),
2. greater than 1560 miles (2510 km) (65 mph (105 km) for 24 hours),
3. average speed less than 1 mph (1.6 km/h) or greater than 75 mph (120 km/h),
4. average speed less than 15 mph (24 km/h) for over 600 minutes,
5. overlapping trips.

---

[1] "Emission Evaluation of the GM Real Time Evaporative Test Procedure," Draft EPA technical report by Julie Hayden, September 1991 (Docket A-89-18, item III-B-2).

[2] "Automobile Usage Data Base," William M. Spreitzer, General Motors Research Labs, 1979.

Compared to U.S. census data, NPD underestimates the average number of secondary and tertiary vehicles per household. To correct for this inconsistency, EPA added additional secondary and tertiary vehicles to the database. Driving patterns for the additional vehicles were created by copying the characteristics of NPD secondary and tertiary trip records. The resulting input file used for the analysis had 2,067 vehicles.

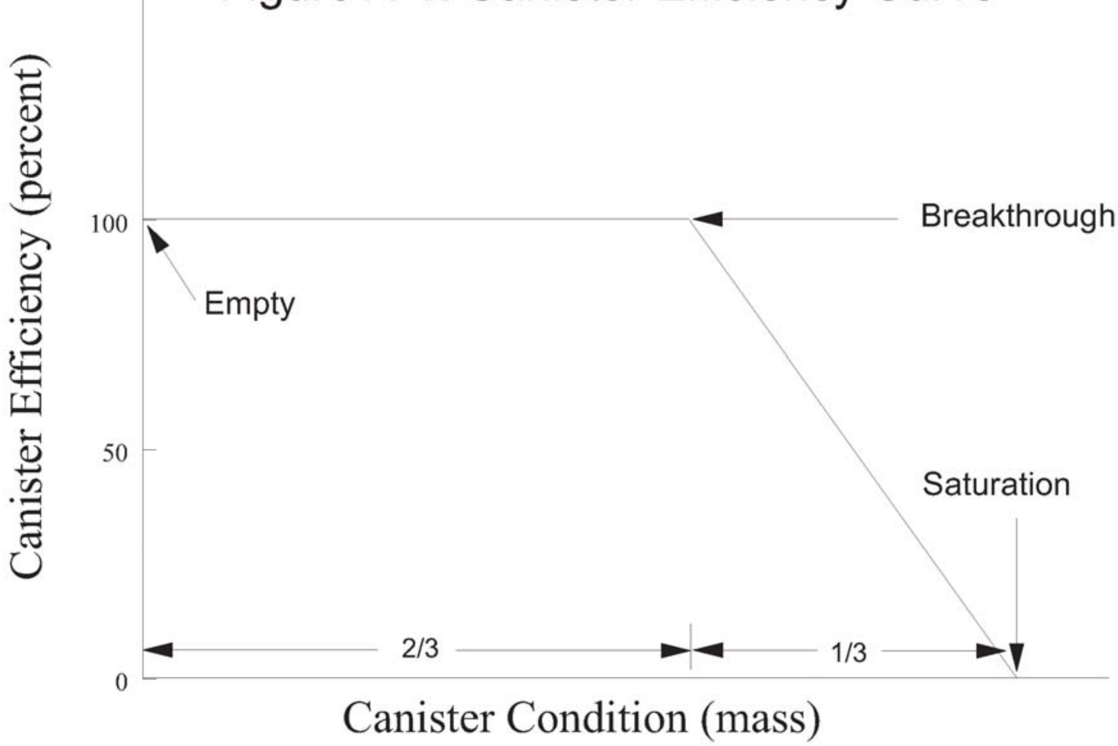
In addition to the revised NPD data, the model provides the option of using an input file with drive characteristics defined by the user. This was necessary for designing a vehicle to pass a given test sequence.

C. Canister Loading

An evaporative canister stores fuel vapors generated from the fuel tank until those vapors are purged from the carbon matrix. When the load exceeds the capacity of the canister, breakthrough occurs. For the purpose of this analysis, breakthrough is defined as the point at which the first significant amount of HC escapes from the canister. For each vehicle, the model tracks the canister condition through the week, calculating how often breakthrough occurs and how much vapor is generated. Figure A-1 shows how the model calculates canister loading efficiency beyond breakthrough.

Once vapors begin escaping, the efficiency gradually decreases until the canister reaches saturation (zero percent collection efficiency). The breakthrough point on the curve is defined

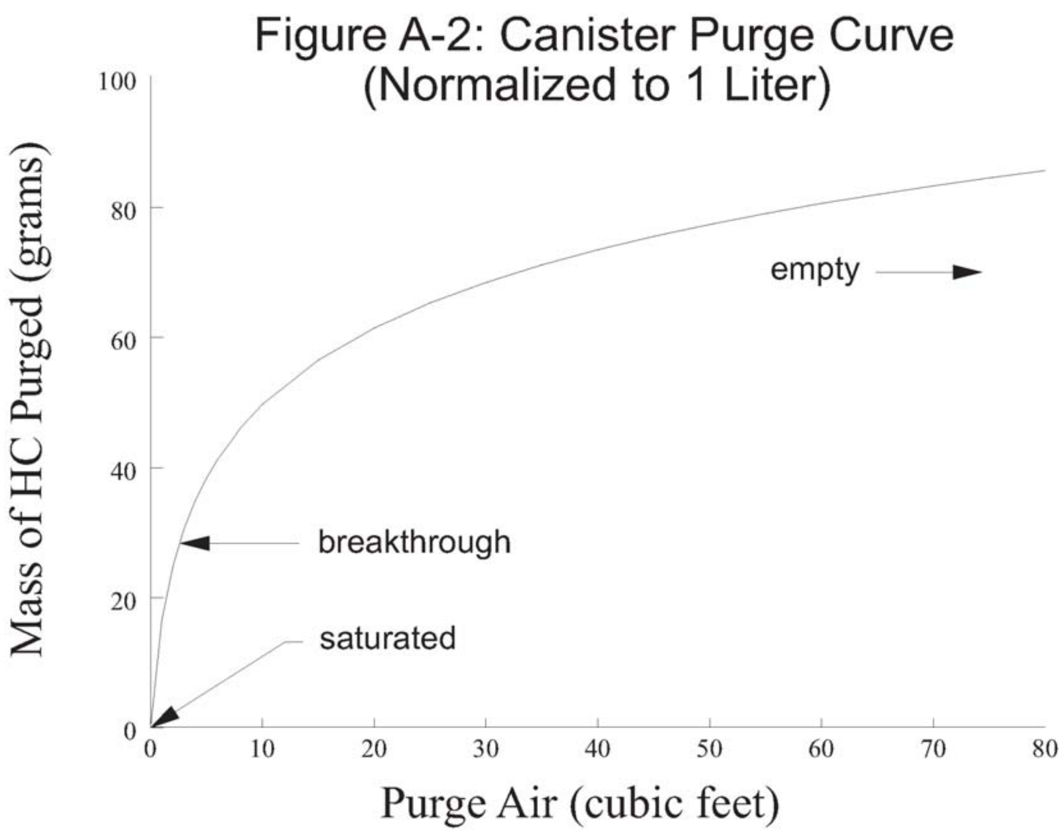
Figure A-1: Canister Efficiency Curve



by a canister load equal to two-thirds of the canister load at saturation. This curve is based on data collected by EPA.

D. Purge Modeling

The model uses a purge curve, developed from General Motors data, to represent the effectiveness of purge from the canister as a function of the volume of air drawn through the canister (Figure A-2). Each point on the curve defines the purge behavior of a canister at a certain fill level. For example, the origin represents a saturated canister. The model uses the purge curve and the load curve to keep track of the canister condition at any time. The purge curve shows that vapor removal is most effective when the canister is full; as the canister empties, an increasing amount of purge air is required to remove the same mass of HC. The model can be run with various purge curves, but the analysis described here relies solely on the curve in Figure A-2.



E. Diurnal

A diurnal heat build is simulated by the model by adding a mass of HC to the canister for every day that the vehicle experiences diurnal loading. This amount is a function of the fuel volatility, ambient temperatures, operation characteristics, and the fill level of the fuel tank. To compare the CARB and EPA test procedures, EPA analysis uses both 7 psi (48 kPa) and 9 psi (62 kPa) RVP fuel, 55 percent fuel tank fill level, and diurnal loading based on both test temperatures and recorded temperatures. The 55 percent fill level represents an average in-use gasoline fuel tank fill level determined by analysis of vehicle refueling data.[3]

The amount of vapor generated each day in a full diurnal event depends on the daily temperature swing. For the modeling discussed in this report, maximum daily temperature data from an actual hot week in Chicago in 1988 were used. These temperatures are not atypical of hot weather conditions in Class C areas of the country. The average of the maximum daily temperatures for the week is equal to 96° F, which matches the maximum daily temperature used in the MOBILE5 modeling discussed in Chapter 5 of the Final RIA for this rulemaking. Modeling the day-to-day variations in maximum temperatures in this way provides canister loadings more typical of real-life conditions than would a hypothetical week of nonvarying hot days. The measured lower temperatures were conservatively increased by 2° F (1.1° C) so that the average temperature swing would match the EPA test temperature swing of 24° F (13.3° C) (i.e. 72° to 96° F (22.2° to 35.6° C)). The temperature data and resulting diurnal canister loadings are shown in Table A-1. The diurnal canister loadings in Table A-1 were determined using a method developed by EPA based on work by Reddy.[4]

Table A-1
HC Grams Loaded During Full Diurnal (Per Day)

Day	Temperature Range in °F (°C)	Vapor Generated in grams
One	75 - 93 (23.9 - 33.9)	16.9
Two	72 - 97 (22.2 - 36.1)	21.0
Three	70 - 103 (21.1 - 39.4)	31.1
Four	78 - 103 (25.6 - 39.4)	28.8
Five	76 - 101 (24.4 - 38.3)	26.8
Six	67 - 92 (19.4 - 33.3)	17.2
Seven	64 - 80 (17.8 - 26.7)	14.3

The model assumes that the canister only experiences diurnal loading when the vehicle is parked and the fuel temperature is less than the ambient temperature. In order to determine whether a vehicle experiences diurnal vapor generation, the model first checks to see if the vehicle is parked during the day's period of increasing ambient temperature. If the vehicle is parked long enough for the fuel to cool to ambient temperature, then the appropriate mass of HC is added to the canister. If the vehicle is never parked and cooled during the increasing temperature period, then no HC is added to the canister.

[3]"Use of RADIAN Fuel Weathering Model to Generate a MOBILE4.0 Fuel Weathering Correlation," EPA memo from Gina Shreve to the Record, June 1, 1989 (Docket A-89-18, item IV-B-7)

[4]"PT Evaporative Emissions Model, Description and Users Guide, Release 2.02" David B. Bartus, U.S. EPA, June 1990, (Docket A-89-18, item IV-B-2).

The period of daily temperature increases and the length of time for the fuel in the tank to cool to ambient temperature are input by the user. For this analysis, EPA assumes a four-hour cool down time and an ambient heating window from 10:00 a.m. to 4:00 p.m. Under these conditions, if a vehicle's last drive were to end at 9:00 a.m., the fuel would be cooled at 1:00 p.m. and the vehicle would receive a diurnal loading for the remainder of the ambient heating time. However, if this vehicle were to be driven again from, say 12:00 p.m. to 12:30 p.m., the fuel would not cool until 4:30 p.m., and the vehicle would receive no diurnal loading for that day.

The relationship between the vapor generated and the period that the vehicle is parked is modeled using the following equation:

$$\text{Load} = a \times [(T_f)^b - (T_i)^b] \qquad (1)$$

where:

T_i = time when ambient temperature begins heating fuel
T_f = time when ambient temperature stops heating fuel
a = $c/[(16)^b - (10)^b]$ (a is constant for each day; 16 and 10 correspond to 4 p.m. and 10 a.m., the limits of the full diurnal heating window)
b = volatility factor = 1.5 for this analysis
c = full diurnal loads from Table A-1

F. Hot Soak

The model simulates a hot soak by estimating vapor generation from the fuel tank, which depends on fuel volatility, trip mileage before the hot soak, and park duration (Table A-2). The model adds HC to the canister following each trip depending on the distance traveled during the trip and the duration of the park time after the trip. Data from CRC-Radian show that about 60 percent of the hot soak loading occurs in the first ten minutes following a drive; about 80 percent of hot soak loading occurs in the first 30 minutes.[5]

Table A-2
Hot Soak Canister Loading (grams)

Trip Distance in miles (km)	Park Duration (minutes)		
	0-10	10-30	30+
0-3 (0-4.8)	2.5	3.6	4.2
3-7 (4.8-11.3)	3.9	5.5	6.5
7-11 (11.3-17.7)	5.1	7.2	8.5
>11 (17.7)	5.6	7.9	9.3

[5]"CRC-Radian Evaporative Emissions Model: Evaluation of Time and Driving Effects," 1990 Annual Report, Radian Corporation, ABRAC VE-4 Project Group, Coordinating Research Council, May 4, 1992.

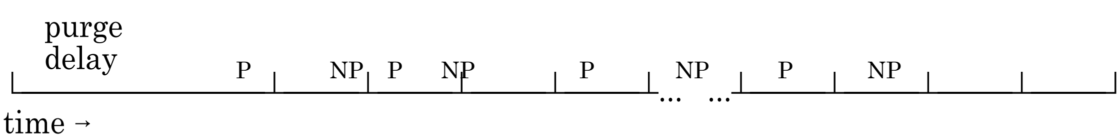
G. Vehicle Operation

1. Purge Design

For periods of vehicle operation, the model calculates the mass of hydrocarbons purged from the canister to the engine. Vehicles are typically designed so that purge does not occur continuously while the engine is running. A purge delay of two minutes is assumed to allow the engine to warm up and begin closed-loop operation before accepting purged hydrocarbons from the canister. The amount of delay is a variable in the model.

The model assumes that no purge will occur during decelerations or at idle. To calculate the amount of purge from the canister during a trip, the model breaks the trip into purge and no-purge intervals that better simulate real driving. The length of the purge delay is subtracted from the trip duration. The remaining trip is divided into seven equal alternating intervals of purge and no-purge (Figure A-3). In addition, the last no-purge period simulates deceleration of the vehicle at the end of a trip. This alternation better simulates actual drive patterns than assuming that the vehicle would purge continuously.

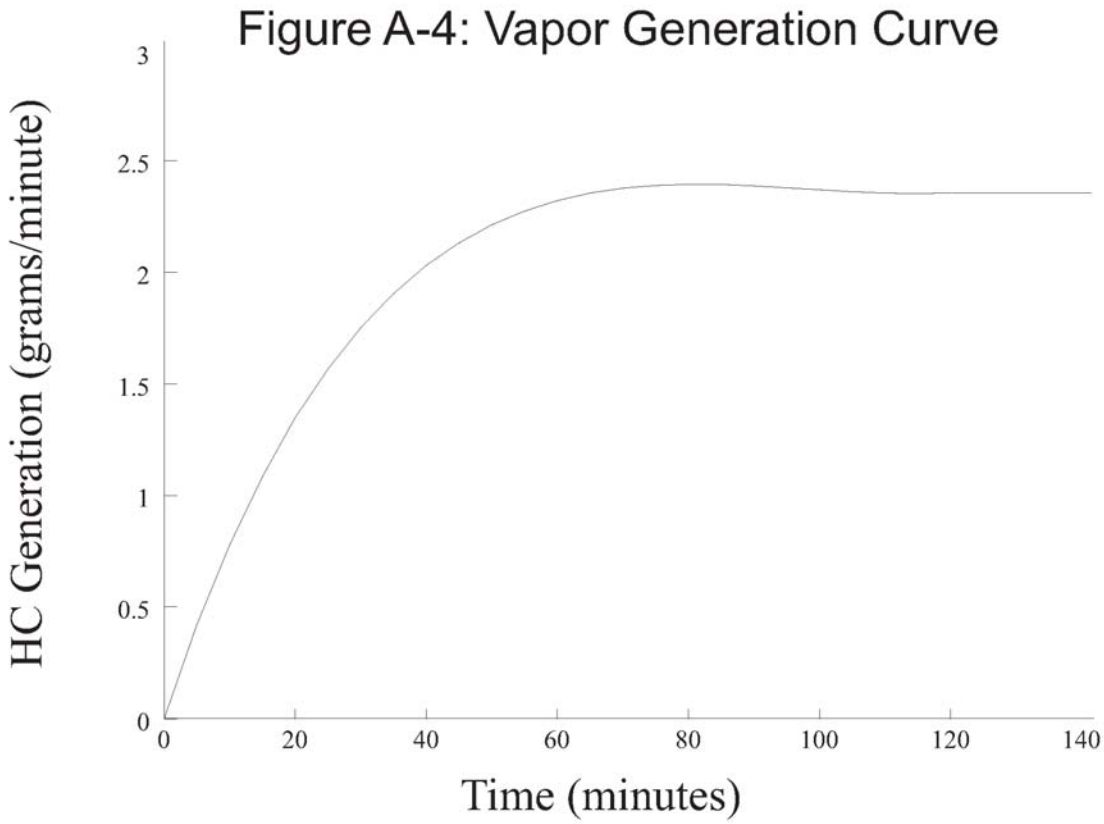
Figure A-3
Representation of Simulated Purge Strategy



P = period of purge NP = period of no-purge

2. Vapor Load

Hydrocarbons generated during drive periods are also added to the canister through the use of a vapor generation curve included in the model (Figure A-4). The figure shows vapor generation as a function of driving time. The model assumes that all vapor generated is sent to the engine during periods of canister purging and that all vapor generated during no-purge periods is sent to the canister.



The model accounts for the fact that fuel temperatures are not the same at the beginning of each trip. Fuel tank temperature rises are calculated using a heating curve and estimates of cooling during non-drive periods are calculated using one of two cooling curves. These temperature curves were developed from test data on in-use vehicles.[6] Slightly different cool down curves are used to model daytime and nighttime ambient temperature conditions.

The heating and cooling curves contained in the model relate temperature to driving time. The fuel tank temperature curves are used in conjunction with the vapor generation curve to provide estimates of vapor generation as a function of both fuel temperature and driving time.

H. Backpurge

In order to represent backpurge due to the cooling of the fuel at night, an amount of HC is removed from the canister for vehicles not driven when ambient temperatures decrease. The model uses a similar method for calculating backpurge as it does for diurnal loading by

[6]EPA Contract 68-C-90027, Automotive Testing Laboratories, 1988 through 1991.

removing a prescribed mass (0.35 ft^3 (9.9 liters) for this analysis) of HC from the canister of those vehicles that are parked in an appropriate time window. This window was assumed to be from 4:00 a.m. to 8:00 a.m.

I. Cases Modeled and Results

Modeling was performed for four cases, using canister sizes and purge rates designed to pass the following test procedures:

1. EPA's current procedure,
2. CARB's procedure (three-diurnal test following exhaust test and running loss test), assuming 9 psi (62 kPa) RVP fuel and 72° to 96° F (22.2° to 35.6° C) diurnal temperatures, and assuming purge is delayed for 20 minutes to avoid exhaust interactions,
3. EPA's proposed procedure for the January 1992 workshop (running loss test following three-diurnal test following exhaust test), and
4. Final rulemaking (FRM) procedure (three-diurnal test following exhaust test and running loss test and supplemental test involving two-diurnal test following exhaust test).

These cases were run using the 2,067 NPD vehicles described above in order to calculate evaporative emissions. The results of this analysis are presented in Table A-3.

The results confirm the conclusion reached by the simpler modeling presented at the January 1992 workshop: if design responses to the CARB test procedure were to include large purge delays in order to avoid exhaust interactions during the exhaust emission test, very large in-use emissions would result. The results also show that the FRM test procedure, by protecting against excessive purge delays, will provide air quality benefits very near those sought in the last EPA proposal.

Table A-3
Test Procedure Effects on Evaporative Emissions

Test Procedure	Emissions in g/mi (g/km)
Current	0.5 (0.3)
CARB with large purge delay	1.0 (0.6)
January 1992 workshop proposal	0.04 (0.02)
EPA Final Rule	0.05 (0.03)

Appendix B

MOBILE5 Input and Output Files

BASELINE INPUT FILE

```
1Enhanced I/M without Reformulated Gasoline & without New Evap Test Procedure (No Phase-In)
 MOBILE5 (4-Dec-92)
0Evaporative Test Procedure Phase-in Years and Percentages:
 Model Year: 2020
 Percentage:   0.
0I/M program #1 selected:                       I/M program #2 selected:

0Start year (Jan 1):  1983                      Start year (Jan 1):  1990
 Pre-1981 stringency: 20%                       Pre-1981 stringency: 20%
 First MYR covered:   1968                      First MYR covered:   1984
 Last MYR covered:    2020                      Last MYR covered:    2020
 Waiver (pre-1981):     1.%                     Waiver (pre-1981):     1.%
 Waiver (1981+):        1.%                     Waiver (1981+):        1.%
 Compliance Rate:      98.%                     Compliance Rate:      98.%
 Inspection type:                               Inspection type:
 Test Only                                      Test Only
 Inspection frequency: Annual                   Inspection frequency: Annual
 I/M program #1 vehicle types                   I/M program #2 vehicle types
      LDGV  - Yes                                    LDGV  - Yes
     LDGT1  - Yes                                   LDGT1  - Yes
     LDGT2  - Yes                                   LDGT2  - Yes
      HDGV  - No                                     HDGV  - No
 1981 & later MYR test type:                    1981 & later MYR test type:
      Idle                                           IM240 test
 Cutpoints, HC:   220.000                       Cutpoints, HC:     0.800
 Cutpoints, CO:     1.200                       Cutpoints, CO:    15.000
 Cutpoints, NOx:  999.000                       Cutpoints, NOx:  999.000

0Functional Check Program Description:
0Check Start   Model Yrs  Vehicle Classes Covered        Inspection          Comp
       (Jan1)  Covered    LDGV   LDGT1  LDGT2  HDGV    Type        Freq      Rate

 Press 1990    1971-2020  Yes    Yes    Yes    No   Test Only    Annual    98.0%
 Purge 1990    1984-2020  Yes    Yes    Yes    No   Test Only    Annual    98.0%
 ATP   1983    1975-2020  Yes    Yes    Yes    No   Test Only    Annual    98.0%
0Air pump system disablements:        Yes  Catalyst removals:                Yes
 Fuel inlet restrictor disablements:  Yes  Tailpipe lead deposit test:       Yes
 EGR disablement:                     No   Evaporative system disablements:  Yes
 PCV system disablements:             Yes  Missing gas caps:                 Yes
0..............                                 Minimum Temp:  72. (F)       Maximum Temp:  96. (F)
                      Period 1 RVP: 11.5        Period 2 RVP:  9.0      Period 2 Start Yr: 1992
0VOC HC emission factors include evaporative HC emission factors.
0
```

Passing Vehicles

0Emission factors are as of July 1st of the indicated calendar year.
0Cal. Year: 2020 I/M Program: Yes Ambient Temp: 90.5 / 90.5 / 90.5 (F) Region: Low
Anti-tam. Program: Yes Operating Mode: 20.6 / 27.3 / 20.6 Altitude: 500. Ft.
Reformulated Gas: No
User-Supplied Pass, Purge Fail, and Pressure Fail Rates (%): 100., 0., 0.

0 Veh. Type:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
+										
Veh. Speeds:	19.6	19.6	19.6		19.6	19.6	19.6	19.6	19.6	
VMT Mix:	0.575	0.207	0.089		0.034	0.002	0.005	0.084	0.004	
0Composite Emission Factors (Gm/Mile)										
VOC HC:	1.53	1.40	1.61	1.46	4.03	0.52	0.73	2.10	6.38	1.655
Exhaust HC:	0.71	0.77	1.00	0.84	1.96	0.52	0.73	2.10	1.89	0.913
Evaporat HC:	0.17	0.18	0.17	0.18	1.19				4.03	0.206
Refuel L HC:	0.20	0.26	0.27	0.26	0.42					0.205
Runing L HC:	0.38	0.11	0.11	0.11	0.38					0.262
Rsting L HC:	0.07	0.07	0.07	0.07	0.08				0.46	0.069
Exhaust CO:	9.76	10.58	13.02	11.31	24.38	1.44	1.61	11.18	26.11	10.847
Exhaust NOX:	1.27	1.41	2.00	1.59	3.73	1.09	1.24	6.58	0.76	1.890

0Evaporative Emissions by Component Weathered RVP: 8.5 Hot Soak Temp: 91.8 (F)
(All Components in Grams per Mile) Running Loss Temp: 92.6 (F)
Resting Loss Temp: 85.2 (F)

	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
Hot Soak	0.07	0.06	0.06	0.06	0.72				2.16	
Diurnal	0.13	0.13	0.12	0.13	0.55				1.87	
Multiple	0.39	0.46	0.42	0.45	1.15					
Crankcase	0.00	0.00	0.00	0.00	0.01				0.00	
8am-11am	0.00	0.00	0.00	0.00						
10am-3pm	0.01	0.01	0.01	0.01						
8am-2pm	0.02	0.02	0.02	0.02						

Purge-Fail Vehicles

0Emission factors are as of July 1st of the indicated calendar year.

0Cal. Year: 2020 I/M Program: Yes Ambient Temp: 90.5 / 90.5 / 90.5 (F) Region: Low

Anti-tam. Program: Yes Operating Mode: 20.6 / 27.3 / 20.6 Altitude: 500. Ft.

Reformulated Gas: No

User-Supplied Pass, Purge Fail, and Pressure Fail Rates (%): 0., 100., 0.

0 Veh. Type:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
+										
Veh. Speeds:	19.6	19.6	19.6		19.6	19.6	19.6	19.6	19.6	
VMT Mix:	0.575	0.207	0.089		0.034	0.002	0.005	0.084	0.004	
0Composite Emission Factors (Gm/Mile)										
VOC HC:	5.45	5.61	5.73	5.65	9.85	0.52	0.73	2.10	2.35	5.325
Exhaust HC:	0.71	0.77	1.00	0.84	1.96	0.52	0.73	2.10	1.89	0.913
Evaporat HC:	1.05	1.09	0.98	1.05	3.97				0.00	1.049
Refuel L HC:	0.20	0.26	0.27	0.26	0.42					0.205
Runing L HC:	3.41	3.41	3.41	3.41	3.41					3.089
Rsting L HC:	0.07	0.07	0.07	0.07	0.08				0.46	0.069
Exhaust CO:	9.76	10.58	13.02	11.31	24.38	1.44	1.61	11.18	26.11	10.847
Exhaust NOX:	1.27	1.41	2.00	1.59	3.73	1.09	1.24	6.58	0.76	1.890

0Evaporative Emissions by Component Weathered RVP: 8.5 Hot Soak Temp: 91.8 (F)

(All Components in Grams per Mile) Running Loss Temp: 92.6 (F)

Resting Loss Temp: 85.2 (F)

	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
Hot Soak	1.11	1.09	0.99	1.07	3.20				0.00	
Diurnal	0.41	0.50	0.46	0.49	1.15				0.00	
Multiple	0.41	0.50	0.46	0.49	1.15					
Crankcase	0.00	0.00	0.00	0.00	0.01				0.00	
8am-11am	0.02	0.04	0.04	0.04						
10am-3pm	0.12	0.17	0.15	0.16						
8am-2pm	0.17	0.22	0.20	0.22						

Pressure-Fail Vehicles

0Emission factors are as of July 1st of the indicated calendar year.
0Cal. Year: 2020 I/M Program: Yes Ambient Temp: 90.5 / 90.5 / 90.5 (F) Region: Low
Anti-tam. Program: Yes Operating Mode: 20.6 / 27.3 / 20.6 Altitude: 500. Ft.
Reformulated Gas: No
User-Supplied Pass, Purge Fail, and Pressure Fail Rates (%): 0., 0., 100.

0 Veh. Type:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
+										
Veh. Speeds:	19.6	19.6	19.6		19.6	19.6	19.6	19.6	19.6	
VMT Mix:	0.575	0.207	0.089		0.034	0.002	0.005	0.084	0.004	
0Composite Emission Factors (Gm/Mile)										
VOC HC:	5.69	5.89	5.99	5.92	10.18	0.52	0.73	2.10	2.35	5.555
Exhaust HC:	0.71	0.77	1.00	0.84	1.96	0.52	0.73	2.10	1.89	0.913
Evaporat HC:	1.29	1.36	1.23	1.32	4.30				0.00	1.278
Refuel L HC:	0.20	0.26	0.27	0.26	0.42					0.205
Runing L HC:	3.41	3.41	3.41	3.41	3.41					3.089
Rsting L HC:	0.07	0.07	0.07	0.07	0.08				0.46	0.069
Exhaust CO:	9.76	10.58	13.02	11.31	24.38	1.44	1.61	11.18	26.11	10.847
Exhaust NOX:	1.27	1.41	2.00	1.59	3.73	1.09	1.24	6.58	0.76	1.890

0Evaporative Emissions by Component Weathered RVP: 8.5 Hot Soak Temp: 91.8 (F)
(All Components in Grams per Mile) Running Loss Temp: 92.6 (F)
Resting Loss Temp: 85.2 (F)

	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
Hot Soak	1.12	1.11	1.01	1.08	3.24				0.00	
Diurnal	0.62	0.74	0.68	0.73	1.58				0.00	
Multiple	0.62	0.74	0.68	0.73	1.58					
Crankcase	0.00	0.00	0.00	0.00	0.01				0.00	
8am-11am	0.31	0.39	0.36	0.38						
10am-3pm	0.40	0.48	0.45	0.47						
8am-2pm	0.44	0.53	0.48	0.51						

Composite

0Emission factors are as of July 1st of the indicated calendar year.

0Cal. Year: 2020 I/M Program: Yes Ambient Temp: 90.5 / 90.5 / 90.5 (F) Region: Low

Anti-tam. Program: Yes Operating Mode: 20.6 / 27.3 / 20.6 Altitude: 500. Ft.

Reformulated Gas: No

0 Veh. Type:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
+										
Veh. Speeds:	19.6	19.6	19.6		19.6	19.6	19.6	19.6	19.6	
VMT Mix:	0.575	0.207	0.089		0.034	0.002	0.005	0.084	0.004	
0Composite Emission Factors (Gm/Mile)										
VOC HC:	1.65	1.54	1.77	1.61	5.85	0.52	0.73	2.10	6.38	1.829
Exhaust HC:	0.71	0.77	1.00	0.84	1.96	0.52	0.73	2.10	1.89	0.913
Evaporat HC:	0.20	0.22	0.20	0.21	2.12				4.03	0.267
Refuel L HC:	0.20	0.26	0.27	0.26	0.42					0.205
Runing L HC:	0.47	0.21	0.23	0.22	1.27					0.375
Rsting L HC:	0.07	0.07	0.07	0.07	0.08				0.46	0.069
Exhaust CO:	9.76	10.58	13.02	11.31	24.38	1.44	1.61	11.18	26.11	10.847
Exhaust NOX:	1.27	1.41	2.00	1.59	3.73	1.09	1.24	6.58	0.76	1.890

0Evaporative Emissions by Component Weathered RVP: 8.5 Hot Soak Temp: 91.8 (F)

(All Components in Grams per Mile) Running Loss Temp: 92.6 (F)

Resting Loss Temp: 85.2 (F)

	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
Hot Soak	0.10	0.10	0.09	0.10	1.45				2.16	
Diurnal	0.14	0.15	0.14	0.15	0.80				1.87	
Multiple	0.41	0.47	0.43	0.46	1.57					
Crankcase	0.00	0.00	0.00	0.00	0.01				0.00	
8am-11am	0.01	0.01	0.01	0.01						
10am-3pm	0.02	0.02	0.02	0.02						
8am-2pm	0.03	0.03	0.03	0.03						

POST-CONTROL INPUT FILE

```
1New Evap Test Procedure with Enhanced I/M & without Reformulated Gasoline
 MOBILE5 (4-Dec-92)
0I/M program #1 selected:                           I/M program #2 selected:

0Start year (Jan 1):  1983                          Start year (Jan 1):  1990
 Pre-1981 stringency: 20%                           Pre-1981 stringency: 20%
 First MYR covered:   1968                          First MYR covered:   1984
 Last MYR covered:    2020                          Last MYR covered:    2020
 Waiver (pre-1981):    1.%                          Waiver (pre-1981):    1.%
 Waiver (1981+):       1.%                          Waiver (1981+):       1.%
 Compliance Rate:     98.%                          Compliance Rate:     98.%
 Inspection type:                                   Inspection type:
 Test Only                                          Test Only
 Inspection frequency: Annual                       Inspection frequency: Annual
 I/M program #1 vehicle types                       I/M program #2 vehicle types
      LDGV  - Yes                                        LDGV  - Yes
     LDGT1  - Yes                                       LDGT1  - Yes
     LDGT2  - Yes                                       LDGT2  - Yes
      HDGV  - No                                         HDGV  - No
 1981 & later MYR test type:                        1981 & later MYR test type:
      Idle                                               IM240 test
 Cutpoints, HC:   220.000                           Cutpoints, HC:     0.800
 Cutpoints, CO:     1.200                           Cutpoints, CO:    15.000
 Cutpoints, NOx:  999.000                           Cutpoints, NOx:  999.000

0Functional Check Program Description:
0Check Start   Model Yrs  Vehicle Classes Covered        Inspection        Comp
       (Jan1)  Covered    LDGV   LDGT1  LDGT2  HDGV    Type        Freq      Rate

 Press 1990    1971-2020  Yes    Yes    Yes    No   Test Only    Annual    98.0%
 Purge 1990    1984-2020  Yes    Yes    Yes    No   Test Only    Annual    98.0%
 ATP   1983    1975-2020  Yes    Yes    Yes    No   Test Only    Annual    98.0%
0Air pump system disablements:       Yes  Catalyst removals:                  Yes
 Fuel inlet restrictor disablements: Yes  Tailpipe lead deposit test:         Yes
 EGR disablement:                    No   Evaporative system disablements:    Yes
 PCV system disablements:            Yes  Missing gas caps:                   Yes
0..............                               Minimum Temp:  72. (F)       Maximum Temp:  96. (F)
                        Period 1 RVP: 11.5    Period 2 RVP:  9.0       Period 2 Start Yr: 1992
0VOC HC emission factors include evaporative HC emission factors.
0
```

POST-CONTROL OUTPUT FILES

Passing Vehicles

0Emission factors are as of July 1st of the indicated calendar year.

0Cal. Year: 2020 I/M Program: Yes Ambient Temp: 90.5 / 90.5 / 90.5 (F) Region: Low
Anti-tam. Program: Yes Operating Mode: 20.6 / 27.3 / 20.6 Altitude: 500. Ft.
Reformulated Gas: No
User-Supplied Pass, Purge Fail, and Pressure Fail Rates (%): 100., 0., 0.

0 Veh. Type:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
+										
Veh. Speeds:	19.6	19.6	19.6		19.6	19.6	19.6	19.6	19.6	
VMT Mix:	0.575	0.207	0.089		0.034	0.002	0.005	0.084	0.004	
0Composite Emission Factors (Gm/Mile)										
VOC HC:	1.08	1.16	1.39	1.23	3.09	0.52	0.73	2.10	6.38	1.296
Exhaust HC:	0.71	0.77	1.00	0.84	1.96	0.52	0.73	2.10	1.89	0.913
Evaporat HC:	0.08	0.08	0.07	0.08	0.60				4.03	0.104
Refuel L HC:	0.20	0.26	0.27	0.26	0.42					0.205
Runing L HC:	0.08	0.02	0.02	0.02	0.09					0.054
Rsting L HC:	0.02	0.02	0.02	0.02	0.03				0.46	0.020
Exhaust CO:	9.76	10.58	13.02	11.31	24.38	1.44	1.61	11.18	26.11	10.847
Exhaust NOX:	1.27	1.41	2.00	1.59	3.73	1.09	1.24	6.58	0.76	1.890

0Evaporative Emissions by Component (All Components in Grams per Mile)
Weathered RVP: 8.5
Hot Soak Temp: 91.8 (F)
Running Loss Temp: 92.6 (F)
Resting Loss Temp: 85.2 (F)

	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
Hot Soak	0.03	0.03	0.03	0.03	0.37				2.16	
Diurnal	0.06	0.07	0.06	0.07	0.28				1.87	
Multiple	0.14	0.17	0.15	0.16	0.43					
Crankcase	0.00	0.00	0.00	0.00	0.01				0.00	
8am-11am	0.00	0.00	0.00	0.00						
10am-3pm	0.01	0.01	0.01	0.01						
8am-2pm	0.01	0.01	0.01	0.01						

Purge-Fail Vehicles

0Emission factors are as of July 1st of the indicated calendar year.
0Cal. Year: 2020 I/M Program: Yes Ambient Temp: 90.5 / 90.5 / 90.5 (F) Region: Low
Anti-tam. Program: Yes Operating Mode: 20.6 / 27.3 / 20.6 Altitude: 500. Ft.
Reformulated Gas: No
User-Supplied Pass, Purge Fail, and Pressure Fail Rates (%): 0., 100., 0.

0 Veh. Type:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
+										
Veh. Speeds:	19.6	19.6	19.6		19.6	19.6	19.6	19.6	19.6	
VMT Mix:	0.575	0.207	0.089		0.034	0.002	0.005	0.084	0.004	
0Composite Emission Factors (Gm/Mile)										
VOC HC:	4.23	4.41	4.57	4.46	8.06	0.52	0.73	2.10	2.35	4.216
Exhaust HC:	0.71	0.77	1.00	0.84	1.96	0.52	0.73	2.10	1.89	0.913
Evaporat HC:	0.83	0.88	0.79	0.85	3.15				0.00	0.836
Refuel L HC:	0.20	0.26	0.27	0.26	0.42					0.205
Runing L HC:	2.48	2.48	2.48	2.48	2.51					2.242
Rsting L HC:	0.02	0.02	0.02	0.02	0.03				0.46	0.020
Exhaust CO:	9.76	10.58	13.02	11.31	24.38	1.44	1.61	11.18	26.11	10.847
Exhaust NOX:	1.27	1.41	2.00	1.59	3.73	1.09	1.24	6.58	0.76	1.890

0Evaporative Emissions by Component (All Components in Grams per Mile)
Weathered RVP: 8.5
Hot Soak Temp: 91.8 (F)
Running Loss Temp: 92.6 (F)
Resting Loss Temp: 85.2 (F)

	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
Hot Soak	0.81	0.81	0.73	0.79	2.38				0.00	
Diurnal	0.41	0.50	0.46	0.49	1.15				0.00	
Multiple	0.41	0.50	0.46	0.49	1.15					
Crankcase	0.00	0.00	0.00	0.00	0.01				0.00	
8am-11am	0.02	0.04	0.04	0.04						
10am-3pm	0.12	0.17	0.15	0.16						
8am-2pm	0.17	0.22	0.20	0.22						

Pressure-Fail Vehicles

0Emission factors are as of July 1st of the indicated calendar year.
0Cal. Year: 2020 I/M Program: Yes Ambient Temp: 90.5 / 90.5 / 90.5 (F) Region: Low
Anti-tam. Program: Yes Operating Mode: 20.6 / 27.3 / 20.6 Altitude: 500. Ft.
Reformulated Gas: No
User-Supplied Pass, Purge Fail, and Pressure Fail Rates (%): 0., 0., 100.

0 Veh. Type:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
+										
Veh. Speeds:	19.6	19.6	19.6		19.6	19.6	19.6	19.6	19.6	
VMT Mix:	0.575	0.207	0.089		0.034	0.002	0.005	0.084	0.004	
0Composite Emission Factors (Gm/Mile)										
VOC HC:	4.47	4.69	4.82	4.73	8.38	0.52	0.73	2.10	2.35	4.443
Exhaust HC:	0.71	0.77	1.00	0.84	1.96	0.52	0.73	2.10	1.89	0.913
Evaporat HC:	1.07	1.15	1.05	1.12	3.46				0.00	1.063
Refuel L HC:	0.20	0.26	0.27	0.26	0.42					0.205
Runing L HC:	2.48	2.48	2.48	2.48	2.51					2.242
Rsting L HC:	0.02	0.02	0.02	0.02	0.03				0.46	0.020
Exhaust CO:	9.76	10.58	13.02	11.31	24.38	1.44	1.61	11.18	26.11	10.847
Exhaust NOX:	1.27	1.41	2.00	1.59	3.73	1.09	1.24	6.58	0.76	1.890

0Evaporative Emissions by Component Weathered RVP: 8.5 Hot Soak Temp: 91.8 (F)
(All Components in Grams per Mile) Running Loss Temp: 92.6 (F)
Resting Loss Temp: 85.2 (F)

	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
Hot Soak	0.82	0.82	0.74	0.79	2.41				0.00	
Diurnal	0.62	0.74	0.68	0.73	1.58				0.00	
Multiple	0.62	0.74	0.68	0.73	1.58					
Crankcase	0.00	0.00	0.00	0.00	0.01				0.00	
8am-11am	0.31	0.39	0.36	0.38						
10am-3pm	0.40	0.48	0.45	0.47						
8am-2pm	0.44	0.53	0.48	0.51						

Composite

0Emission factors are as of July 1st of the indicated calendar year.
0Cal. Year: 2020 I/M Program: Yes Ambient Temp: 90.5 / 90.5 / 90.5 (F) Region: Low
Anti-tam. Program: Yes Operating Mode: 20.6 / 27.3 / 20.6 Altitude: 500. Ft.
Reformulated Gas: No

0 Veh. Type:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
+										
Veh. Speeds:	19.6	19.6	19.6		19.6	19.6	19.6	19.6	19.6	
VMT Mix:	0.575	0.207	0.089		0.034	0.002	0.005	0.084	0.004	
0Composite Emission Factors (Gm/Mile)										
VOC HC:	1.18	1.27	1.51	1.34	4.64	0.52	0.73	2.10	6.38	1.437
Exhaust HC:	0.71	0.77	1.00	0.84	1.96	0.52	0.73	2.10	1.89	0.913
Evaporat HC:	0.10	0.11	0.11	0.11	1.43				4.03	0.157
Refuel L HC:	0.20	0.26	0.27	0.26	0.42					0.205
Runing L HC:	0.15	0.10	0.11	0.10	0.81					0.142
Rsting L HC:	0.02	0.02	0.02	0.02	0.03				0.46	0.020
Exhaust CO:	9.76	10.58	13.02	11.31	24.38	1.44	1.61	11.18	26.11	10.847
Exhaust NOX:	1.27	1.41	2.00	1.59	3.73	1.09	1.24	6.58	0.76	1.890

0Evaporative Emissions by Component Weathered RVP: 8.5 Hot Soak Temp: 91.8 (F)
(All Components in Grams per Mile) Running Loss Temp: 92.6 (F)
Resting Loss Temp: 85.2 (F)

	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
Hot Soak	0.06	0.06	0.06	0.06	0.97				2.16	
Diurnal	0.08	0.09	0.08	0.09	0.61				1.87	
Multiple	0.15	0.18	0.17	0.18	0.85					
Crankcase	0.00	0.00	0.00	0.00	0.01				0.00	
8am-11am	0.01	0.01	0.01	0.01						
10am-3pm	0.01	0.02	0.02	0.02						
8am-2pm	0.02	0.02	0.02	0.02						

BASELINE INPUT FILE - WITH REFORMULATED GASOLINE

```
1Enhanced I/M with Reformulated Gasoline & without New Evap Test Procedure (No Phase-In)
 MOBILE5 (4-Dec-92)
0Evaporative Test Procedure Phase-in Years and Percentages:
 Model Year: 2020
 Percentage:   0.
0I/M program #1 selected:                          I/M program #2 selected:

0Start year (Jan 1):  1983                         Start year (Jan 1):  1990
 Pre-1981 stringency: 20%                          Pre-1981 stringency: 20%
 First MYR covered:   1968                         First MYR covered:   1984
 Last MYR covered:    2020                         Last MYR covered:    2020
 Waiver (pre-1981):     1.%                        Waiver (pre-1981):     1.%
 Waiver (1981+):        1.%                        Waiver (1981+):        1.%
 Compliance Rate:      98.%                        Compliance Rate:      98.%
 Inspection type:                                  Inspection type:
 Test Only                                         Test Only
 Inspection frequency: Annual                      Inspection frequency: Annual
 I/M program #1 vehicle types                      I/M program #2 vehicle types
      LDGV - Yes                                        LDGV - Yes
     LDGT1 - Yes                                       LDGT1 - Yes
     LDGT2 - Yes                                       LDGT2 - Yes
      HDGV - No                                         HDGV - No
 1981 & later MYR test type:                       1981 & later MYR test type:
      Idle                                              IM240 test
 Cutpoints, HC:   220.000                          Cutpoints, HC:     0.800
 Cutpoints, CO:     1.200                          Cutpoints, CO:    15.000
 Cutpoints, NOx:  999.000                          Cutpoints, NOx:  999.000

0Functional Check Program Description:
0Check Start   Model Yrs  Vehicle Classes Covered       Inspection        Comp
       (Jan1)  Covered    LDGV   LDGT1  LDGT2  HDGV    Type       Freq      Rate

 Press 1990    1971-2020  Yes    Yes    Yes    No  Test Only    Annual    98.0%
 Purge 1990    1984-2020  Yes    Yes    Yes    No  Test Only    Annual    98.0%
 ATP   1983    1975-2020  Yes    Yes    Yes    No  Test Only    Annual    98.0%
0Air pump system disablements:        Yes  Catalyst removals:                 Yes
 Fuel inlet restrictor disablements: Yes  Tailpipe lead deposit test:        Yes
 EGR disablement:                     No   Evaporative system disablements:   Yes
 PCV system disablements:             Yes  Missing gas caps:                  Yes
0..............                                 Minimum Temp:  72. (F)        Maximum Temp:  96. (F)
                        Period 1 RVP: 11.5      Period 2 RVP:  9.0       Period 2 Start Yr: 1992
0VOC HC emission factors include evaporative HC emission factors.
0
```

BASELINE OUTPUT FILES - WITH REFORMULATED GASOLINE

Passing Vehicles

0Emission factors are as of July 1st of the indicated calendar year.
0Cal. Year: 2020 I/M Program: Yes Ambient Temp: 90.5 / 90.5 / 90.5 (F) Region: Low
Anti-tam. Program: Yes Operating Mode: 20.6 / 27.3 / 20.6 Altitude: 500. Ft.
Reformulated Gas: Yes ASTM Class: C
User-Supplied Pass, Purge Fail, and Pressure Fail Rates (%): 100., 0., 0.

0 Veh. Type:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
+										
Veh. Speeds:	19.6	19.6	19.6		19.6	19.6	19.6	19.6	19.6	
VMT Mix:	0.575	0.207	0.089		0.034	0.002	0.005	0.084	0.004	
0Composite Emission Factors (Gm/Mile)										
VOC HC:	1.12	1.14	1.31	1.19	3.29	0.52	0.73	2.10	7.14	1.319
Exhaust HC:	0.57	0.61	0.79	0.67	1.63	0.52	0.73	2.10	1.80	0.766
Evaporat HC:	0.10	0.10	0.10	0.10	1.00				4.88	0.140
Refuel L HC:	0.17	0.22	0.23	0.22	0.36					0.174
Runing L HC:	0.22	0.13	0.13	0.13	0.22					0.170
Rsting L HC:	0.07	0.07	0.07	0.07	0.08				0.46	0.069
Exhaust CO:	7.73	8.35	10.15	8.89	17.27	1.44	1.61	11.18	22.45	8.706
Exhaust NOX:	1.27	1.40	2.00	1.58	3.77	1.09	1.24	6.58	0.76	1.886

0Evaporative Emissions by Component Weathered RVP: 7.1 Hot Soak Temp: 91.8 (F)
(All Components in Grams per Mile) Running Loss Temp: 92.6 (F)
Resting Loss Temp: 85.2 (F)

	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
Hot Soak	0.05	0.05	0.05	0.05	0.58				1.89	
Diurnal	0.04	0.05	0.04	0.04	0.55				2.99	
Multiple	0.23	0.27	0.24	0.26	0.81					
Crankcase	0.00	0.00	0.00	0.00	0.01				0.00	
8am-11am	0.00	0.00	0.00	0.00						
10am-3pm	0.00	0.00	0.00	0.00						
8am-2pm	0.01	0.01	0.01	0.01						

Purge-Fail Vehicles

0Emission factors are as of July 1st of the indicated calendar year.

0Cal. Year: 2020   I/M Program: Yes   Ambient Temp: 90.5 / 90.5 / 90.5 (F) Region: Low

Anti-tam. Program: Yes   Operating Mode: 20.6 / 27.3 / 20.6   Altitude: 500. Ft.

Reformulated Gas: Yes   ASTM Class: C

User-Supplied Pass, Purge Fail, and Pressure Fail Rates (%): 0., 100., 0.

0 Veh. Type:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
+										
Veh. Speeds:	19.6	19.6	19.6		19.6	19.6	19.6	19.6	19.6	
VMT Mix:	0.575	0.207	0.089		0.034	0.002	0.005	0.084	0.004	
0Composite Emission Factors (Gm/Mile)										
VOC HC:	3.19	3.32	3.43	3.35	6.19	0.52	0.73	2.10	2.26	3.225
Exhaust HC:	0.57	0.61	0.79	0.67	1.63	0.52	0.73	2.10	1.80	0.766
Evaporat HC:	0.59	0.62	0.56	0.60	2.33				0.00	0.595
Refuel L HC:	0.17	0.22	0.23	0.22	0.36					0.174
Runing L HC:	1.79	1.79	1.79	1.79	1.79					1.621
Rsting L HC:	0.07	0.07	0.07	0.07	0.08				0.46	0.069
Exhaust CO:	7.73	8.35	10.15	8.89	17.27	1.44	1.61	11.18	22.45	8.706
Exhaust NOX:	1.27	1.40	2.00	1.58	3.77	1.09	1.24	6.58	0.76	1.886

0Evaporative Emissions by Component   Weathered RVP: 7.1   Hot Soak Temp: 91.8 (F)

(All Components in Grams per Mile)   Running Loss Temp: 92.6 (F)

Resting Loss Temp: 85.2 (F)

	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
Hot Soak	0.62	0.61	0.55	0.59	1.78				0.00	
Diurnal	0.24	0.30	0.28	0.30	0.81				0.00	
Multiple	0.24	0.30	0.28	0.30	0.81					
Crankcase	0.00	0.00	0.00	0.00	0.01				0.00	
8am-11am	0.01	0.02	0.02	0.02						
10am-3pm	0.05	0.08	0.07	0.08						
8am-2pm	0.08	0.12	0.11	0.12						

Pressure-Fail Vehicles

0Emission factors are as of July 1st of the indicated calendar year.
0Cal. Year: 2020 I/M Program: Yes Ambient Temp: 90.5 / 90.5 / 90.5 (F) Region: Low
Anti-tam. Program: Yes Operating Mode: 20.6 / 27.3 / 20.6 Altitude: 500. Ft.
Reformulated Gas: Yes ASTM Class: C
User-Supplied Pass, Purge Fail, and Pressure Fail Rates (%): 0., 0., 100.

0 Veh. Type:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
+ Veh. Speeds:	19.6	19.6	19.6		19.6	19.6	19.6	19.6	19.6	
VMT Mix:	0.575	0.207	0.089		0.034	0.002	0.005	0.084	0.004	
0Composite Emission Factors (Gm/Mile)										
VOC HC:	3.44	3.61	3.70	3.64	6.55	0.52	0.73	2.10	2.26	3.466
Exhaust HC:	0.57	0.61	0.79	0.67	1.63	0.52	0.73	2.10	1.80	0.766
Evaporat HC:	0.84	0.91	0.83	0.89	2.69				0.00	0.837
Refuel L HC:	0.17	0.22	0.23	0.22	0.36					0.174
Runing L HC:	1.79	1.79	1.79	1.79	1.79					1.621
Rsting L HC:	0.07	0.07	0.07	0.07	0.08				0.46	0.069
Exhaust CO:	7.73	8.35	10.15	8.89	17.27	1.44	1.61	11.18	22.45	8.706
Exhaust NOX:	1.27	1.40	2.00	1.58	3.77	1.09	1.24	6.58	0.76	1.886

0Evaporative Emissions by Component Weathered RVP: 7.1 Hot Soak Temp: 91.8 (F)
(All Components in Grams per Mile) Running Loss Temp: 92.6 (F)
Resting Loss Temp: 85.2 (F)

	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
Hot Soak	0.62	0.61	0.56	0.60	1.81				0.00	
Diurnal	0.49	0.59	0.54	0.58	1.32				0.00	
Multiple	0.49	0.59	0.54	0.58	1.32					
Crankcase	0.00	0.00	0.00	0.00	0.01				0.00	
8am-11am	0.29	0.36	0.33	0.35						
10am-3pm	0.34	0.42	0.39	0.41						
8am-2pm	0.37	0.45	0.41	0.44						

Composite

0Emission factors are as of July 1st of the indicated calendar year.

0Cal. Year: 2020 I/M Program: Yes Ambient Temp: 90.5 / 90.5 / 90.5 (F) Region: Low

Anti-tam. Program: Yes Operating Mode: 20.6 / 27.3 / 20.6 Altitude: 500. Ft.

Reformulated Gas: Yes ASTM Class: C

0 Veh. Type:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
+										
Veh. Speeds:	19.6	19.6	19.6		19.6	19.6	19.6	19.6	19.6	
VMT Mix:	0.575	0.207	0.089		0.034	0.002	0.005	0.084	0.004	
0Composite Emission Factors (Gm/Mile)										
VOC HC:	1.18	1.22	1.39	1.27	4.24	0.52	0.73	2.10	7.14	1.413
Exhaust HC:	0.57	0.61	0.79	0.67	1.63	0.52	0.73	2.10	1.80	0.766
Evaporat HC:	0.12	0.13	0.12	0.13	1.49				4.88	0.176
Refuel L HC:	0.17	0.22	0.23	0.22	0.36					0.174
Runing L HC:	0.26	0.18	0.19	0.18	0.68					0.228
Rsting L HC:	0.07	0.07	0.07	0.07	0.08				0.46	0.069
Exhaust CO:	7.73	8.35	10.15	8.89	17.27	1.44	1.61	11.18	22.45	8.706
Exhaust NOX:	1.27	1.40	2.00	1.58	3.77	1.09	1.24	6.58	0.76	1.886

0Evaporative Emissions by Component Weathered RVP: 7.1 Hot Soak Temp: 91.8 (F)

(All Components in Grams per Mile) Running Loss Temp: 92.6 (F)

Resting Loss Temp: 85.2 (F)

	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
Hot Soak	0.07	0.07	0.07	0.07	0.94				1.89	
Diurnal	0.06	0.06	0.06	0.06	0.72				2.99	
Multiple	0.24	0.27	0.25	0.27	1.14					
Crankcase	0.00	0.00	0.00	0.00	0.01				0.00	
8am-11am	0.01	0.01	0.01	0.01						
10am-3pm	0.01	0.01	0.01	0.01						
8am-2pm	0.01	0.02	0.02	0.02						

POST-CONTROL INPUT FILE - WITH REFORMULATED GASOLINE

```
1New Evap Test Procedure with Enhanced I/M and Reformulated Gasoline
 MOBILE5 (4-Dec-92)
0I/M program #1 selected:                         I/M program #2 selected:

0Start year (Jan 1):  1983                         Start year (Jan 1):  1990
 Pre-1981 stringency: 20%                          Pre-1981 stringency: 20%
 First MYR covered:   1968                         First MYR covered:   1984
 Last MYR covered:    2020                         Last MYR covered:    2020
 Waiver (pre-1981):    1.%                         Waiver (pre-1981):    1.%
 Waiver (1981+):       1.%                         Waiver (1981+):       1.%
 Compliance Rate:     98.%                         Compliance Rate:     98.%
 Inspection type:                                  Inspection type:
 Test Only                                         Test Only
 Inspection frequency: Annual                      Inspection frequency: Annual
 I/M program #1 vehicle types                      I/M program #2 vehicle types
      LDGV - Yes                                        LDGV - Yes
     LDGT1 - Yes                                       LDGT1 - Yes
     LDGT2 - Yes                                       LDGT2 - Yes
      HDGV - No                                         HDGV - No
 1981 & later MYR test type:                       1981 & later MYR test type:
      Idle                                              IM240 test
 Cutpoints, HC:   220.000                          Cutpoints, HC:     0.800
 Cutpoints, CO:     1.200                          Cutpoints, CO:    15.000
 Cutpoints, NOx:  999.000                          Cutpoints, NOx:  999.000

0Functional Check Program Description:
0Check Start   Model Yrs  Vehicle Classes Covered        Inspection        Comp
       (Jan1)  Covered    LDGV   LDGT1  LDGT2  HDGV    Type       Freq      Rate

 Press 1990    1971-2020  Yes    Yes    Yes    No   Test Only    Annual    98.0%
 Purge 1990    1984-2020  Yes    Yes    Yes    No   Test Only    Annual    98.0%
 ATP   1983    1975-2020  Yes    Yes    Yes    No   Test Only    Annual    98.0%
0Air pump system disablements:        Yes  Catalyst removals:                   Yes
 Fuel inlet restrictor disablements:  Yes  Tailpipe lead deposit test:          Yes
 EGR disablement:                     No   Evaporative system disablements:     Yes
 PCV system disablements:             Yes  Missing gas caps:                    Yes
0..............                                 Minimum Temp:  72. (F)        Maximum Temp:  96. (F)
                          Period 1 RVP: 11.5    Period 2 RVP:  9.0      Period 2 Start Yr: 1992
0VOC HC emission factors include evaporative HC emission factors.
0
```

POST-CONTROL OUTPUT FILES - WITH REFORMULATED GASOLINE

Passing Vehicles

0Emission factors are as of July 1st of the indicated calendar year.
0Cal. Year: 2020 I/M Program: Yes Ambient Temp: 90.5 / 90.5 / 90.5 (F) Region: Low
Anti-tam. Program: Yes Operating Mode: 20.6 / 27.3 / 20.6 Altitude: 500. Ft.
Reformulated Gas: Yes ASTM Class: C
User-Supplied Pass, Purge Fail, and Pressure Fail Rates (%): 100., 0., 0.

0 Veh. Type:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
Veh. Speeds:	19.6	19.6	19.6		19.6	19.6	19.6	19.6	19.6	
VMT Mix:	0.575	0.207	0.089		0.034	0.002	0.005	0.084	0.004	
0Composite Emission Factors (Gm/Mile)										
VOC HC:	0.84	0.93	1.10	0.98	2.57	0.52	0.73	2.10	7.14	1.071
Exhaust HC:	0.57	0.61	0.79	0.67	1.63	0.52	0.73	2.10	1.80	0.766
Evaporat HC:	0.04	0.05	0.04	0.05	0.51				4.88	0.077
Refuel L HC:	0.17	0.22	0.23	0.22	0.36					0.174
Runing L HC:	0.04	0.03	0.03	0.03	0.05					0.035
Rsting L HC:	0.02	0.02	0.02	0.02	0.03				0.46	0.020
Exhaust CO:	7.73	8.35	10.15	8.89	17.27	1.44	1.61	11.18	22.45	8.706
Exhaust NOX:	1.27	1.40	2.00	1.58	3.77	1.09	1.24	6.58	0.76	1.886

0Evaporative Emissions by Component Weathered RVP: 7.1 Hot Soak Temp: 91.8 (F)
(All Components in Grams per Mile) Running Loss Temp: 92.6 (F)
Resting Loss Temp: 85.2 (F)

	LDGV	LDGT1	LDGT2	LDGT	HDGV	MC
Hot Soak	0.03	0.03	0.03	0.03	0.30	1.89
Diurnal	0.02	0.02	0.02	0.02	0.29	2.99
Multiple	0.08	0.10	0.09	0.09	0.30	
Crankcase	0.00	0.00	0.00	0.00	0.01	0.00
8am-11am	0.00	0.00	0.00	0.00		
10am-3pm	0.00	0.00	0.00	0.00		
8am-2pm	0.00	0.00	0.00	0.00		

Purge-Fail Vehicles

0Emission factors are as of July 1st of the indicated calendar year.
0Cal. Year: 2020 I/M Program: Yes Ambient Temp: 90.5 / 90.5 / 90.5 (F) Region: Low
Anti-tam. Program: Yes Operating Mode: 20.6 / 27.3 / 20.6 Altitude: 500. Ft.
Reformulated Gas: Yes ASTM Class: C
User-Supplied Pass, Purge Fail, and Pressure Fail Rates (%): 0., 100., 0.

0 Veh. Type:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
+										
Veh. Speeds:	19.6	19.6	19.6		19.6	19.6	19.6	19.6	19.6	
VMT Mix:	0.575	0.207	0.089		0.034	0.002	0.005	0.084	0.004	
0Composite Emission Factors (Gm/Mile)										
VOC HC:	2.52	2.66	2.79	2.70	5.20	0.52	0.73	2.10	2.26	2.613
Exhaust HC:	0.57	0.61	0.79	0.67	1.63	0.52	0.73	2.10	1.80	0.766
Evaporat HC:	0.47	0.50	0.45	0.49	1.87				0.00	0.477
Refuel L HC:	0.17	0.22	0.23	0.22	0.36					0.174
Runing L HC:	1.30	1.30	1.30	1.30	1.32					1.177
Rsting L HC:	0.02	0.02	0.02	0.02	0.03				0.46	0.020
Exhaust CO:	7.73	8.35	10.15	8.89	17.27	1.44	1.61	11.18	22.45	8.706
Exhaust NOX:	1.27	1.40	2.00	1.58	3.77	1.09	1.24	6.58	0.76	1.886

0Evaporative Emissions by Component Weathered RVP: 7.1 Hot Soak Temp: 91.8 (F)
(All Components in Grams per Mile) Running Loss Temp: 92.6 (F)
Resting Loss Temp: 85.2 (F)

	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
Hot Soak	0.45	0.45	0.41	0.44	1.32				0.00	
Diurnal	0.24	0.30	0.28	0.30	0.81				0.00	
Multiple	0.24	0.30	0.28	0.30	0.81					
Crankcase	0.00	0.00	0.00	0.00	0.01				0.00	
8am-11am	0.01	0.02	0.02	0.02						
10am-3pm	0.05	0.08	0.07	0.08						
8am-2pm	0.08	0.12	0.11	0.12						

Pressure-Fail Vehicles

0Emission factors are as of July 1st of the indicated calendar year.

0Cal. Year: 2020 I/M Program: Yes Ambient Temp: 90.5 / 90.5 / 90.5 (F) Region: Low
Anti-tam. Program: Yes Operating Mode: 20.6 / 27.3 / 20.6 Altitude: 500. Ft.
Reformulated Gas: Yes ASTM Class: C
User-Supplied Pass, Purge Fail, and Pressure Fail Rates (%): 0., 0., 100.

0 Veh. Type:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
+										
Veh. Speeds:	19.6	19.6	19.6		19.6	19.6	19.6	19.6	19.6	
VMT Mix:	0.575	0.207	0.089		0.034	0.002	0.005	0.084	0.004	
0Composite Emission Factors (Gm/Mile)										
VOC HC:	2.77	2.95	3.06	2.98	5.55	0.52	0.73	2.10	2.26	2.853
Exhaust HC:	0.57	0.61	0.79	0.67	1.63	0.52	0.73	2.10	1.80	0.766
Evaporat HC:	0.72	0.79	0.72	0.77	2.22				0.00	0.717
Refuel L HC:	0.17	0.22	0.23	0.22	0.36					0.174
Runing L HC:	1.30	1.30	1.30	1.30	1.32					1.177
Rsting L HC:	0.02	0.02	0.02	0.02	0.03				0.46	0.020
Exhaust CO:	7.73	8.35	10.15	8.89	17.27	1.44	1.61	11.18	22.45	8.706
Exhaust NOX:	1.27	1.40	2.00	1.58	3.77	1.09	1.24	6.58	0.76	1.886

0Evaporative Emissions by Component Weathered RVP: 7.1 Hot Soak Temp: 91.8 (F)
(All Components in Grams per Mile) Running Loss Temp: 92.6 (F)
Resting Loss Temp: 85.2 (F)

	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
Hot Soak	0.46	0.45	0.41	0.44	1.34				0.00	
Diurnal	0.49	0.59	0.54	0.58	1.32				0.00	
Multiple	0.49	0.59	0.54	0.58	1.32					
Crankcase	0.00	0.00	0.00	0.00	0.01				0.00	
8am-11am	0.29	0.36	0.33	0.35						
10am-3pm	0.34	0.42	0.39	0.41						
8am-2pm	0.37	0.45	0.41	0.44						

Composite

0Emission factors are as of July 1st of the indicated calendar year.
0Cal. Year: 2020 I/M Program: Yes Ambient Temp: 90.5 / 90.5 / 90.5 (F) Region: Low
Anti-tam. Program: Yes Operating Mode: 20.6 / 27.3 / 20.6 Altitude: 500. Ft.
Reformulated Gas: Yes ASTM Class: C

0 Veh. Type:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
+										
Veh. Speeds:	19.6	19.6	19.6		19.6	19.6	19.6	19.6	19.6	
VMT Mix:	0.575	0.207	0.089		0.034	0.002	0.005	0.084	0.004	
0Composite Emission Factors (Gm/Mile)										
VOC HC:	0.89	0.99	1.17	1.04	3.43	0.52	0.73	2.10	7.14	1.150
Exhaust HC:	0.57	0.61	0.79	0.67	1.63	0.52	0.73	2.10	1.80	0.766
Evaporat HC:	0.06	0.07	0.06	0.07	0.99				4.88	0.109
Refuel L HC:	0.17	0.22	0.23	0.22	0.36					0.174
Runing L HC:	0.08	0.07	0.07	0.07	0.43					0.081
Rsting L HC:	0.02	0.02	0.02	0.02	0.03				0.46	0.020
Exhaust CO:	7.73	8.35	10.15	8.89	17.27	1.44	1.61	11.18	22.45	8.706
Exhaust NOX:	1.27	1.40	2.00	1.58	3.77	1.09	1.24	6.58	0.76	1.886

0Evaporative Emissions by Component Weathered RVP: 7.1 Hot Soak Temp: 91.8 (F)
(All Components in Grams per Mile) Running Loss Temp: 92.6 (F)
Resting Loss Temp: 85.2 (F)

	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
Hot Soak	0.04	0.04	0.04	0.04	0.61				1.89	
Diurnal	0.03	0.04	0.04	0.04	0.53				2.99	
Multiple	0.09	0.11	0.10	0.10	0.63					
Crankcase	0.00	0.00	0.00	0.00	0.01				0.00	
8am-11am	0.01	0.01	0.01	0.01						
10am-3pm	0.01	0.01	0.01	0.01						
8am-2pm	0.01	0.01	0.01	0.01						