State of California
AIR RESOURCES BOARD

STAFF REPORT: INITIAL STATEMENT OF REASONS FOR RULEMAKING

Technical Status and Proposed Revisions to Malfunction and Diagnostic System Requirements for 1994 and Subsequent Model-Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles and Engines (OBD II)

Date of Release: October , 1994
Scheduled for Consideration: December 8, 1994
Agenda Item No.: [__-__-__]

State of California
AIR RESOURCES BOARD

Staff Report: Initial Statement of Reasons for Proposed Rulemaking[1]

PUBLIC HEARING TO CONSIDER TECHNICAL STATUS AND PROPOSED REVISIONS TO MALFUNCTION AND DIAGNOSTIC SYSTEM REQUIREMENTS FOR 1994 AND SUBSEQUENT MODEL-YEAR PASSENGER CARS, LIGHT-DUTY TRUCKS, AND MEDIUM-DUTY VEHICLES AND ENGINES (OBD II)

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I. INTRODUCTION

The Air Resources Board (ARB or Board) originally adopted Section 1968.1 of Title 13, California Code of Regulations on September 14, 1989. This section contains the malfunction and diagnostic system requirements known as On-Board Diagnostics II or OBD II. The regulation requires manufacturers to implement comprehensive monitoring systems on vehicles to detect and aid in the diagnosis of malfunctions within vehicle emission and emission-related components and systems. OBD II systems are being phased-in beginning with 1994 model year vehicles sold in California. With minor exceptions, the regulation requires that by the 1996 model year, all vehicles subject to the regulation shall be equipped with OBD II systems.

When the OBD II requirements were adopted, the Board recognized the technology forcing nature of some aspects of the regulation. The Board, therefore, directed the staff to follow manufacturers' progress towards meeting the OBD II requirements, and to report back to the Board with proposed amendments should they be deemed necessary to ensure that the requirements would be effective and feasible within the required timeframe. In response to this direction, the staff has already presented one update to the Board, in September of 1991.

Since the hearing in 1991, the staff has continued to carefully follow manufacturers' progress in developing OBD II monitoring technologies, and believes that manufacturers have largely been able to design diagnostic strategies that satisfy the requirements. However, some

[1] The discussion that follows is intended to satisfy the requirements of Government Code Section 11343.2 which requires a non-controlling, "plain-english" summary of the regulations be made available to the public.

concern continues to be expressed regarding specific monitoring requirements that will apply to future model year vehicles. Modifications to the OBD II requirements are being proposed to address these concerns. The ARB staff had originally intended to return to the Board within two years of the 1991 hearing to address any further OBD II concerns; however, it is only recently that sufficient information has been available upon which to base proposed modifications (although a hearing was held in 1993 at the request of one manufacturer to address potential compliance concerns in the 1994 and 1995 model years).

Additionally, the staff is proposing modifications based on the experience gained as OBD II systems have been brought to production. These modifications either address minor OBD II implementation concerns or clarify requirements that are sometimes misunderstood.

II. BACKGROUND INFORMATION

Purpose of OBD Systems

OBD systems detect the occurrence of malfunctions within vehicle powertrains that cause increases in emissions. As a result, the time between the occurrence of such problems and necessary repairs is shortened, yielding lifetime in-use emission reductions from motor vehicles. OBD systems also generate diagnostic information to direct service technicians to the specific area of detected malfunctions, or to otherwise inform the technician regarding the performance of the vehicle.

How OBD Systems Work

Today's vehicles utilize on-board computers to carry out many powertrain management functions, such as fuel metering, evaporative purge system control, and automatic transmission operation. The computers obtain the information necessary to carry-out these tasks, such as engine speed and the amount of air entering the engine, from an array of sensors installed on the vehicle. In addition to using sensor information for control purposes, the same information can be evaluated by the computer to determine if components and systems are working properly. Most emission control systems and components can be monitored in this way without the need for any additional hardware on vehicles. For a very few other cases, such as the evaporative control system, an additional sensor is necessary to provide key information to the computer regarding the performance of the system.

When an abnormality is detected, the vehicle operator is notified through the illumination of a malfunction indicator light on the instrument panel. The computer also stores a code in its memory identifying the malfunctioning component and the nature of the problem. Service technicians download these standardized codes with a microprocessor-based diagnostic "scan tool."

OBD II Requirements

OBD II systems will replace systems designed to meet California's original OBD requirements, known as OBD I. OBD I required monitoring of fuel delivery, the exhaust gas recirculation (EGR) valve, and emission-related components that provide input information to the on-board computer. Under OBD II, the monitoring requirements have been expanded to cover virtually every emission control system and electronic component that can affect emissions when malfunctioning. Included are important monitoring strategies that were not considered feasible when the OBD I requirements were formulated (for example, monitoring of catalyst efficiency, engine misfire, and evaporative system leaks).

For the systems and components that significantly impact emissions when malfunctioning, the OBD II regulation requires that manufacturers correlate system performance with emission increases. Generally, the OBD II system must be able to determine when system performance has deteriorated to the point that emissions will be in excess of 1.5 times the vehicle's applicable standards. Systems and components that measurably impact emissions when malfunctioning, but not to the extent that this emission threshold will be exceeded, must be monitored for function by the OBD II system (but not necessarily for degree of performance). Some in industry have stated that it is inappropriate for the MIL to be illuminated for a malfunction that has not, by itself, caused vehicle emissions to exceed the applicable standards; however, monitoring requirements for all powertrain systems that can affect emissions are necessary in order to prevent high emission levels (without an indication of a malfunction) caused by a combination of several otherwise minor emission related problems. At one time during the formulation of the OBD II requirements, the ARB staff considered requiring manufacturers to evaluate the emission impact of the array of possible combinations of emission-related problems that can occur on vehicles, and to illuminate the MIL when combinations resulting in high emissions occurred. However, manufacturers strongly preferred single fault monitoring for measurable increases in emissions, even if the increase is small, in order to reduce the amount of development testing required, and to guard against recalls associated with not foreseeing every possible high-emission malfunction combination. This is the approach that has been adopted.

The OBD II regulation also includes specific requirements for stored fault codes and other diagnostic information. Fault codes are standardized throughout the industry based on Society of Automotive Engineers' specifications, and will be available to service technicians through a standardized communication link incorporated into each vehicle. Standardization of the communication protocol will lead to the availability of diagnostic tools that will work for every OBD II-equipped vehicle make and model (separate tools are no longer necessary to obtain diagnostic information from each make of vehicle). Besides fault codes, the OBD II system will provide information regarding the vehicle operating conditions that existed at the time a malfunction was detected. This will enable service technicians to recreate the conditions in order to better diagnose problems and to verify repairs, particularly those which may be intermittent. Continuously updated engine parameter data will also be available to further help technicians efficiently service emission-related problems.

OBD II and Inspection and Maintenance Programs

The utility of OBD II systems is in concept the same as an Inspection and Maintenance (I/M) program (i.e., the identification and repair of malfunctioning vehicles). However, even with California's I/M program (Smog Check), OBD systems are necessary to more fully realize the potential air quality benefits from reducing in-use vehicle emissions. Further, OBD systems can be used to create a more effective, efficient, and less expensive I/M program.

OBD II systems will detect emission-related malfunctions as they occur, thereby reducing emissions from malfunctions that occur months to potentially years before the next scheduled I/M inspection. Many emission-related malfunctions are unnoticeable to the vehicle operator without an indication from the OBD system. Manufacturers implementing OBD II systems for the 1994 model year have indicated to the ARB staff that OBD II systems have proven very effective in detecting vehicles that were built with defects that otherwise would have gone undetected. Such vehicles would have been operated for at least two years prior to going through an I/M test, but instead were fixed under warranty.

OBD II systems will also be able to detect malfunctions that would not otherwise be found even with a loaded-mode tailpipe emission test. Such tests are conducted with the vehicle warmed-up. Therefore, the performance of critical cold-start emission reduction devices (e.g., electrically heated catalysts, oxygen sensors, secondary air systems, and others) can not be fully evaluated in current I/M programs, but are monitored by the OBD II system. Further, for practical reasons, I/M tests generally use a generic pass/fail emission threshold for flagging high emitting vehicles. With OBD II, the monitoring systems are tailored to the design of the vehicle and the emission standards to which the vehicle is certified. As a result, malfunctions will be detected at much lower tailpipe emission levels with OBD II compared to, for example, the I/M 240 loaded mode emission test. These advantages are especially important for vehicles designed to meet California's Transitional Low Emission Vehicle (TLEV), Low Emission Vehicle (LEV), or Ultra Low Emission Vehicle (ULEV) emission standards, which achieve progressively more stringent emission levels primarily through reductions in cold-start emissions.

OBD II Regulatory History

The OBD II requirements were first adopted by the Board on September 14, 1989. The Board's resolution (number 89-77) directed the staff to report back to the Board in two year's time regarding the progress of manufacturers towards complying with the requirements of the regulation which would be phased-in beginning with the 1994 model year.

On September 12, 1991, the staff presented the update requested by the Board. The Board found that most manufacturers had identified monitoring technologies capable of satisfying the requirements; however, work still had to be done to ensure that the monitoring systems developed would function reliably in customers' hands. In addition to providing an update, the staff proposed a number of regulatory modifications based on knowledge gained since the regulation was first adopted. These modifications were made to address concerns expressed by manufacturers, to promote consistency with federal OBD requirements, and to improve the effectiveness of the requirements in light of monitoring technology advances made by the industry.

Among the most significant changes to the regulation that were adopted was the proposal to separate catalyst monitoring requirements for vehicles meeting California's Low-Emission Vehicle program emission standards, and non-low-emission vehicles meeting less stringent emission standards (i.e., vehicles meeting California's equivalent to the federal Tier I standards). The requirements for California non-low-emission vehicles were designed to be consistent with the federal monitoring requirements for the essentially identical Tier I vehicles. However, the staff felt that separate requirements were necessary for low-emission vehicle applications to better fulfill the goal of identifying malfunctions with respect to marginal exceedances of the emission standards. A more detailed discussion of the LEV catalyst monitoring requirements is included later in this report. Another significant modification was the inclusion of an evaporative system leak detection monitoring strategy. With the change, OBD II systems will be able to ensure the integrity of the full evaporative system whereas previously, only proper function of the evaporative purge components would have been monitored. Additional leadtime for the incorporation of both of these monitoring strategies was included in the adopted amendments.

The 1994 model year marked the first year of the phase-in for OBD II implementation. As manufacturers scheduled to produce OBD II-equipped vehicles for the 1994 model year finalized their system designs, Ford Motor Company (Ford) revealed that two of its monitoring strategies could not be made to meet the minimum requirements of the regulation in time for production. As a result, Ford petitioned the Board to seek relief from these requirements based on its demonstrated good-faith effort to implement fully compliant OBD II systems in the 1994 model year when, by the nature of the phase-in provisions, it could have delayed the introduction of these systems to the 1995 or 1996 model years. The Executive Officer granted Ford's petition and the Board adopted modifications to the regulation to permit limited relief from specific monitoring requirements on a case-by-case basis. Subsequent to the hearing, a number of other manufacturers have used the provisions to obtain an exemption, usually for minor monitoring system deficiencies.

Overall to date, the ARB staff has approved the OBD II system designs for more than 35 engine families developed by 14 manufacturers. Four of the engine families are certified to the TLEV emission standards.

III. TECHNICAL STATUS AND PROPOSED MONITORING SYSTEM AMENDMENTS

CATALYST MONITORING

As indicated earlier, at the 1991 OBD II Board Hearing, the Board adopted amendments that put into place separate monitoring requirements for low-emission vehicle applications, and non-low-emission vehicles. For non-low-emission vehicles, the requirement is based on the performance of the catalyst system overall. A malfunction is to be indicated when the catalyst system has deteriorated to the point that vehicle emissions increase by more than 1.5 times the vehicle's applicable standard over the emission level when near new (i.e., at 4000 miles). This requirement has been accepted by the industry and, accordingly, the staff proposes no amendments. However, some manufacturers have expressed concern with respect to the OBD II requirements for monitoring catalysts on low-emission vehicles.

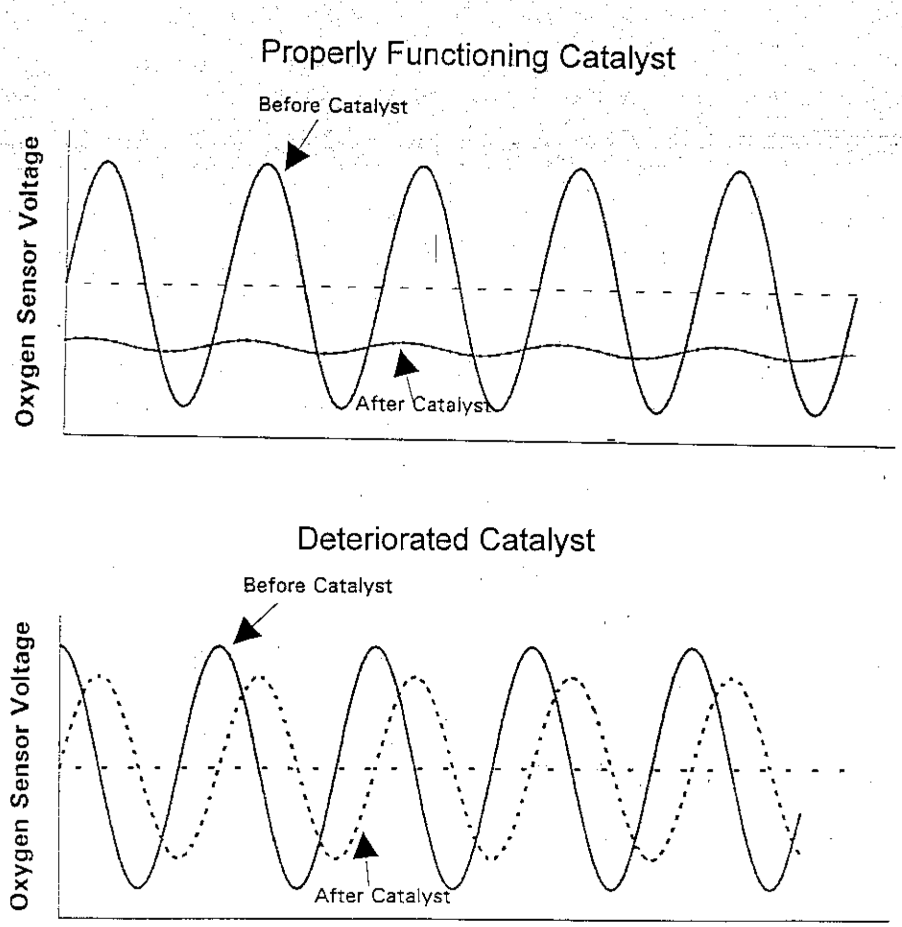
Background

To meet California's stringent Low-Emission Vehicle standards, manufacturers will use a variety of sophisticated emission control strategies and advanced catalyst systems. While considerable attention is being focused on reducing engine-out emissions to the lowest possible levels, manufacturers will rely on electronic fuel controls operating in conjunction with newly-developed catalysts to further reduce hydrocarbon (HC), carbon monoxide (CO), and nitrogen oxide (NOx) emissions to regulated levels. Emission control systems on virtually all new California vehicles include three-way catalysts. These catalysts consist of ceramic or metal honeycomb structures (commonly referred to as "substrates"), coated with precious metals such as platinum, rhodium, or palladium.[1] These precious metals are dispersed within an alumina washcoat containing ceria, and the substrates are mounted in a stainless steel container in the vehicle exhaust system. Three-way catalysts are so-designated because they are capable of simultaneously oxidizing HC and CO emissions into water and carbon dioxide (CO_2), and of reducing NOx emissions (by reacting with CO and hydrogen) into elemental nitrogen, CO_2, and water.

This three-way conversion activity only takes place efficiently, however, when the fuel system operates at a single air-fuel ratio, called stoichiometric (where there is just the required amount of air to completely burn all of the fuel in the engine). To achieve and maintain stoichiometric fuel delivery, manufacturers have incorporated closed-loop fuel control systems that utilize an exhaust gas oxygen sensor downstream of the engine to provide feedback on the status of the air/fuel ratio being achieved. All closed-loop fuel control systems actively cycle the air-fuel ratio slightly above and below the stoichiometric point to maximize three-way catalyst conversion efficiency. The precious metals are used to temporarily retain the HC, CO, and NOx molecules in the catalyst while the ceria in the washcoat is used to store and release oxygen which is needed to complete the reactions. Oxygen is stored in the catalyst during the lean portion of the fuel system's cycling (i.e., when the air/fuel ratio is slightly higher than stoichiometric) and is released during the rich excursion. Without ceria, there would be insufficient oxygen at the active sites of the catalyst to achieve the most efficient performance.

As emission conversion efficiency of catalysts containing ceria deteriorates, generally the oxygen storage capacity is also diminished. Accordingly, oxygen storage can be used as an indicator of catalyst performance, discriminating between catalysts with sufficient and insufficient oxygen storage capability. By utilizing the information from the upstream oxygen sensor and a second sensor located downstream of the catalyst (or catalysts), the oxygen storage can be measured by comparing the oxygen sensor signals. In addition to being used for catalyst monitoring, the rear sensor can be used to monitor and correct for front oxygen sensor aging as needed to maintain the stoichiometric air-fuel mixture at high mileage. With a properly functioning catalyst, the rear oxygen sensor signal will be fairly steady since the fluctuating oxygen concentration (due to the fuel system cycling about stoichiometric) at the inlet of the catalyst is damped by the storage and release of oxygen in the catalyst (see Figure 1). When a catalyst is deteriorated, such damping is reduced, causing the frequency and peak-to-peak voltage of the rear oxygen sensor signal to approximate the signal from the oxygen sensor before the catalyst because the catalyst is no longer capable of storing and releasing oxygen.

FIGURE 1

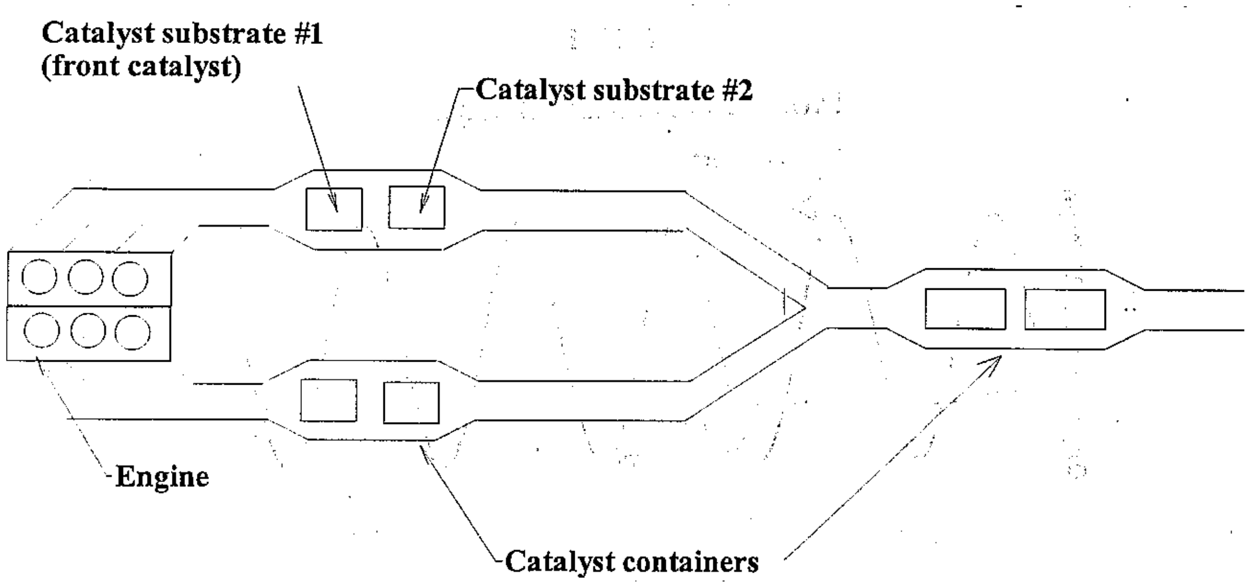


Current Requirement

Currently, the OBD II regulation requires manufacturers to monitor the front catalyst on low-emission vehicles for deterioration in HC conversion efficiency. A malfunction is to be indicated when the efficiency of the front catalyst falls to between 50 and 60 percent based on the Federal Test Procedure (FTP) driving cycle. The regulation defines a front catalyst as the first "substrate" which receives untreated engine-out exhaust gas. A common catalyst system configuration places two or more substrates into a single container, but each substrate is considered a separate catalyst for purposes of the regulation (as illustrated in Figure 2). Manufacturers generally plan to use a series of catalysts in the exhaust system to meet the Low-Emission Vehicle standards (all certified TLEV's to date use multiple catalyst substrates).

FIGURE 2

Typical Catalyst Configuration



The catalyst monitoring requirements currently adopted for low-emission vehicles were designed to provide for the detection of catalyst system deterioration on vehicles with multiple catalysts by the time vehicle emissions marginally exceed the applicable HC standard. For a typical engine-out (i.e., untreated) exhaust gas level of 2.0 grams per mile (g/mi), an overall catalyst system efficiency of about 92% is needed to meet the TLEV HC standard at 100,000 miles while an efficiency of 88% would cause an increase in emissions to 1.5 times the standard (generally, the point at which the OBD-II malfunction light is required to illuminate). Such a drop in efficiency would be difficult to detect using the correlation between oxygen storage and hydrocarbon efficiency with respect to the whole catalyst system. However, through monitoring of the front catalyst only, the timely detection of deterioration can be achieved.

This approach permits reliable detection of small but crucial decreases in overall catalyst system efficiency for low-emission vehicles by monitoring the front catalyst for a relatively large loss in conversion efficiency. In multiple catalyst exhaust configurations, downstream catalysts tend to increase in efficiency as more hydrocarbons pass through the deteriorated front catalyst and, therefore, minimize the increase in tailpipe emissions resulting from the deterioration. The strategy presumes that unmonitored downstream catalysts are normally aged, which is reasonable considering that front catalysts are most susceptible to deterioration.[2] Therefore, a monitoring strategy that looks for a significant loss of the front catalyst conversion efficiency would be able to reliably detect a smaller loss in overall catalyst system performance as early as possible (it should be noted that even if downstream catalysts were deteriorated as well, front catalyst substrates alone are usually more than 90% efficient, so that replacement of just the front catalyst would restore most of the overall system conversion capability. In addition, front catalysts are often housed with a second downstream substrate, so that the replacement of a deteriorated front catalyst could include the second catalyst as part of a replacement assembly). The staff estimated that a 50-60 percent conversion efficiency of the front catalyst would generally result in tailpipe emissions of less than 2 times the HC emission standard; however, the actual emission level does depend on the configuration of the catalyst system as well as catalyst volume and composition.

Some manufacturers, however, have expressed concern over what they feel is a weak correlation between oxygen storage and catalyst HC conversion efficiency for front catalysts located close to the engine. They contend that sintering of the precious metals in the catalyst due to excessive temperatures can lead to decreased oxygen storage apparently without a significant decrease in HC conversion efficiency, thus increasing the chance for illumination of the malfunction indicator light when the HC conversion efficiency is still high. However, recent improvements in catalyst washcoat technology including recently developed high temperature resistant palladium-only catalysts appear to have improved the correlation between HC conversion efficiency and oxygen storage, particularly in the 75% to 95% efficiency range.[3]

Another concern that has been expressed regarding the catalyst monitoring

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[2] Front catalysts reach higher operating temperatures than downstream catalysts due to being closest to the engine's exhaust manifold and because of the heat generated in the oxidation of a high percentage of the engine out pollutants.

[3] Palladium-only catalysts with high temperature resistant washcoats have been presented in Society of Automotive Engineers (SAE) papers by Allied Signal Inc. (SAE 930386) and Ford/Englehard/Johnson Matthey (SAE 941058).

requirements for low-emission vehicles is that front catalysts may be too small to have enough oxygen storage for reliable monitoring, even when the catalyst is new. Some manufacturers have stated that catalysts need to be at least 0.4 to 0.7 liters in volume in order for catalyst monitoring to be reliable.

However, despite these concerns, manufacturers have certified vehicles meeting the catalyst monitoring requirements for low-emission vehicles. The monitored catalysts use platinum/rhodium formulations with conventional washcoat technology. One such application uses front catalysts that are only 0.25 liters in volume. Nonetheless, the staff is proposing catalyst monitoring requirement amendments that should address the above stated concerns while providing for uniform and timely detection of catalyst system malfunctions.

Proposed Monitoring Requirement Amendments

The staff proposes to remove the requirement for the independent evaluation of front catalyst efficiency, and to instead require a catalyst system monitoring requirement in which the malfunction criteria will be based on tailpipe emission levels (similar in concept to the monitoring requirements for non-low-emission vehicles). The staff believes that catalyst monitoring techniques have matured to the point that a system-based approach can be adopted for low-emission vehicles without having to specify a tailpipe malfunction criteria that in some instances would be many times the vehicle's emission standards. A system-based requirement satisfies manufacturers' requests for more flexibility in catalyst system monitoring, and would better ensure that malfunctions will be appropriately detected in all catalyst configurations (i.e., the effectiveness of the requirements would no longer depend significantly on the design of the catalyst system). Specifically, the staff's proposal would require the manufacturer to monitor the catalyst system such that a malfunction is determined before tailpipe HC emissions exceed 1.5 times the applicable standard.

To satisfy the proposed requirement, manufacturers would determine an appropriate portion of overall catalyst system volume to be monitored and, from the measured efficiency of that portion, infer the overall catalyst system efficiency to determine if the emission threshold has been exceeded.[4] Therefore, manufacturers could maintain a front catalyst monitoring strategy if desired, but would have the flexibility to monitor a downstream catalyst

[4] The staff's proposal also requires the OBD II system to indicate a malfunction when the NMHC conversion efficiency of the monitored portion of the catalyst system falls below 50 percent. The staff believes that in the vast majority of cases, compliance with the emission threshold malfunction criteria will require illumination of the malfunction indicator light at a significantly higher efficiency; however, the inclusion of this requirement is considered important as a backstop to ensure that a reasonable portion of the catalyst system will be monitored.

in combination with the front catalyst, or to monitor the entire volume of the catalyst system.[5]

The proposed changes to the regulation would also eliminate the potential undesirable situation where a manufacturer can meet the TLEV emission standard with a single catalyst substrate, and by the provisions in the current OBD II regulation would not be required to indicate a malfunction until the HC conversion efficiency of the single catalyst dropped to a 50-60% level. With a typical engine-out raw HC emission level of 2.0 g/mi, a vehicle certified to the TLEV standards (0.125 g/mi HC) with a single catalyst substrate would not indicate a malfunction until emissions increased to 0.8 g/mi, about 6.5 times the emission standard. The staff did not envision several years ago that TLEV standards could be met reliably with a single substrate catalyst but manufacturers have revealed several models for which such a catalyst system is planned. With the amendments proposed, the OBD II system on all vehicles, regardless of catalyst system design, would be required to illuminate the malfunction indicator light at a consistent tailpipe emission level.

Feasibility of the Proposed Amendments

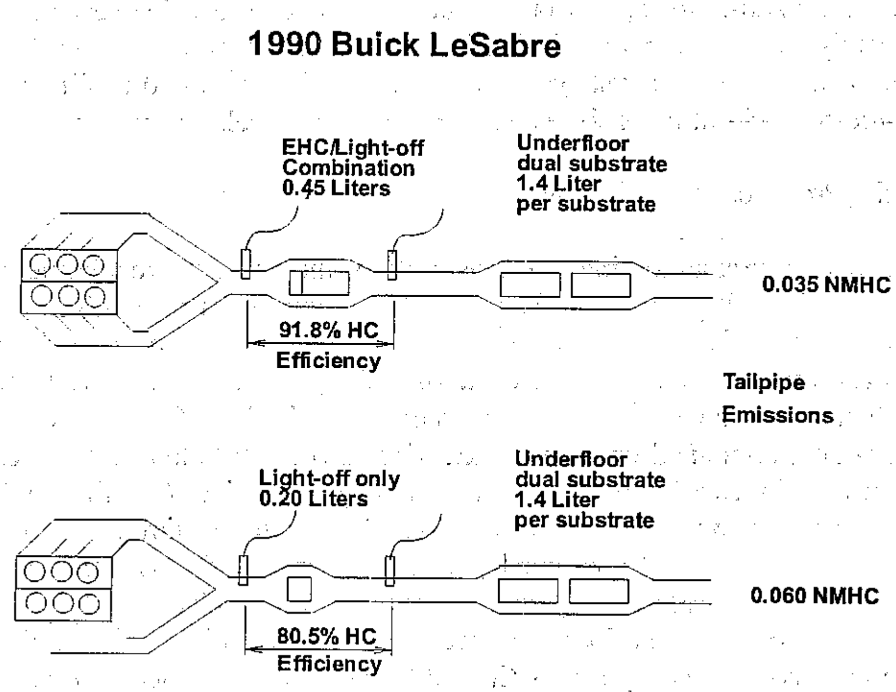
As part of its investigation into the feasibility of the proposed requirement, the staff has conducted limited testing on a 1990 Buick LeSabre equipped with a 3.8 liter, V-6 engine that has been modified to be a prototype ULEV. This vehicle achieves a baseline Non-Methane Hydrocarbon (NMHC) emission value of 0.035 g/mi (the ULEV standard is 0.040 g/mi Non-Methane Organic Gas).[6] The Buick is configured with a 0.45 liter electrically heated catalyst (EHC) combined with a non-heated light-off substrate as a front catalyst, followed downstream by two 1.4 liter catalysts in a single container (see Figure 3). Preliminary test results show that the EHC/light-off combination achieves an average FTP total HC conversion efficiency of approximately 92 percent. Testing was then conducted with the 0.45 liter EHC/light-off catalyst combination removed and replaced with a 0.2 liter conventional catalyst to simulate a loss of conversion efficiency across the monitored front catalyst. HC conversion efficiency across the 0.2 liter catalyst was measured at approximately 80 percent, resulting in a tailpipe emission level of 0.060 g/mi NMHC. Thus, even with a relatively large (approximately 12 percent) drop in front catalyst efficiency over the front catalyst, tailpipe emissions did not exceed 1.5 times the HC standard. This indicates that if

[5] Using the oxygen storage method for catalyst monitoring, it still appears that compliance with these proposed requirements would be very difficult if the entire catalyst system is evaluated; however, some manufacturers are examining on-board HC concentration sensor concepts in place of using oxygen sensor information. If this technology develops sufficiently, the sensor could be most effective when placed downstream of the entire catalyst system.

[6] To simplify testing, emissions were measured in terms of NMHC even though the Low-Emission Vehicle standards are based on Non-Methane Organic Gas (NMOG). However, for gasoline vehicles, NMHC and NMOG emissions are nearly identical.

the volume of the front catalyst is sized properly, a sufficiently large decrease in its conversion efficiency can be used as the basis for identifying a fault before tailpipe emissions would exceed the 1.5 times the standard emission threshold.[7] It should be noted that production ULEV's are likely to be certified with emission levels below 0.03 g/mi NMHC in order to provide an adequate in-use margin with respect to the emission standard. With optimized production catalyst systems, a greater loss in HC efficiency would probably be tolerable before emissions would exceed 1.5 times the standard.

FIGURE 3

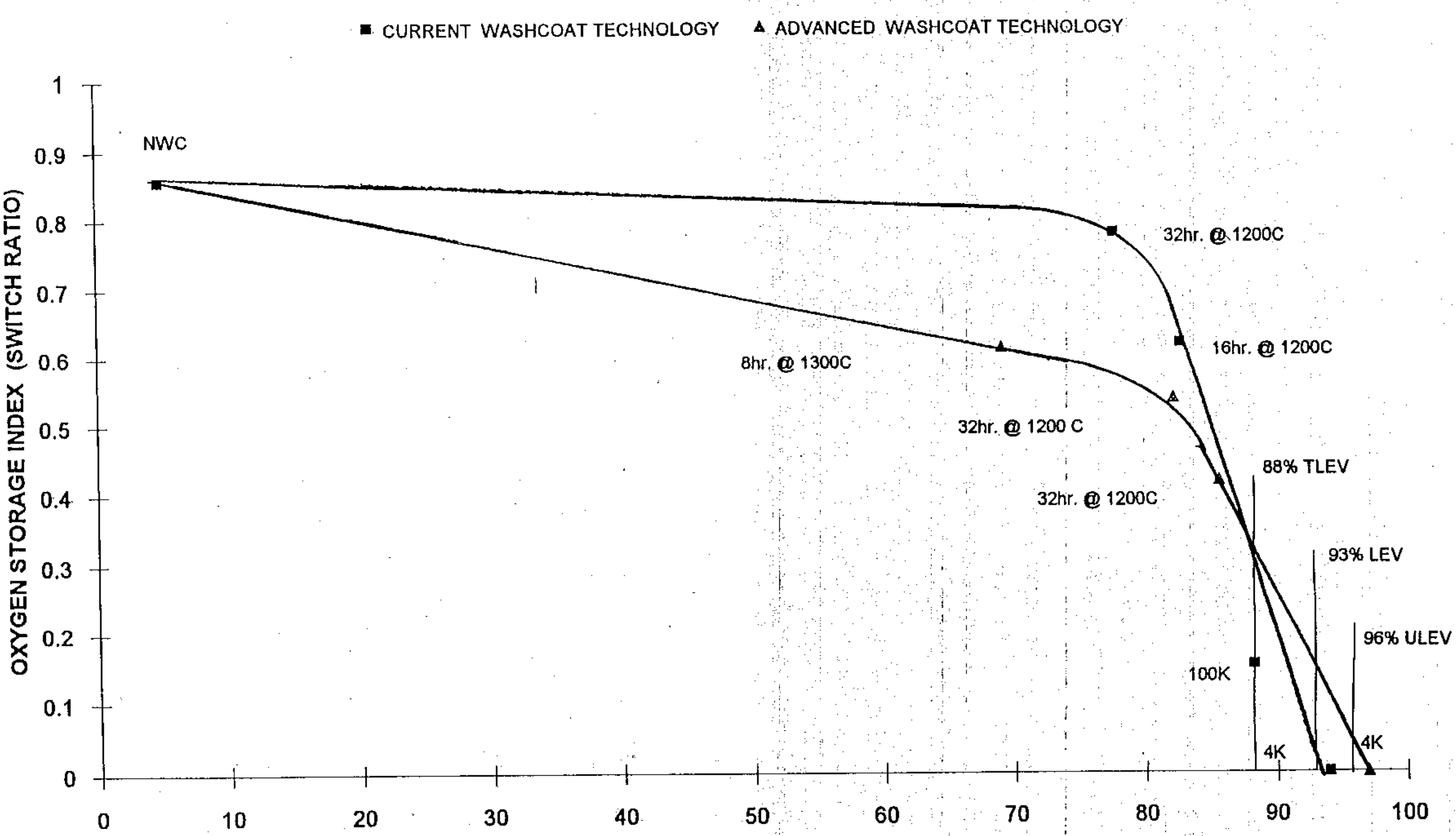


The staff's testing illustrates that by appropriating the right amount of catalyst volume in the front, monitored catalyst, manufacturers can identify a fault when its conversion efficiency drops significantly (e.g., in the 90% to 75% region, where catalyst monitoring is sufficiently reliable) yet tailpipe emissions are still relatively low. As the graph provided by Ford shows (figure 4), new washcoats exhibit an improved relationship between oxygen storage and HC conversion efficiency, resulting in significantly more reliable catalyst monitoring. In the range from 75% to 95% HC conversion efficiency, the correlation between oxygen storage and conversion efficiency is fairly linear, resulting in a reliable separation between a good catalyst and a bad one. By using this relationship, manufacturers

[7] The overall catalyst system conversion efficiency dropped by only 1.2 percent (from 97.9 percent to 96.7 percent) even through the front catalyst active surface area was reduced by over 50 percent.

F re 4

FTP CATALYST MONITOR CAPABILITY FOR 76 Cu.In. Pt/Rd CATALYST



* THRESHOLDS ASSUME 2 GRAMS HC FEEDGAS

* NWC = NO WASH COAT, NO PRECIOUS METAL, BARE SUBSTRATE

* THERMALLY AGED, HRS. @ TEMP.

7/25/94

can size the front catalyst such that a monitorable decrease in efficiency results in the desired tailpipe emission threshold.

Impact of Amendments on Catalyst System Design

In optimizing catalyst systems to meet the previous OBD-II regulatory requirements and the Low Emission Vehicle standards, manufacturers generally are adopting configurations that utilize single or multiple catalysts in a close-coupled location. In some cases, the total volume of these catalysts could be either too small or too large to reliably monitor for an increase of 1.5 times the HC emission standard at the tailpipe. If the front catalyst is too small, a malfunction could be indicated before tailpipe emissions reach the proposed threshold. If the volume of the front monitored catalyst is too large, a malfunction might not be indicated until tailpipe emissions have exceeded the proposed threshold.

For instance, in several cases manufacturers are planning to place a single substrate catalyst in the front catalyst position. By placing an oxygen sensor downstream of the catalyst and monitoring it alone, as discussed previously, manufacturers can infer an overall system efficiency without directly measuring the efficiency of the downstream catalyst(s). In most cases, no modifications to this configuration should be necessary to meet the proposed change to the regulation. However, if the front catalyst is too small or too large (i.e., a malfunction would be indicated too early or too late, respectively), manufacturers can alter catalyst size by shifting volume from the front to rear catalysts or vice-versa. Other options that manufacturers can use to achieve a configuration that is capable of being monitored to the proposed emission threshold without affecting catalyst configuration include alterations of the washcoat formulation, substrate cell density, amount of precious metals in the catalyst, or other variables.

In systems where the front catalyst container contains multiple substrates which in total represent a volume which is too large to monitor in accord with the proposed regulatory requirement, one possible option to manufacturers (in addition to those previously mentioned) is to place an oxygen sensor in the container between the catalyst substrates to reduce the amount of monitored catalyst volume. The relative sizes of the individual catalysts in the front container could be modified without affecting the overall container size. This option would allow catalyst systems to be adapted to meet the proposed regulatory requirement without requiring major redesign of the underbody of the vehicle in many cases. One manufacturer is currently pursuing this option and reports that it looks very promising while another manufacturer has already begun implementation of plans for a future model year that will include an oxygen sensor mounted between an EHC/light-off catalyst combination and a downstream catalyst that are in the same container.

An example of a catalyst container with two substrates and a rear oxygen sensor mounted in the middle of the catalyst container is shown below in Figure 5A. If the volume of the front catalyst is too large to reliably monitor to the proposed threshold, catalyst volume can be redistributed (Figure 5B). Conversely, front catalyst volume can be increased in a similar manner, if it is too small for reliable monitoring.

FIGURE 5A

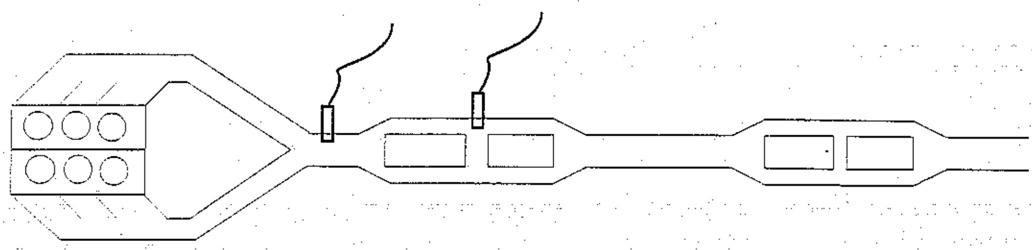
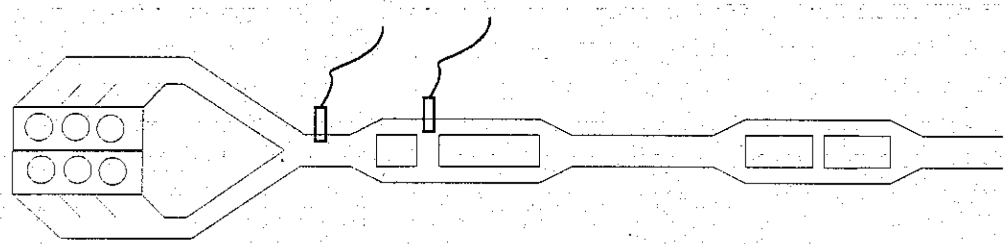


FIGURE 5B



In view of the above considerations, and to minimize potentially costly vehicle alterations in implementing the proposed requirement, staff is proposing to phase-in compliance of the new catalyst monitoring requirement. The proposed phase-in schedule would require compliance for 40 percent of a manufacturer's projected low-emission vehicle sales in model year 1998, 70 percent compliance in model year 1999, and full compliance in model year 2000. This should allow manufacturers to schedule any catalyst system changes in conjunction with their internal design changes and minimize the amount of redesign needed.

In the interim, all vehicles certified to the TLEV standard would be required to indicate a malfunction when emissions exceeded 2.0 times the TLEV HC standard plus the 4000 mile emission level. All vehicles certified to the LEV standard would be required to indicate a malfunction at a slightly lower threshold, specifically, 2.5 times the LEV HC standard plus the 4000 mile emission level. These higher interim malfunction criteria should enable manufacturers to implement a monitoring strategy which allows them to monitor most or all of the total catalyst volume reliably until systems configured to meet the proposed requirement can be designed.

With the improvements in washcoat and catalyst technology and the number of options that manufacturers have to meet the new regulation (i.e., adjusting catalyst volumes, cell density, washcoat formulations, precious metal concentrations, locating an oxygen sensor in the catalyst container, etc.), the changes to the regulation should provide a means for all manufacturers to comply within the allotted timeframe. However, as with previous sections of this regulation, staff will continue to monitor industry's progress towards compliance with these requirements and plans to revisit the issue in 1996 to determine if any mid-course corrections are needed.

EVAPORATIVE SYSTEM LEAK DETECTION

Background

As exhaust emissions are controlled to the maximum extent feasible for California vehicles, evaporative HC emissions become a greater relative contributor to the ozone problem than exhaust emissions. Compared to a ULEV, for example, which must emit no more than 0.040 g/mi of exhaust HC, evaporative emissions from vehicles meeting the high temperature evaporative emission standards could be as much as 0.077 g/mi (assuming 2 grams per test HC emissions and using a 26 mile-per-day average trip length). In addition, 0.05 g/mi running loss emissions (evaporative emissions generated during vehicle operation) are permitted. Clearly, since they could exceed exhaust emissions, the strict control of evaporative emissions in-use is very important to attainment of the National Ambient Air Quality or state health-based standards in many areas of California.

Fortunately, the control of evaporative emissions is not as difficult, perhaps, as exhaust emissions, since the control hardware is comparatively simple. Further, vehicle manufacturers have been upgrading materials and minimizing leak sources to ensure that these systems perform reliably for many years. Unlike exhaust emission controls, however, where small amounts of system or component deterioration can be corrected through adaptive learning strategies in order to maintain the needed low-emission levels, even a very small leak in an evaporative system can lead to a gross-emitting vehicle. Data from General Motors, for example, shows that during a high temperature evaporative emission test, an evaporative system leak equivalent to a 0.020 inch diameter orifice or larger can yield about 35 grams per test (figure 6). Data from other manufacturers is similar.[8] This is equivalent on average to about 1.35 g/mi HC, or over 30 times the allowable exhaust HC emissions for a ULEV. Realizing the importance of leak-free evaporative control systems, the OBD-II regulation currently requires monitoring for leaks equivalent in magnitude to an orifice as small as 0.040 inches in diameter. When the Board adopted this requirement in 1991, a 0.040 inch leak appeared to be the smallest leak which could be reliably detected on a routine basis. Even achieving this level of leak detection has not been easy, but industry has developed both pressure and vacuum systems which now appear capable of reliably meeting the current requirement. These systems will begin phase-in with the 1996 model year.

Despite this progress, the staff believes it is still necessary to strive to detect leaks as small as 0.020 inches in diameter to ensure that evaporative emissions are controlled to the

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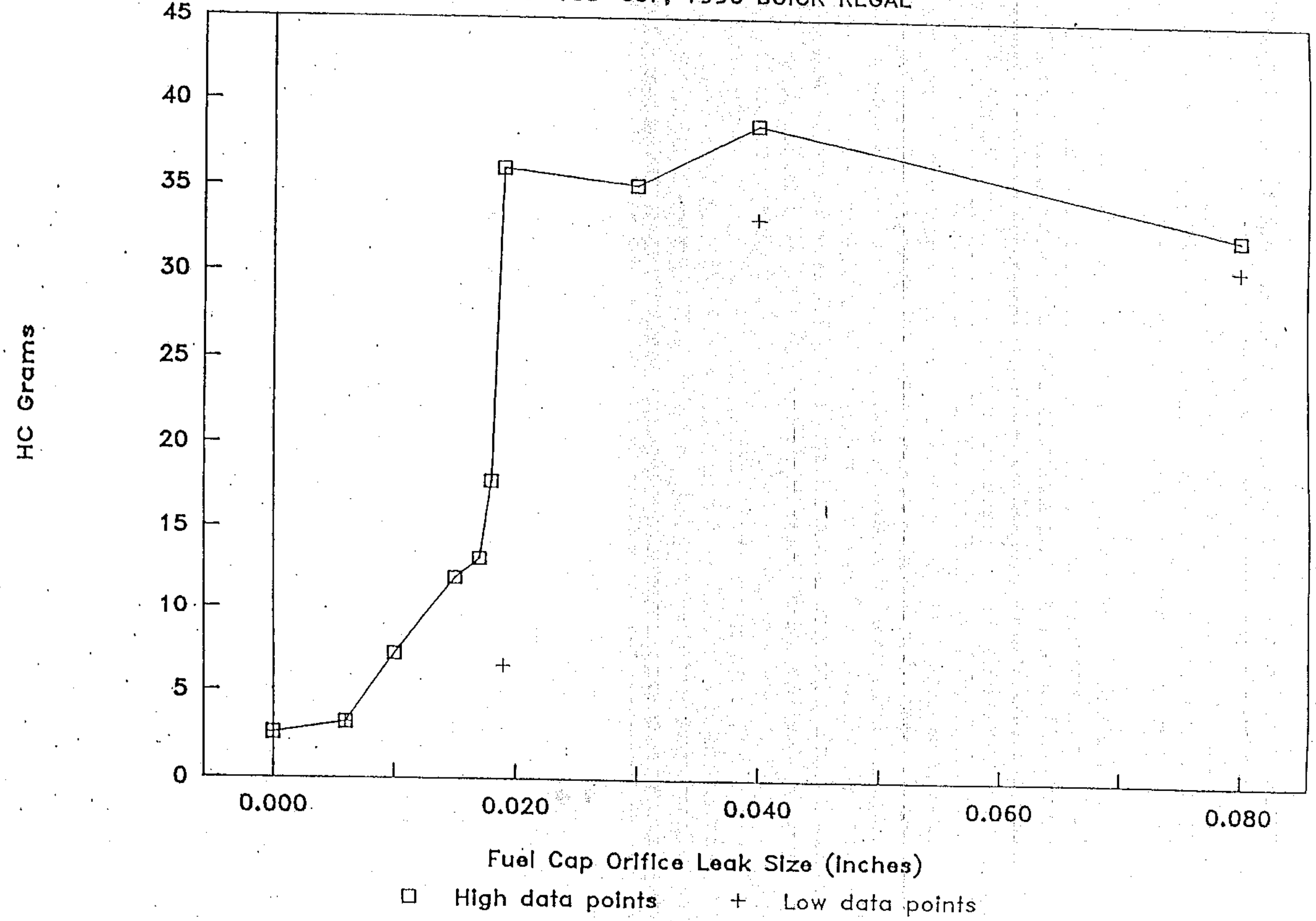
[8] Recent additional data are discussed later in this section.

Figure 6

24 HR DIURNAL EMISSIONS VS LEAK SIZE

65–105–65F, 1990 BUICK REGAL



needed level. The obvious benefit of such a requirement would be the early detection of leaks that are of a magnitude equal or greater than a 0.020 inch orifice but less than a 0.040 inch leak. The industry has questioned the existence of such leaks on in-use vehicles; however, tests conducted by the ARB indicate that leaks smaller than a 0.040 inch orifice are likely present in a significant number of vehicles on the road.

The staff has been monitoring the results of leak detection testing being performed on in-use surveillance cars at the ARB laboratory over the last several years. At this time, almost 2,000 vehicles have been checked for evaporative system leaks. In an effort to determine whether there are significant numbers of vehicles in the California fleet with leaks in the evaporative system ranging in size equivalent to a 0.020 to 0.040 inch orifice, the staff analyzed pressure decay data from a number of in-use surveillance projects. Vehicles in the surveillance program ranged from the 1970 model year (when evaporative canister systems were first required on California vehicles) to the 1989 model year. The ARB surveillance program vehicles were leak checked generally before noon (during the cooler hours of the day) and within 10 to 30 minutes of arrival at the ARB laboratory, thereby limiting the range of fuel tank temperatures for the test sample. Vehicle evaporative systems were pressurized to 14 inches of water and monitored for the loss of pressure over a two-minute period to determine if a leak was present. The staff has analyzed the data to correlate the pressure drop, if any, to evaporative system leak size. The pressure drop to leak size relationship was determined based on ARB test data from four vehicles (VW Jetta, Buick LeSabre, Toyota Celica, and a Ford F150 truck) whose tank sizes nominally range from 14 to 18 gallons. Each of these vehicles was tested over a range of leak sizes (0 to 0.052 inches), fuel temperatures, and fuel Reid Vapor Pressure (RVP) values to simulate the range of conditions under which the in-use surveillance vehicles may have been tested. The pressure drops corresponding to 0.020 and 0.040 inch leaks are listed in Table 1 for the range of fuel RVP and temperature conditions.

In determining the criteria for categorizing leaks on the in-use surveillance vehicles, the staff chose near worst case values based on the test vehicle data. Specifically, in determining the upper limit for a 0.020 inch leak, the staff chose the lowest two minute pressure yielded when such a leak was installed (11 inches of water), although in several cases, the pressure was 12 or more inches of water.[9] In a similar manner, the staff chose the criteria for a leak greater than 0.020 inches, but less than 0.040 inches, to be 8 inches of water. Because the criteria were based on the limits of the test data generated using multiple vehicles under greatly varying fuel tank conditions, the staff believes they provide for a *very conservative* estimate of the number of small leaks occurring in in-use vehicles. Using these criteria, the staff counted 151 vehicles with leaks between 0.020 and 0.040 inches among a total of 1,936 vehicles (7.8 percent).

[9] The criteria were rounded to the nearest inch, which is the format in which the in-use surveillance data was recorded.

Table 1

Vehicle	Initial Fuel Temp (F)	RVP (psi)	2 min Press. for No Leak (in H2O)	2 min Press. for 0.020 in leak (in H2O)	2 min Press. for 0.040 in leak (in H2O)
'91 VW Jetta	77 118 81 102	9.0 9.0 7.8 7.8	13.8 12.6 13.1 13.0	10.5 12.8 10.6 11.2	3.1 5.9 2.8 4.7
'90 Buick Le Sabre	76 78 95	9.0 7.8 7.8	14.0 13.7 13.3	12.0 12.0 12.3	5.0 5.3 5.5
'90 Toyota Celica	73 76 126	9.0 7.8 7.8	14.0 13.7 14.9	11.2 10.9 11.7	2.5 2.1 3.5
'94 Ford F150	80 115 76 120	9.0 9.0 7.8 7.8	14.0 14.0 14.0 12.1	11.1 12.1 11.5 11.5	4.3 7.6 4.2 5.6

Some industry representatives who have already reviewed a portion of the data presented have expressed concern that significant fuel cooling may have occurred on the in-use surveillance vehicles during the two minute pressure test, potentially causing a system with no leak to appear as a leaking system (falling fuel temperature would reduce the vapor generation and system pressure). In response to this concern, the staff recorded the drop in fuel temperature on the four test vehicles over the two minute period. Two test cases in particular illustrate industry's point: the Jetta was tested at 118 degrees Fahrenheit and the Ford at 120 degrees. In both cases, the fuel temperature dropped by approximately 2.5 degrees over the two minute no-leak test, and nearly a 2 inch drop in pressure was seen in the case of the Ford (1.4 inches for the Jetta).[10] However, despite such cooling, neither pressure value fell below the staff's upper criterion of 11 inches of water (a 3 inch drop in pressure) that was used in determining if a leak was present. Therefore, the staff does not believe that

[10] These high fuel temperatures were generated using a heat blanket which was removed prior to conducting the pressure tests. Ambient temperatures were in the mid-70s for both tests, making the difference between fuel and ambient temperatures between approximately 40 to 45 degrees Fahrenheit. In-use, the difference between the two temperatures is usually much less, in which case less fuel cooling would be expected.

a significant number of vehicles were miscounted for this reason. Further, to the extent that cooling could have affected the pressure drop numbers causing vehicles without leaks to appear as if a leak existed, it is likely that on some vehicles with a leak between the sizes of a 0.020 to 0.040 inch orifice, the leak would have appeared to be larger for the same reason and, therefore, would not have been counted (thereby cancelling any error in determining the incidence of leaks in this category).

In the most recent portion of the surveillance testing program covering 437 1980 and newer vehicles, with the majority of vehicles newer than 1985 (or less than 10 years old), the survey results were a little better than the overall results, as would be expected. Vehicles with leaks equivalent to between 0.020 to 0.040 inches still comprised 3.7 percent of the sample (16 vehicles). For leaks greater than a 0.040 inch orifice, 23 vehicles (5.3 percent) were identified. As these vehicles age further, these percentages will undoubtedly increase. Given the relatively older, high mileage proportion of vehicles in California, evaporative system leaks are likely to occur on a significant portion of vehicles.

There are several factors which can affect evaporative system integrity such as improper or incomplete vehicle repairs after collisions involving evaporative system components, removal of engines or other powertrain components for rebuilding (which can require at least partial disassembly of evaporative system components), use of deteriorated wrecking yard components on older vehicles, and manufacturing problems. Regarding the latter, recent news articles have been published describing the recall of late model Chrysler and General Motors trucks for fuel tank leak problems that occurred as a result of improper vehicle construction.[11] In one instance, cracked fuel tank gaskets were found that reportedly were the result of overtightened fuel pump assemblies, and in the other, it was found that leakage could result from improper fuel filler neck construction. In addition, vehicle manufacturers are planning on installing an evaporative system service port to allow access for checking the evaporative system for leaks without otherwise disturbing the system.[12] The port consists of a valve similar to those used in automotive tires which can also leak after many years of service. Although a tethered cap would be included with the valve, it may not always be reinstalled after service, which would permit dirt to accumulate and may eventually cause the valve to stick or otherwise not seat completely. In addition, the service port would have 2 or 3 vapor lines connected to it, which each pose an additional integrity concern. Therefore, while such a port would be useful, it is also another potential source of small leaks which would contribute to the need to monitor for them.

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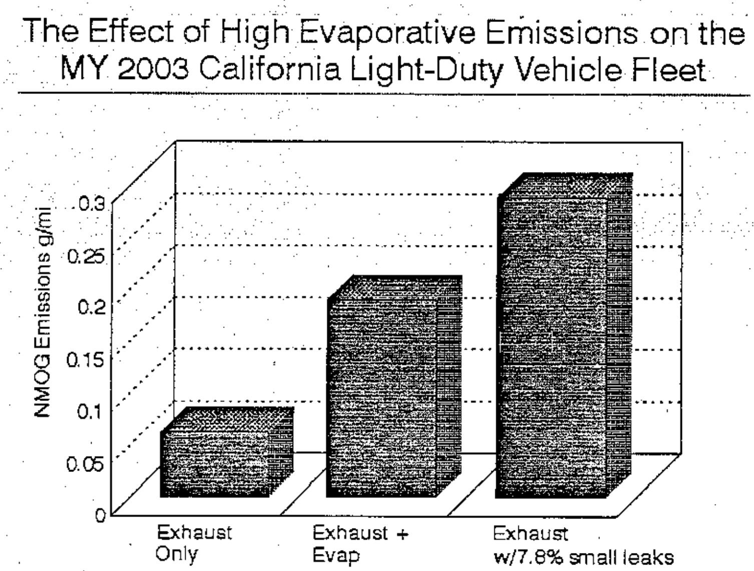
[11] Wall Street Journal, August 25, 1994, and Automotive News, January 31, 1994

[12] The service port would facilitate access in checking the evaporative system for leaks in an Inspection/Maintenance program, or for pressurizing the system for the purpose of diagnosing the location of a leak. Presently, some evaporative systems are very difficult to access and breaking into an evaporative system might induce faults by disturbing aged components or through failure to reconnect some of the lines.

It is likely that small leaks grow into larger leaks in situations where vapor lines age and start cracking, or when components are mishandled or eventually fatigue due to cycling, weathering, or other aging effects. While complete breakage of fittings or disconnection of vapor lines could result in leaks greater in size than a 0.040 inch orifice, gradual deterioration in evaporative system components seems plausible. Leaks in the service port could start small as well.

Given the estimated percentage of vehicles with small leaks, there is little choice but to pursue detection of leaks at least as small as a 0.020 inch orifice. To illustrate the magnitude of the problem in terms of fleet average HC emissions, if the 2003 fleet average requirement of 0.062 g/mi HC is adjusted for allowable evaporative emissions, fleet average HC emissions could (as indicated earlier) be as high as 0.189 g/mi. If, as the staff's data suggest, 7.8 percent of the vehicles contained an evaporative leak between 0.020 to 0.040 inches, the fleet average would rise to 0.288 g/mi, *over a 50 percent increase* (see Figure 7).

FIGURE 7



The staff has very recently received data suggesting that evaporative emission increases due to small system leaks could be significantly less than the 35 grams per test previously reported by manufacturers. Apparently, with a new evaporative system design, the majority of fuel vapor generated can be captured under most conditions in the charcoal canister even if a leak is present in, for example, the fuel tank or the fuel filler neck. The data suggest that the resulting evaporative emission increases could be as low as 3 grams per test. While this is an encouraging improvement, it is not at all clear that all future vehicles will perform similarly. From the data presented to the staff, it appears that the emission impact of a leak depends greatly on subtle evaporative system design variations. Further, even at 3 grams per test, based on 26 miles per day (on average) of vehicle operation, emissions from a vehicle would increase by the equivalent of approximately 0.115 grams per mile, which is almost three times the ULEV emission standards. Therefore, relative to future emission standards, the emission benefit of having such leaks detected and repaired is still significant.

Proposed Amendment

The staff proposes to phase-in the requirement to detect leaks as small as a 0.020 inch orifice. The phase-in would begin with the 1998 model year. Fifty percent of manufacturers' projected sales would need to comply with the requirement. This would increase to 75 percent for the 1999 model year, with 100 percent implementation required with the 2000 model year.

The amendments would permit a manufacturer to more narrowly specify the monitoring conditions when checking for a 0.020 inch leak provided that the monitoring system will function with reasonable frequency in-use (e.g., a few times a week), and provided the diagnostic system will check for 0.040 inch leaks routinely. This would permit manufacturers, should it be necessary, to better address in-use variability concerns associated with detecting smaller leaks that could, for example, lead to the false detection of evaporative system malfunctions.

Feasibility of the Requirement

In order to satisfy the current requirement to detect leaks equivalent to or greater than a 0.040 inch orifice, manufacturers are implementing strategies to either create a vacuum or pressure condition within the evaporative system. Once the condition is created, the evaporative system is sealed by closing the purge valve and the fresh air vent. If a significant change in pressure occurs during a subsequent short period of time (generally 15 to 30 seconds), it is assumed that a leak is present. If the pressure or vacuum is essentially maintained in the system, the diagnostic system concludes that the system is leak-free.

Based on recent data obtained by the staff, detecting leaks as small as a 0.020 inch orifice appears feasible. At this time, the capability of pressure based systems to detect small leaks appears to be greater than that of vacuum-based systems; however, data generated by the ARB staff indicate that capability adequate to satisfy the requirement should also exist for the vacuum-based systems.

The staff's testing was conducted on the four test vehicles previously identified. The fuel tank volumes for each vehicle are 18 gallons for the Buick LeSabre and the Ford F150 truck, 14 gallons for the Volkswagen Jetta, and 16 gallons for the Toyota Celica. Testing was conducted generally during vehicle cruise conditions (approximately 40-50 miles per hour on a city street), with some of the tests conducted at idle. The fuel tanks were 60 percent filled with California Phase-II gasoline with an RVP of 7.0 psi. Tests were conducted for a no-leak condition, a 0.020 inch orifice leak, and a 0.040 inch orifice leak. The testing sequence included sealing of the evaporative system under the normal operating conditions and recording the rise in pressure in the system due to vapor generation from the fuel for each of the leak scenarios. The evaporative system was then evacuated to about 7 inches of water and sealed (except for the implanted leaks). The rise in pressure in the system was then recorded at 10 second intervals up to 80 seconds. These tests were conducted five times for each condition. Plots were then prepared showing the net leak rate due to the presence of a leak by adjusting the leak rate observed during the vacuum test for the pressure build up noted when the evaporative system was sealed, but not evacuated. The results for the Buick LeSabre are shown in Figure 8. Plots for the other test vehicles are included in Appendix B.

From the figures, it appears that adequate separation between the no leak case and the 0.020 inch orifice does exist. It is recognized that additional variability may be present with a large number of production vehicles. In examining criteria used by some manufacturers in determining the presence of a 0.040 inch orifice leak, it was learned that detecting a rise in pressure within a 15 second interval was a typical criterion. Looking at the results of testing conducted by the ARB, it appears that achieving a similar change in pressure for the 15 second period for a 0.040 inch leak could be seen after about 60 seconds for a 0.020 inch leak, as might be projected since the area of a 0.040 inch diameter leak is four times the area of a 0.020 inch diameter leak. Therefore, by lengthening the monitoring period, sufficient separation appears obtainable. Figure 9 illustrates this point for the Buick. Normal distributions were constructed based on the averages and standard deviations calculated for the test data with respect to specific time intervals.

Consistent with the indications from vehicle manufacturers, the staff's assessment based on the testing is that the check will be most reliable in-use under conditions of low vapor generation. Such conditions should be encountered often. Phase II fuel with a 7.0 psi RVP will be sold exclusively in California beginning with the 1996 model year, and fuel temperatures lower than 80 degrees Fahrenheit would be encountered routinely during all but the hottest months of the year (even during the summer, such temperatures would generally be encountered during morning or evening vehicle operation). Therefore, manufacturers are expected to be able to implement monitoring strategies that will operate reliably in-use with adequate frequency. The staff's proposal allows manufacturers to appropriately restrict monitoring conditions, even if the check is not always run during an FTP test (the upper ambient temperature limit for the FTP is 86 degrees Fahrenheit). If in-use a vehicle is filled with a higher RVP fuel, or if for other reasons vapor generation is higher than expected, OBD II systems should not be subject to falsely detecting a malfunction because the first stage of the monitoring strategy will provide a direct indication of the magnitude of vapor generation. Should it be unacceptably high, the check could simply be disabled until appropriate conditions are encountered.

Figure 8

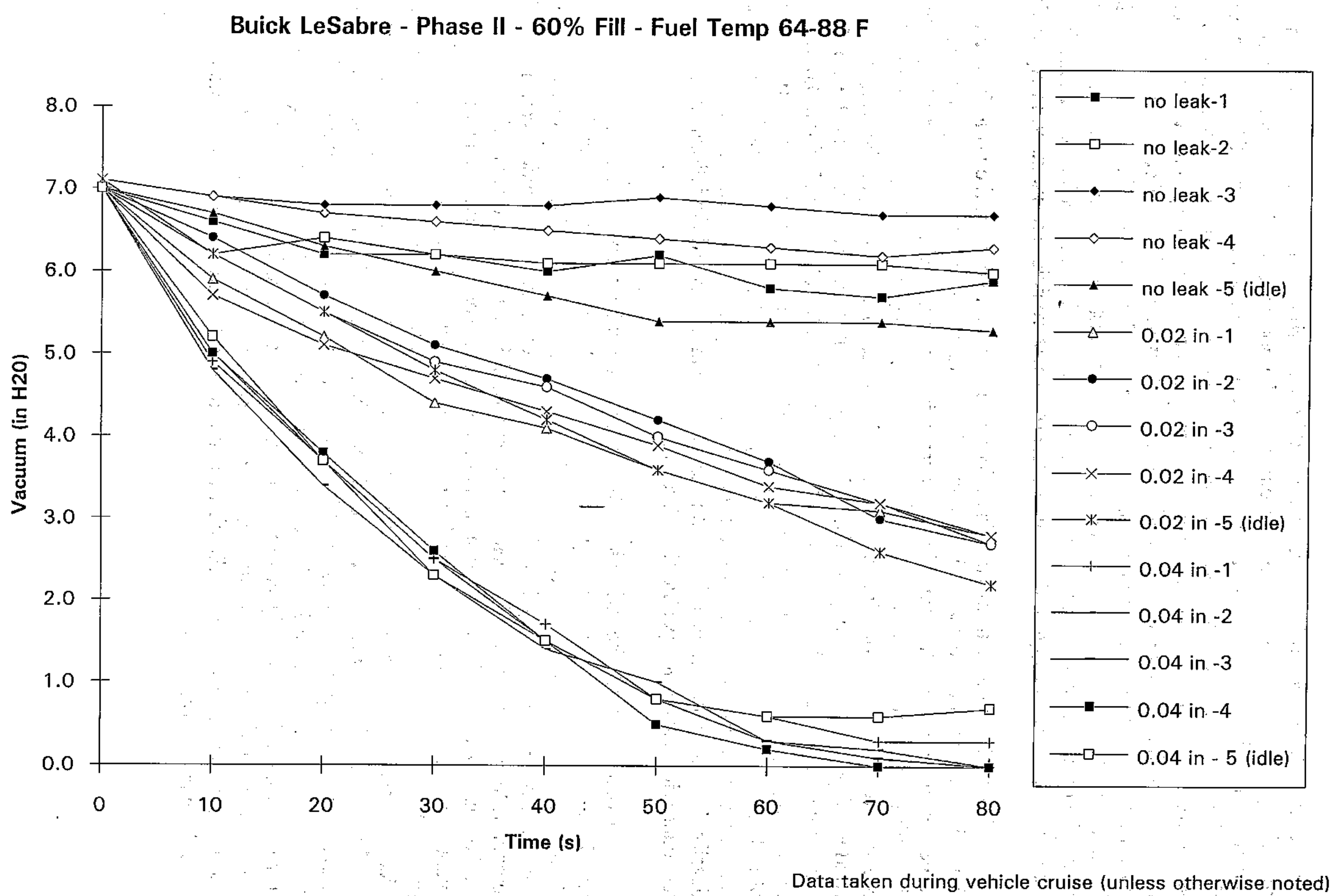
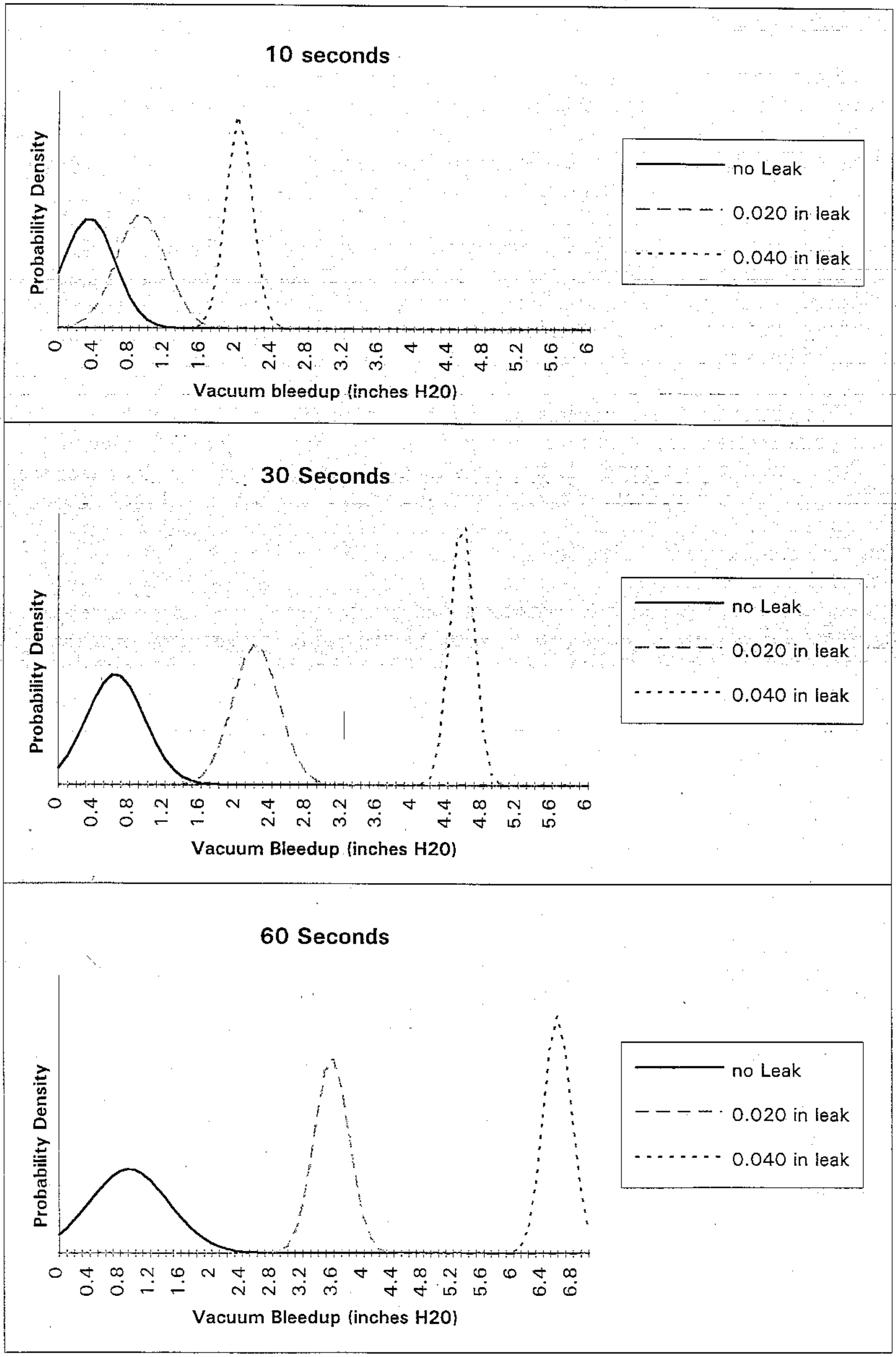

Buick LeSabre - Phase II - 60% Fill - Fuel Temp 64-88 F
Vacuum (in H20)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
10
20
30
40
50
60
70
80
Time (s)
no leak-1
no leak-2
no leak -3
no leak -4
no leak -5 (idle)
0.02 in -1
0.02 in -2
0.02 in -3
0.02 in -4
0.02 in -5 (idle)
0.04 in -1
0.04 in -2
0.04 in -3
0.04 in -4
0.04 in - 5 (idle)
Data taken during vehicle cruise (unless otherwise noted)

Figure 9

Buick LeSabre | Fuel Temp Range 64-88 F | Phase II Gas | 60 % Fuel Fill



Other Considerations

From the manufacturers' perspective there are additional issues to consider. First, they point out that in-use field experience even with systems capable of detecting a 0.040 inch leak will not begin to accrue until after the 1996 model year. Until it is known how reliable these systems will be, they believe further constraining the check may be premature. In addition, just finding a leak does not mean that it will be easy to diagnose and repair. Manufacturers have developed a new leak detection device which should be capable of finding small leaks, but its success in the hands of service technicians is not well known. Further, if a leak equivalent in size to a 0.020 inch orifice is the result of a combination of even smaller leaks, the diagnosis would be even more difficult, they maintain. However, the service industry has successfully located much smaller leaks in air conditioning systems for decades, so that detection of leaks in evaporative systems should not prove insurmountable.

While manufacturers' concerns are understood, the staff has concluded that pursuit of detecting smaller leaks is necessary in view of the potential air quality effects of settling for less. Since detection of a smaller leak is envisioned to be done primarily by lengthening the monitoring period, perhaps further constraining the checking conditions, and correcting for vapor generation, there should be no increase in hardware cost to accomplish the goal. There is also time between now and beginning implementation of the proposed 0.020 inch leak detection requirement in 1998 to review the industry's progress. Should it appear that manufacturers would have to make significant hardware changes to meet the amended requirement, the staff could provide for a revised phase-in of the requirement. Any needed alterations could be considered by the Board in a 1996 review of progress in meeting OBD II requirements.

MISFIRE DETECTION

Since adoption of the OBD II regulation in 1989, the ARB has been seeking misfire monitoring capability which extends throughout the full engine operating speed and load range. At the 1991 Board review of progress in meeting the OBD II requirements, it was determined that technology had not progressed sufficiently to ensure that full-range monitoring capability could be achieved in the 1994-1996 OBD II phase-in time frame. Accordingly, the goal was moved to the 1997 model year, and industry agreed to redouble their internal efforts and include evaluation of a number of independent sources of misfire detection capability before the next Board review of the OBD II requirements.

For models introduced before the 1997 model year, the current regulation requires misfire monitoring over the engine operating range encountered during an FTP test. The OBD II malfunction light is to illuminate when the level of misfire is high enough to lead to catalyst damage, cause emissions to exceed the applicable emission standards by a factor of 1.5, or to result in failure of an Inspection/Maintenance program test. In addition, the malfunction light is to flash when misfire is occurring at a rate which could lead to catalyst damage, and remain steadily illuminated otherwise once the misfire rate exceeds the applicable thresholds.

The ARB staff has continued to seek full engine operating range monitoring capability for a number of reasons. Engine misfire does not necessarily occur at all engine speeds and loads; sometimes misfire occurs only at high engine speeds and loads, light load part throttle operation, idle, or other isolated operating conditions. Moreover, under high speed and load conditions, for example, even small amounts of misfire can very quickly lead to catalyst overheating and failure. Misfire may also occur during the cold start and warm-up period, which could contribute substantially to excess emissions, but then may subside during warm engine operation. Even high engine speed operation under light load conditions needs to be monitored since some vehicles may encounter these conditions in mountainous terrain during alternating periods of engine braking and acceleration, or in congested traffic conditions (when owners of manual transmission vehicles are prone to minimize shifting and let the engine speed climb to high levels during frequent stop and go intervals). Since it is not possible to predict the likely misfire characteristics of older vehicles, it is important to cover as much of the full range of engine operation as possible in monitoring for misfire. From a regulatory implementation standpoint, the staff would also like to avoid making judgment calls on the appropriate monitoring range capability for every engine certified in California, as each engine will have different characteristics which can affect the misfire monitoring range. If all engines must generally meet the full range monitoring requirement, then certification acceptance is simplified, and there would be little potential for inequities in judging the acceptability of each manufacturer's misfire detection capability[13].

Since the last Board review, the misfire monitoring capability of the automobile manufacturers has steadily improved, and the capabilities of independent parties in this arena have also improved. Manufacturers have generally increased their computer processing speed, improved their misfire detection algorithms in numerous areas including incorporation of adaptive learning compensation for irregularities in manufacture of the ignition signal pick-up wheels, relocated the pick-up sensor to optimum locations to minimize signal noise, improved base-engine roughness through improved fuel targeting, and other enhancements.

At this time it appears that industry will be capable of certifying 50 percent of their projected sales volumes to almost all of the full speed and load engine operating range by the 1997 model year. Only a very small portion of the full engine operating range would need to be excluded from the full-range monitoring requirement. This is a very light load operating condition occurring above 3000 RPM where driving would be relatively rare. The engine speed and load region over which misfire monitoring would be required is shown in Figure 10. Ford Motor Company has indicated notable success in its misfire detection capability.

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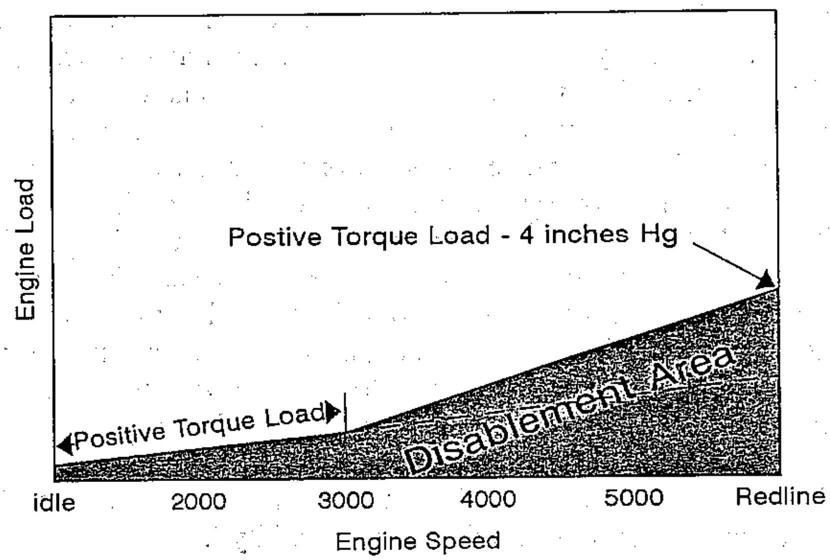
[13]There is still some allowance in the regulatory proposal, however, for engines with fundamental design limitations which hinder reliable misfire detection to forego monitoring in a very narrow operating range.

Working with Motorola on a high data rate system which incorporates pattern recognition techniques, it appears that very high speed misfire monitoring is possible. The only drawback to the system appears to be some limitation in identifying the misfiring cylinder at high engine speeds, but this limitation is offset by the otherwise excellent reported capability of the system. Another significant benefit is that the cost of this added capability is expected to be surprisingly low.

Figure 10



At this time it appears that some engine and driveline characteristics still preclude reliable misfire monitoring over the full range of operating conditions; in particular, engines with 10 or 12 cylinders may yet pose a challenge for meeting the misfire monitoring requirements. Because these engines require further evaluation, staff is proposing to phase-in the full-range misfire monitoring requirement beginning in 1997 at 50 percent of a manufacturer's projected sales volume, 75 percent in 1998, 90 percent in 1999, and full compliance in 2000 (small volume manufacturers would comply in 2000). In addition to manufacturers' efforts, staff is aware that Technical Advances, Inc. in conjunction with SSI Technologies, Inc, Professor Citron at Purdue University, Professor Ribbens at the University of Michigan, Kavlico, Analytical Methods, ABB Industrial Systems, and others are working to solve the misfire detection problems of the remaining difficult engines.

With the current proposal, then, time remains for industry to continue to improve misfire monitoring capability for the more difficult to control engines. Staff will again evaluate progress at a review hearing in 1996 to determine if changes would be needed to the regulation for 1998 and later model year vehicles.

OBD II IMPLEMENTATION ON DIESELS

In 1991, the Board adopted amendments to the regulation making the OBD II requirements applicable to diesel engines beginning with the 1996 model year. Recognizing that some OBD II requirements would not apply, or could not be met on diesel applications, the regulation currently requires manufacturers of diesel engines to submit an OBD II monitoring plan for ARB review. After a number of discussions with manufacturers since the time diesels were included in the OBD II regulation, the staff believes enough has been learned to more specifically detail the minimum monitoring requirements for diesel applications.

Generally, diesels are not equipped with evaporative systems, secondary air, or oxygen sensors. These monitoring requirements would, therefore, not apply. Regarding catalyst monitoring, the ARB staff has not yet identified a technology that can be put into production to detect diesel catalyst deterioration. Because diesel vehicles operate lean of stoichiometric, the principle of oxygen storage as discussed earlier for vehicles using three-way catalysts could not be used. Catalyst monitoring is not proposed for diesels on this basis.

However, with respect to misfire monitoring the ARB staff believes that a form of misfire detection on diesels is feasible and would be useful in reducing in-use emissions, especially at high mileages (i.e., beyond 100,000 miles). It is recognized that diesel engines are not likely to develop intermittent misfire problems as are spark ignited engines; however, malfunctions can occur that prevent combustion in one or more cylinders. If compression is lost, the air/fuel mixture would pass through the cylinder unburned, and a large portion of the mixture would also pass through the catalyst (if equipped) into the atmosphere. The staff's proposal is to require the detection of the complete loss of combustion in one or more cylinders. The proposal would allow the misfire detection strategy to be active only during certain operating conditions (e.g., during idle), and monitoring would be required only once per driving cycle. Implementation of this requirement is proposed to begin with the 1998 model year. Manufacturers of spark-ignited engines have been able to implement misfire detection systems based on engine speed fluctuations that are capable of detecting one to two percent engine misfire over a wide range of operating conditions. Compared with the requirements for spark ignited engines, the diesel manufacturers should be able to implement monitoring strategies to detect complete cylinder misfire under specific operating conditions using similar techniques by the 1998 model year.

Regarding fuel system monitoring, diesel engines do not employ the type of closed-loop fuel control systems found on vehicles with three way catalysts (i.e., feedback information on exhaust composition with the use of an oxygen sensor), although some diesel control system designs are capable of providing feedback regarding fuel injector performance. Therefore, the staff has proposed an amendment to clarify that diesel fuel system monitoring is required to the extent possible to detect fuel system malfunctions that would cause the vehicle or engine to exceed 1.5 times any of its emission standards; however, manufacturers would not be responsible for detecting malfunctions for which the system is incapable of providing necessary feedback (e.g., a fuel injector with a broken tip).

Consistent with the requirements for spark-ignited engines, manufacturers of diesels would also be required to implement OBD II monitoring strategies for EGR system performance and for any electronic components that can affect emissions when malfunctioning (e.g., intake air heating, electronic transmission components, wait-to-start lamp, etc.).

1996-2000 MODEL YEAR COMPLIANCE

Compliance with the OBD II regulation requires the implementation of a large number of monitoring strategies. Manufacturers are required to design and work with new monitoring concepts for components and systems that up until now, have not been monitored on-board. The staff recognizes that manufacturers face a heavy workload in bringing such strategies to production across their product lines in a manner that will ensure that OBD II systems are effective and reliable in-use.

The Board has recognized the difficulty of initially implementing OBD II systems on vehicles. In July, 1993, the Board adopted an amendment to the regulation that provides for limited relief from specific requirements if, despite a good-faith effort, full OBD II compliance with the requirements could not be obtained. For 1994 and 1994 1/2 models, the regulation permits the certification of OBD II equipped vehicles even if one or more monitoring strategies do not meet the minimum requirements of the regulation. For 1995 models, the number of allowed monitoring deficiencies is limited to two per engine family. If a manufacturer has more than two deficiencies on a particular engine family, the vehicle could still be certified, but fines would be applied to the third and subsequently identified deficiency. The amount of the fines is 50 dollars per vehicle per deficiency for a major monitoring system deficiency (e.g., catalyst monitoring, misfire monitoring, evaporative system leak detection, and others), and 25 dollars for deficiencies associated with monitoring systems for other electronic components.

The adoption of this provision has proven to be valuable, since despite best efforts, most manufacturers have needed to certify vehicles with deficiencies when problems arose which were unanticipated and which could not be immediately resolved. It is also clear, especially for 1995 model year vehicles, that manufacturers have generally taken every reasonable step to avoid having to request use of the deficiency provision due to the risk of being subject to fines for subsequent unanticipated problems.

Given the newness and complexity of designing OBD II systems, it is likely that deficiencies will continue to occur as manufacturers will implement OBD II across their full product lines in 1996. Accordingly, the staff is recommending carry-over of the allowance for two deficiencies per engine family for the 1996 model year. With respect to electronic transmissions, it is possible that a particular problem (such as the inability to incorporate a communication link between the transmission and engine control units due to a late change in the type of transmission to be used) could prevent monitoring of several, or even all transmission components subject to monitoring under the Comprehensive Component Monitoring requirements. To address this, the staff further proposes (for the 1996 model year only) to count multiple transmission component monitoring problems as a single deficiency. Staff is convinced that manufacturers will use permitted deficiencies sparingly since most 1996 engine families are not expected to require variances based on preliminary reviews of most manufacturers' planned systems. Although some manufacturers may need to utilize one of the deficiencies for some models in 1996, few are even suggesting that the second allowed deficiency will be required since they are saving it for an unexpected shortfall.

Concerning post-1996 models, the changes being proposed for this hearing would continue to require innovation by manufacturers in the area of catalyst monitoring, misfire detection, evaporative system leak detection, and issues associated with introducing more low-emission vehicles in this timeframe. Although most of the other monitors will have been developed for the 1994 to 1996 model year vehicles, 1997 and later vehicles may encounter potential deficiencies in trying to meet the proposed changes to the regulation. In discussing the proposed changes for some of the major monitoring requirements with manufacturers, it appeared many were willing to try hard to meet the new proposed requirements. In return, they asked for continuing latitude in case they fall short in meeting some of the requirements and requested that the ARB consider some additional latitude with regard to in-use recall liability until they can gain more real world experience with some of the new requirements.

The staff considers industry's request to be reasonable, and is, therefore, proposing that one deficiency be permitted for each engine family for 1997 through 2000 model year vehicles, although unlike previous deficiencies, complete lack of a monitor would not be permitted without incurring a fine. This latter requirement is important with respect to the ARB's plans to begin evaluating the potential of using a check of the OBD II system in place of the current Inspection and Maintenance testing methods. The staff also proposes that deficiencies occurring in the 1997 and later model years could not be carried over to the following model year unless it can be demonstrated that correction of the deficiency would require hardware modifications that could not be accomplished due to lead-time or similar issues. Further, the staff proposes that in no case could a deficiency be carried over more than one year without a fine. This would preclude a manufacturer from using the proposed latitude to avoid development of a fully complying monitoring system for an extended period.

Regarding in-use compliance, the staff is proposing that for TLEVs, manufacturers would not be subject to compliance actions until emissions exceed 2.0 times the applicable standards through the 1998 model year for those monitors which must be designed to meet a 1.5 times the emission standard threshold. LEVs and ULEVs would have the same allowance apply through model year 2000. Further, because the catalyst monitoring requirements would continue to evolve in the 1998-2000 model year timeframe even for TLEVs, if the staff proposal is approved by the Board, the 2.0 times the emission standard threshold in-use would apply to catalyst monitoring for all low-emission vehicles through model year 2000.

Given the stated willingness of some manufacturers to continue to strive to meet the ultimate objectives of OBD II which are now in sight, the staff considers the allowable deficiency provisions coupled with intermediate in-use compliance latitude to be an optimum balance for promoting the best innovation and development from industry while ensuring that the resulting OBD II systems are as reliable and complete as possible.

OTHER PROPOSED MODIFICATIONS

In addition to the proposed modifications to the OBD II requirements that have already been discussed, the staff is proposing a number of more minor modifications. As manufacturers have begun to place OBD II systems into production, the staff has found that manufacturers have misunderstood or have been uncertain of the intent of some requirements. The proposed modifications would clarify the regulation in this respect, and would make adjustments to the requirements when necessary based on the staff's experience in reviewing OBD II system designs. The more notable modifications are presented below. A full listing of proposed amendments can be found in Appendix A.

MIL Illumination and Fault Code Storage Protocol:

Section (a)(1.9): The addition of this section is proposed to slightly modify the requirements for the OBD II MIL illumination and fault code storage protocol. Currently, illumination of the MIL is generally not required unless a malfunction is detected during two sequential trips. A trip is defined in part as a period of driving during which all components and systems are monitored at least once by the OBD II system. Therefore, if a specific monitoring strategy detects a malfunction in two sequential *driving cycles*, MIL illumination is not required unless all other (even non-related) monitoring strategies have operated during both of the driving cycles. The staff proposes to modify the protocol such that MIL illumination would be required if a malfunction is detected in two sequential driving cycles regardless of whether or not other monitoring systems have functioned. However, manufacturers would still be permitted to verify the proper function of components critical to a particular monitoring strategy before the monitoring system operates or before the results are validated. To allow for any OBD II system software changes necessary to incorporate the revised protocol, its implementation is not required until the 1997 model year. Other sections modified to incorporate the proposed change: (b)(1.3.1), (1.4.1), (2.3), (2.4), (3.4.2), (3.4.3), (3.8), (3.9), (4.3), (4.4.1), (5.3), (5.4), (6.3), (6.4), (7.4.1), (7.4.2), (7.4.3), (8.3.2), (8.3.3), (8.4), (8.5.1), (9.3), (9.4), (10.3.1), (10.3.2), (10.4), (c)(2.2).

Misfire Monitoring Cylinder Identification:

Section (b)(3.1): Currently, the regulation requires the specific identification of the misfiring cylinder during all operating conditions under which misfire detection systems are active. However, in working towards meeting the expanded monitoring conditions for misfire detection that are to begin with the 1997 model year, some manufacturers have found that specific cylinder identification can be unreliable at higher engine speeds. The staff proposes an amendment that would permit manufacturers to request Executive Officer approval to disable algorithms employed to identify the misfiring cylinder under certain operating conditions if it can be demonstrated that the algorithm would not operate reliably when such conditions exist. This amendment would not affect the operating conditions under which misfire is to be detected. If misfire is detected under a condition where the specific cylinder cannot be reliably identified, the OBD II system would be required to store a general misfire fault code.

Tamper Resistance:

Section (d): The staff has proposed regulatory language to make more specific the requirements for making OBD II vehicle calibrations resistant to tampering. On vehicles that use Electronically Erasable Programmable Read Only Memory (EEPROM), which provide the capability for a vehicle to be reprogrammed electronically through its communication link, the staff's proposal would require manufacturers to utilize reprogramming strategies that require access to a centralized computer maintained by the manufacturer as well as the use of full data encryption (scrambling of the software code). Equivalent strategies would also be acceptable. The staff is concerned that an incentive to tamper with OBD II system calibrations could exist should California implement an Inspection and Maintenance test based on the use of OBD II systems, especially considering the high cost repair limits that are likely to be part of the program. The success of this I/M concept depends greatly on the extent to which OBD II system information is reliable. Implementation of these more sophisticated proposed measures would not be required until the 1999 model year in order to provide manufacturers with adequate leadtime to make necessary vehicle and reprogramming equipment modifications.

Apart from the Inspection/Maintenance program concerns, the staff believes that effective security measures are necessary to ensure the integrity of OBD II systems and engine control calibrations on vehicles using EEPROMs. With this type of computer chip, vehicles can be recalibrated without physically modifying or replacing any on-board computer components in an attempt to enhance vehicle performance. Without tamper resistance measures, vehicles could be modified with commonly available computer equipment. Although information regarding the location of key engine parameters within the vehicles programming would be necessary to successfully tamper with the vehicle, such information, once learned by a few, could spread over computer bulletin boards and networks, for example, which are being used to a greater extent within the service industry. With the staff's proposed amendments, individuals would face a much more difficult task in trying to "reverse engineer" the reprogramming protocol. Further, if the basic protocol is learned, the requirement to access a centralized computer would complicate the task of reprogramming on a wide scale basis, and would allow the manufacturer to monitor reprogramming activity.

It should be noted that the aftermarket parts industry has expressed concern over the anti-tampering provisions which have been present in the OBD II regulation since it was adopted by the Board in 1989, and the proposed changes to make these provisions more specific has heightened its concern. In the past, the aftermarket industry has relied on decoding manufacturers' software to enable it to integrate replacement or specialty equipment into vehicles. The requirements of OBD II substantially complicate their design task in that aftermarket parts must be compatible with OBD II systems to prevent inadvertent malfunction indications. With additional security provisions, the aftermarket is concerned that successfully integrating its products into vehicles equipped with OBD II will be very difficult to accomplish.

However, it should be noted that some vehicle manufacturers will likely implement tougher security measures than currently required without the proposed modifications (in which case, the OBD II tamper resistance requirements would primarily only ensure that manufacturers remain consistent in implementing adequate security measures). This action would be taken primarily in response to recent indications from the United States Environmental Protection Agency regarding requirements for greater information availability to the aftermarket and service industries which would include the capability to install vehicle software calibrations. Manufacturers will want to implement additional security measures to ensure that only authorized reprogramming occurs. In some cases, vehicle manufacturers already have computer designs which are very difficult to access. Realistically, it appears that the aftermarket parts industry will need to work with vehicle manufacturers to gain assistance in developing calibrations necessary for its products in a business relationship, even in the absence of more specific security measures in OBD II. The ARB staff has spoken with the vehicle manufacturers about this issue, and it appears that the aftermarket industry is viewed as a valuable asset in marketing certain kinds of vehicles, so that working with them should eventually occur. Unfortunately, at the present time, vehicle manufacturers are busy developing their full product lines to meet the OBD II requirements in the 1996 model year, so that sufficient dialog has not yet taken place among both parties.

The purpose of the security measures specified in OBD II is to ensure that tampering will not reasonably occur with respect to Inspection and Maintenance programs and vehicle performance. Insofar as legitimate aftermarket products manufacturers are concerned, it appears they will need to form business relationships with the vehicle manufacturers regardless of the security measures being proposed for OBD II. The staff will monitor the developments in this area and determine if additional measures to accommodate legitimate aftermarket parts manufacturers interests would be appropriate during the 1996 OBD II review hearing.

<u>Alternate Fuel Vehicles:</u>

Section (m)(5.1): Vehicles designed to operate on alternate fuels are currently required to comply with the OBD II requirements beginning with the 1996 model year. However, manufacturers have stated that due to the workload associated with complying fully with the OBD II requirements on conventional vehicles in the 1996 model year, coupled with the low volumes projected for alternate fuel vehicles, OBD II development and testing with respect to these vehicles cannot be completed in time for 1996 model year implementation. Manufacturers have stated that more time is needed to evaluate the effects of alternate fuels on component performance to ensure that OBD II diagnostic strategies will be reliable in-use. As a result, manufacturers have considered pulling back plans to sell alternate fuel vehicles in 1996 and possibly subsequent model years.

Recognizing manufacturers' concerns, the staff proposes to delay full OBD II implementation until the 1999 model year for alternate fuel vehicles. Between the 1996 and 1998 model years, manufacturers would be required to implement diagnostic strategies to the extent feasible, but would not be required to include monitoring strategies for which the effects of alternate fuels are of concern. Specifically, manufacturers would be required to implement circuit continuity and functional checks at a minimum as well as unaffected major system monitors such as fuel system monitoring, or monitoring of the EGR valve, but could request Executive Officer approval to delay, for example, oxygen sensor response rate monitoring, or catalyst efficiency checks until the 1999 model year.

Similarly, the staff proposes an amendment to California's certification procedures for alternate fuel retrofit vehicles. The proposal would provide retrofit system manufacturers some leniency until the 1999 model year with respect to maintaining full operation of OBD II monitoring strategies developed for use with gasoline. For example, a retrofit system manufacturer would be permitted to request Executive Officer approval to disable the vehicle manufacturer's oxygen sensor response rate check, but would be required to maintain other oxygen sensor output voltage checks that would not be affected by the use of an alternate fuel. The proposed modifications to the procedures are included in Appendix D.

VI. IMPACT ON COSTS, THE ENVIRONMENT, AND BUSINESS AND ECONOMY OF THE STATE

Costs

The proposed modifications to the OBD II regulation do not necessitate the use of additional monitoring hardware. The changes revise and clarify already adopted requirements and do not expand the scope of the regulation. To this extent, the staff does not expect an incremental cost per vehicle to result from these proposed modifications. Manufacturers may need to make some design modifications to meet, for example, the revised catalyst and evaporative system monitoring requirements; however, the staff estimates that the overall OBD II development burden will decrease with the proposed amendments in comparison to the current requirements. A more detailed discussion with respect to the costs associated with the more significant proposed amendments is provided below.

Regarding catalyst monitoring, in many instances, the revised malfunction criteria will not require any substantive vehicle design changes, with the exception of software changes to ensure that the emission thresholds will be met in-use. However, manufacturers have indicated that on some models, catalyst modifications such as the incorporation of an oxygen sensor between catalyst substrates in the same container will be necessary. There will be some additional cost associated with confirming the durability of this revised catalyst design, although when spread over the large numbers of catalysts expected in the future, the incremental cost would be negligible. In a few cases, catalysts will need to be relocated in the exhaust system to be optimized for monitoring. In order to reduce tooling and development costs, the staff's proposal for catalyst monitoring includes an interim emission threshold that will prevent the need for any such modifications until the 1998 model year at the earliest, and possibly until as late as the 2000 model year. Manufacturers, therefore, will have the opportunity to make necessary changes concurrently with other vehicle modifications. In other instances, the proposed modifications provide substantial regulatory relief. Some manufacturers have indicated that the current front catalyst monitoring requirements for low-emission vehicles cannot be practically implemented on certain 1996 or 1997 model year applications without significant product design changes or the last minute development of a new monitoring technology. With the proposed modifications, such changes would no longer be necessary for near-term OBD II compliance.

For misfire monitoring, the proposed revisions for the 1997 and later model years ease the burden of OBD II compliance compared to the current requirements. Manufacturers would be permitted to phase-in expanded monitoring conditions in place of full 1997 model year compliance. Further, the regulation would define a small positive torque engine speed and load range where misfire detection is not required. Both aspects of the staff's proposal would reduce the resources necessary for OBD II misfire detection compliance. Regarding misfire monitoring for diesels, the requirements for these vehicles are less difficult overall to satisfy than those already in place for spark-ignited engines. Therefore, the staff expects the cost of compliance with respect to diesels to be less than that for spark-ignited engines.

Regarding evaporative system monitoring, as discussed previously, it appears that manufacturers will be able to incorporate a method to detect leaks equivalent to a 0.020 inch orifice through software modifications. These modifications should not have a significant impact in terms of cost per vehicle

The last proposed modification that could significantly impact the cost of OBD II compliance is the incorporation of provisions for OBD II certification with deficiencies beginning with the 1996 model year and extending through the 2000 model year. These provisions permit the certification of OBD II systems even though one or more monitoring system deficiencies have been identified. Fines of 25 to 50 dollars per deficiency per vehicle would apply to the third and subsequent deficiency identified in a 1996 model year engine family, and to the second and subsequent deficiency for 1997 through 2000 model year vehicles. Despite the proposed fines, use of the provision will result in a net cost savings to the manufacturer in that the regulation does not currently allow certification of vehicles with monitoring system deficiencies after the 1995 model year. The cost to the manufacturer and affected California businesses of having to remove developed product from the California marketplace would almost certainly far exceed any fine that may apply.

The Environment

Many of the proposed modifications to the OBD II regulation are intended to clarify the monitoring requirements and to make minor regulatory adjustments based on the recent experience obtained in certifying OBD II compliant vehicles. As a result, these changes should simplify the task of understanding and implementing the OBD II requirements, and are not expected to significantly affect the performance of OBD II systems in-use or have any adverse impact on the environment. More significant amendments are proposed for catalyst monitoring, misfire monitoring, and evaporative system leak detection. While in some instances the requirements would be relaxed slightly in the near term, the staff believes overall that the modifications proposed will provide for greater emission reductions from California's OBD II program.

For catalyst monitoring on low-emission vehicle applications, it is difficult to compare the impact on emissions resulting from the proposed system-based requirements relative to the current front catalyst monitoring requirements. As stated previously, the tailpipe emission level of a vehicle when the front catalyst has deteriorated to the malfunction criteria depends significantly on the design of the catalyst system as a whole. In some instances it is clear that a front catalyst monitoring strategy would illuminate the MIL before the proposed interim system-based malfunction criteria would be exceeded; however, in other instances (particularly when only one catalyst substrate is located in the exhaust stream), such a monitoring strategy could illuminate the MIL at a HC emission level many times the interim criteria. Once the phase-in of the 1.5 times the standard emission threshold is complete, catalyst monitoring systems should in all cases be equally or more effective in achieving emission reductions in-use than systems developed to meet the current requirements.

Regarding the OBD II misfire monitoring requirements, the staff has proposed additional leadtime for meeting the expanded misfire monitoring conditions through the use of a 4 year phase-in, and has defined a small region of positive torque operation wherein misfire detection disablement would be permitted. As such, a significant percentage of vehicles in the 1997 to 2000 model year time-frame would have misfire detection systems that are operational over a significantly smaller portion of the engine operating range in comparison to the current requirements for the 1997 and later model years. However, in following the progress of manufacturers towards meeting the current requirements, the staff believes it is likely that a number of manufacturers will not be able to meet the current requirements on all engine families. Consequently, should the staff's proposal not be adopted, many vehicle manufacturers would not receive certification for some engine families after the 1996 model year. It is the staff's determination that the exclusion of vehicles from the California market would have an adverse economic impact on California businesses (including dealerships, automotive suppliers, and service centers) that would be proportionately greater than any resulting negative impact on the environment. The reduced availability of vehicles would also likely translate into higher consumer costs for new vehicle purchases. As such, the staff believes that overriding economic considerations exist that on balance outweigh the potential increase in emissions resulting from the phase-in of the misfire detection requirements.

For alternate fuel vehicles, the staff's proposal would allow manufacturers to delay the implementation of some monitoring strategies until the 1999 model year. The staff believes that any negative impact on emissions would be minor since manufacturers' projected sales volume for alternate fuel vehicles are very low. Further, manufacturers indicate that their alternate fuel engine families will generally be designed to meet Low-Emission Vehicle standards (the only currently certified ULEV model operates on compressed natural gas). It is expected, therefore, that fleet average emissions from alternate fuel vehicles will be lower than the fleet average emissions of gasoline powered vehicles in the 1996 through 1998 timeframe. Accordingly, any negative emission impact would be somewhat mitigated, since both vehicle manufacturers and retrofit system manufacturers are likely to pull back alternate fuel vehicle plans should full OBD II compliance continue to be required with the 1996 model year.

Regarding the provision for the certification of OBD II systems through the 2000 model year with system deficiencies, it is likely that any negative impact on emissions would be small from the certification of such systems. This is because the number of permitted deficiencies is limited, and basic monitoring capabilities must be implemented for every monitoring requirement after the 1996 model year, even though the monitor may fall short of the complete regulatory requirement. In addition, manufacturers would avoid use of the deficiency provisions to guard against unanticipated problems which would require their use in order to avoid a fine situation. These points are discussed in greater detail in section III of this report. As with the proposed misfire monitoring amendments, in the absence of such provisions, the possibility of vehicles being excluded from the California market would be significantly greater, resulting in an overriding negative impact on the economy of California.

Finally, with respect to the evaporative system monitoring requirement amendments, as previously discussed, the enhanced requirement should result in a significant reduction in evaporative emissions to the extent that small leaks occur in-use with new evaporative system designs. Based on available information, the staff believes the emission benefits from these revisions should more than compensate for any negative impact on the environment associated with the staff's proposals for misfire monitoring, alternate fuel vehicles, and 1996 through 2000 model year compliance.

<u>Business and Economy of the State of California</u>

The modifications proposed by the staff should not, in general, have any significant impact on the economy of California, or employment or business within the state. The OBD II requirements are directed at manufacturers of new motor vehicles, nearly all of which are located outside of the state. As discussed above, the proposed modifications should ensure that manufacturers will be able to keep current product plans intact throughout the early years of OBD II implementation in California. This will prevent any disruption within the

California businesses associated with the automotive industry.

However, the requirements may have a significant adverse impact on businesses which design and produce aftermarket components and systems for light- and medium-duty vehicles. As mentioned previously, the potential exists for increased development and production costs associated with having to certify that aftermarket parts will not adversely affect the performance of original equipment OBD II monitoring strategies. Nevertheless, the proposed amendments should not adversely affect ability of California businesses to compete with businesses outside the state in that all aftermarket parts producers must obtain certification in order to sell their products for use on California vehicles.

Conclusion

After several years of development and discussion, OBD II systems have become a reality in California. Monitoring system concepts have gone from the drawing board into production on more than 35 engine families already, with many more to follow. The regulatory amendments proposed by the staff would help in the process of reviewing and certifying manufacturers' systems by clarifying requirements, and by making minor adjustments to the regulation based on the valuable experience gained to date. Further, the staff's proposal would maximize the long-term effectiveness of the OBD II program by restructuring and enhancing current monitoring requirements based on the latest improvements in monitoring technologies. However, at the same time, amendments are proposed that would ease the burden manufacturers face in implementing OBD II systems by addressing a number of technical and practical concerns. Many of the amendments proposed are the result of a high level of cooperation between the staff and the industry in general. The staff plans to continue to follow manufacturers' progress towards meeting the OBD II requirements, and will be ready to address any issues that arise in this process.

APPENDIX A

Listing of Proposed Regulatory Amendments in "Plain English"

Section (a)(1.1): In response to questions from manufacturers, a modification is proposed to clarify that use of the International Standards Organization (ISO) engine symbol is acceptable in place of the word "engine" or "powertrain" for purposes of the Malfunction Indicator Light (MIL). The staff believes use of the symbol will provide for equal effectiveness in alerting vehicle operators of malfunction occurrences.

Section (a)(1.2): For purposes of clarity, an additional sentence is proposed to state that, unless otherwise noted, all section references are contained within the OBD II regulation.

Section (a)(1.4): Consistent with the modifications proposed for diesel applications, this section would be deleted.

Section (a)(1.8): The ARB staff has had several discussions with manufacturers regarding the use of alternate statistical MIL illumination criteria. The staff has determined that more specific approval criteria are necessary to ensure that alternate protocols will be comparably effective in indicating malfunctions in timely manner. Specifically, language is proposed that would require manufacturers to demonstrate the effectiveness of the alternate protocol relative to criteria specified in the regulation (i.e., illumination of the MIL if a malfunction is detected in two sequential driving cycles). Further, the staff's proposal would make clear that the ARB would not accept as comparably timely a protocol that required more than six driving cycles on average to detect a specific component or system failure mode.

Section (a)(1.9): An amendment is proposed that would modify the protocol for illuminating the malfunction indicator light and storing fault codes when malfunctions are detected. The amendment would remove the unnecessary restriction that all monitoring strategies must operate before a detected malfunction is indicated to the vehicle operator.

Section (a)(2.0): Vehicle operation at very low temperatures or high elevations can potentially cause a temporary effect on the performance of a system or component. Manufacturers have indicated that monitoring system disablement is necessary under such conditions to prevent falsely detecting such components as broken. The staff has proposed the addition of this section to clarify the expected ambient temperature and altitude limits for the operation of OBD II monitoring strategies. Upon demonstrating the need, manufacturers may request Executive Officer approval to disable monitoring systems at ambient engine starting conditions below 20 degrees Fahrenheit, and at altitudes above 8000 feet above sea level. In special circumstances, a manufacturer may request approval to disable monitoring systems at starting temperatures above 20 degrees.

Section (a)(2.1): The staff proposes to allow monitoring system disablement when the vehicle's fuel tank level is low (below 15 percent of the nominal capacity) in order to avoid the false detection of engine misfire or other malfunctions should the vehicle run out of fuel.

Section (a)(2.2): Manufacturers often design medium-duty applications to accommodate Power Take-Off (PTO) units. These units harness the engine's power to drive auxiliary devices such as a dump truck bed, a snow plow blade, or an aerial bucket. The staff proposes to permit OBD II monitoring system disablement while such devices are active to avoid the false detection of malfunctions. When a PTO unit is activated, the proposed section would require the OBD II system to clear the system readiness code in order to avoid vehicle tampering. Section (n)(19.0) contains a proposed definition for Power Take-Off Unit.

Section (b)(1): The staff proposes to modify the catalyst monitoring requirements for low-emission vehicle applications. Under the proposal, catalyst monitoring would be based on tailpipe emissions instead of front catalyst hydrocarbon conversion efficiency. The regulation would require the OBD II system to indicate a catalyst system malfunction when degraded catalyst system performance causes emissions to exceed 1.5 times the hydrocarbon standard for the vehicle. Higher emission malfunction criteria that would be phased-out by the 2000 model year are proposed to address immediate implementation concerns.

Section (b)(2.1.2): An amendment is proposed to make the monitoring requirements for heated catalysts consistent with the requirements specified in section (b)(1) for conventional catalysts.

Section (b)(2.2.1): An amendment is proposed to delete separate catalyst heating monitoring requirements for pre-start and after-start heating strategies. After further reviewing catalyst heating technologies, the staff believes a single criteria (failure to obtain designated temperature within a specific time period after engine starting such that emissions would exceed 1.5 times the standard) is applicable to both designs, making separate criteria unnecessary. Sections (b)(2.3.2) and (g)(2.7) have also been modified under the staff's proposal to reflect this amendment.

Section (b)(3): The staff proposes to provide additional leadtime to manufacturers to meet expanded monitoring conditions for the detection of engine misfire. Further, the staff's proposal defines a high engine speed, light engine load vehicle operating region wherein misfire monitoring may be disabled.

Section (b)(3.1): Manufacturers have expressed concerns that misfire detection systems may not be capable of reliably identifying misfiring cylinders when the misfire occurs at high engine speeds. An amendment is proposed that would allow manufacturers to request approval to disable cylinder identification strategies under such conditions as long as a general misfire fault code is stored should misfire be detected.

Section (b)(3.2)(A): Currently, misfire at levels high enough to cause catalyst damage must be detected using 200 revolution intervals. An amendment is proposed to extend this interval to up to 1000 revolutions if the manufacturer can demonstrate that catalyst damage would not occur before the additional evaluation time has elapsed. The amendment would provide manufacturers with greater flexibility in detecting such misfire problems.

Section (b)(3.2)(B): This section contains a provision for the use of a misfire detection threshold on low-emission vehicles that is higher than the level of misfire that would cause emissions to exceed 1.5 times the standard. The intent of the provision is to provide manufacturers with some relief from the misfire detection requirements should significant reliability concerns exist with respect to these vehicles. The staff proposes to delete this provision. Adequate flexibility regarding for the use of higher malfunction thresholds on low-emission vehicles is provided in section (a)(1.4) making a specific provision with respect to misfire monitoring unnecessary.

Section (b)(3.4.2): Language is proposed to clarify the MIL illumination protocol when engine misfire is detected. The amendment would make clear the section's intent that a malfunction is to be indicated if misfire is detected on sequential driving cycles regardless of the conditions under which it is detected, or if misfire is detected twice sequentially under similar operating conditions even if the occurrence of the operating conditions is separated by one or more driving cycles.

Section (b)(3.5): Misfire monitoring requirements are proposed for diesel vehicles and engines. Manufacturers of diesel applications would be required to implement monitoring systems capable of detecting the lack of combustion in one or more cylinders beginning with the 1998 model year.

Section (b)(4.1.3): The staff proposes a modification to make clear that evaporative system leak monitoring may be disabled, subject to Executive Officer approval, at fuel levels greater than 85 percent of the nominal tank capacity. Manufacturers have stated that misdiagnosis of the evaporative system can occur at very high fuel levels.

Section (b)(4.2.2): The staff proposes to require manufacturers to phase-in evaporative system monitoring strategies capable of detecting system leaks equal or greater in magnitude to a 0.020 inch diameter orifice. The phase-in would extend from the 1998 model year to the 2000 model year.

Section (b)(5.2.2): An amendment is proposed to clarify the criteria that will be used by the Executive Officer to determine if a secondary air system will be sufficiently resistant to deterioration to qualify for a functional check. Manufacturers requesting an Executive Officer determination have sometimes misunderstood the extent to which the durability of the secondary air system must be demonstrated.

Section (b)(7.1): An amendment is proposed to clarify the fuel system monitoring requirements for diesel vehicles and engines. Manufacturers would not be responsible for detecting fuel system failures for which insufficient information would be available to the diagnostic system.

Section (b)(7.4.2): Language is proposed to clarify the MIL illumination protocol when a fuel system malfunction is detected. The amendment would make clear the sections intent that a malfunction is to be indicated if a fuel system malfunction is detected on sequential driving cycles regardless of the conditions under which it is detected, or if a malfunction is detected twice sequentially under similar operating conditions even if the occurrence of the operating conditions is separated by one or more driving cycles.

Section (b)(8.2.2): The staff proposes a modification to clarify the malfunction criteria for oxygen sensor heaters. Some manufacturers have presented oxygen sensor heater monitoring strategies that essentially verify only proper circuit continuity of the heater, and do not adequately verify its proper performance. Language is also proposed to clarify that data and/or an engineering evaluation must be submitted when a request for Executive Officer approval is made. Amendments are proposed to the following sections to similarly clarify the type of information that is required to support a request for Executive Officer approval: (b)(9.1.2), (b)(10.1.1)(C), (g)(3.0),

Section (b)(10.1): An amendment is proposed to make clear that any component used as part of the diagnostic strategy for any other monitored system or component must itself be monitored for proper function. Some manufacturers have initially neglected to incorporate monitoring strategies for such components. Manufacturers can be exempted from having to illuminate the MIL when such a component is detected as malfunctioning, provided the OBD II system would no longer use information provided by the component as criteria for temporary monitoring system disablement.

Section (b)(10.1.1)(A): A new example is proposed to clarify the requirements for input component rationality checking.

Section (b)(10.1.1)(C): This section requires manufacturers to monitor coolant temperature sensors for performance with respect to indicating the stabilized temperature necessary for closed-loop operation within a specified time period after engine starting. However, diesel vehicles generally do not employ closed-loop fuel control. The staff proposes an amendment for diesel applications that would tie coolant temperature sensor performance with the beginning of warmed-up fuel control instead. Additionally, the staff proposes that permitted warm-up times for all vehicles should be a function of starting coolant temperature and/or intake air temperature to ensure that specified maximum warm-up times reasonably correlate with expected times. In reviewing manufacturers' OBD II system designs, the staff has found that manufacturers tend to focus on worst case operating conditions, making the monitoring strategies overly conservative under normal conditions. By correlating the maximum time with ambient temperature information, monitoring system effectiveness would be improved.

Section (b)(10.1.2)(C): It is proposed to add the wait-to-start lamp on diesel applications as an example of output components that may need to be monitored under the Comprehensive Component Monitoring requirements. The modification clarifies that the lamp is an output component for which monitoring must be considered.

Section (b)(10.2.1): The staff proposes to delete regulatory text that is redundant with language in section (b)(10.1.1)(C).

Section (b)(10.3): A modification is proposed to clarify the monitoring conditions for computer input and output components consistent with the original intent of the requirements. The modification would make clear that input components are to be monitored continuously with respect to out of range values, and once per trip at a minimum for rationality checking. Output components are to be monitored at least once per trip for proper function, and continuously with respect to circuit continuity or out of range values if such monitoring is included.

Section (b)(10.5): A modification is proposed to make clear that the determination of a component's impact on emissions is not limited to formal test procedures such as the FTP cycle or the Highway Fuel Economy Test (HWFET). Manufacturers have incorrectly determined that a component does not have to be monitored if an emission impact is not noticeable during an FTP test, regardless of the potential impact on emissions during other driving conditions such as freeway driving or hard accelerations.

Section (d): The staff proposes an amendment that would require enhanced tamper resistance measures for vehicles using Electronically Eraseable Programmable Read Only Memory (EEPROM) devices, which allow for electronic reprogramming of vehicle on-board computers. The measures could include the use of data scrambling and required access to off-site computers when installing new programming.

Section (e): Modifications are proposed to clarify the readiness/function code requirements. The proposed language would indicate that the readiness code is to be stored according to the protocol established in SAE J1979 or SAE J1939, whichever applies. Some manufacturers have misunderstood how the readiness/function code is to be implemented. Further, for evaporative system monitoring readiness, the proposed language would make clear that readiness should be indicated when a full diagnostic check with respect to the 0.040 inch orifice malfunction criteria has been completed if more constrained monitoring conditions are required with respect to detecting 0.020 inch leaks. This modification would ensure timely setting of the readiness code in-use.

Section (g)(1.0): The requirements for selecting OBD II demonstration vehicles have been clarified to better reflect the intent of the section. Some manufacturers have not understood that any OBD II equipped engine family can be selected by the ARB for demonstration. The provisions for using an alternate high mileage vehicles instead of a certification Durability Demonstration Vehicle have also been misunderstood.

Section (g)(2.4): A modification is proposed to exclude diesel applications from the requirements to demonstrate misfire detection capability. Diesel applications have separate misfire detection requirements and the demonstration test specified would not be applicable.

Sections (g)(2.6.2), (g)(4.4.5), (h)(9): Modifications are proposed to make the demonstration test protocol for catalyst monitoring on low-emission vehicles consistent with the proposed modifications to the monitoring requirements.

Section (g)(3.0): Language is proposed to make clear that a cold start is not to be required for demonstration test preconditioning cycles. A required cold start for preconditioning would unnecessarily complicate the demonstration test procedure.

Section (g)(4.0): Amendments to this section are proposed to clarify the testing sequence for demonstration evaluations to better reflect the ARB's intent.

Section (h): A modification is proposed to grant the Executive Officer the authority to waive or modify any of the requirements for certification documentation if it is determined that generation of the information would be redundant or excessively burdensome to the manufacturer. This amendment would prevent manufacturers from having to provide unnecessary information.

Section (h)(12): The staff proposes to require a description of deteriorated components used for all required OBD II demonstration tests in order to verify that the components are appropriate for OBD II demonstration and to aid in OBD II confirmation testing.

Section (h)(13): The addition of this section is proposed to require manufacturers to submit a listing of all powertrain computer input and output components in the certification application. This information is necessary for the staff to verify that all components subject to the regulation are monitored.

Section (i)(3): An amendment is proposed to make clear that manufacturers will not be held responsible during in-use recall testing for undetected malfunctions caused by tampering or abuse when it is clear that the diagnostic system could not reasonably be expected to detect such failures.

Section (i)(5): When it is determined that an OBD II system design is subject to systematic false activation of the MIL, the staff proposes to allow manufacturers to request Executive Officer approval to take corrective action other than a formal recall if the manufacturer demonstrates that alternative action would be equally effective in capturing and correcting vehicles in the field.

Section (i)(6): The catalyst monitoring requirements permit monitoring of a portion of the catalyst system to infer total system performance. The addition of this section is proposed to clarify that unmonitored catalysts are to be normally aged during in-use testing in order to limit manufacturers' liability in instances where abnormal deterioration or damage of such catalysts has occurred.

Sections (f), (h)(3), (k)(1.0), (k)(2.0), (k)(3.0), (k)(4.0): The staff proposes to update the referenced industry standards to the most recent published versions. The industry has incorporated a number of modifications to the referenced documents since they were referenced in 1991.

Section (k)(1.0): The staff proposes to limit restrictions on the use of inter-byte separation and checksums to only the messages specified in SAE J1979 in order to provide additional flexibility in transmitting other emission- and non-emission related messages. The staff does not believe that the added flexibility will have any significant impact on diagnostic tool designs.

Section (k)(5.0): Manufacturers of medium-duty vehicles and engines have requested approval to use the heavy-duty vehicle communication protocol specified in SAE J1939 as an alternative to the referenced SAE and ISO protocols. Medium-duty vehicles are often serviced at establishments specializing in maintaining heavy-duty vehicles, and often require the use of different diagnostic tools than used for passenger cars and light-duty trucks. Inclusion of the J1939 protocol as an option for these vehicles is likely to promote better standardization of heavy/medium-duty diagnostic equipment which could more adequately satisfy the goals of the standardization requirements than would forcing manufacturers to implement a "light-duty" communication protocol solely for emission diagnostics. While the staff believes the request is reasonable, the SAE J1939 document is currently in draft form and has not been thoroughly evaluated by the ARB staff. Therefore, the staff proposes to make use of the protocol optional only with Executive Officer approval in order to provide the ARB with the opportunity to ensure that its use will satisfy OBD II goals and benefit the vehicle service industry.

Section (l)(2.0): This section requires manufacturers to publish certain engine operating parameters in factory service manuals. The parameters are specific to spark ignited engines. Therefore, a modification is proposed to make clear that the section does not apply to diesels. Further, modifications are proposed to make the information requirements compatible with engines that have a low maximum engine speed and engines that do not use mass air flow sensors.

Section (l)(3.0): The staff proposes a modification to provide an additional year's leadtime to incorporate means to provide some of the information required under the section. Manufacturers have requested additional leadtime to facilitate necessary software modifications. Modifications are also proposed to clarify the scope of required information. Industry representatives have requested this clarification.

Section (m)(5.1): The staff proposes to provide manufacturers with additional leadtime to address concerns regarding OBD II implementation on alternate fuel vehicles. The proposal would allow manufacturers, up until the 1999 model year, to request exemption from certain monitoring requirements for these vehicles if the use of alternate fuels could affect the reliability of the monitoring strategy. A similar provision is proposed for California's certification procedures for retrofit alternate fuel vehicles.

Section (m)(5.2): An amendment is proposed to clarify that medium-duty engines certified on an engine dynamometer may comply with the OBD II regulation on an engine model year basis instead of a vehicle model year basis, consistent with provisions for emissions certification.

Section (m)(6.1), (6.2): Amendments are proposed that would provide for the certification of OBD II systems with identified monitoring systems shortcomings through the 2000 model year. For the 1996 model year, manufacturers would be permitted to certify engine families with up to two monitoring system deficiencies without penalty, but would be required to pay fines for the third deficiency and every additional deficiency. For the 1997 model year through the 2000 model year, only one deficiency would be permitted per engine family before fines would be imposed. The staff's proposal would not allow the carry over of deficiencies after the 1997 model year, except that carry over for one year is permitted if hardware changes are needed to fix the deficiency. Also, after the 1996 model year, fines would be imposed for all monitoring system deficiencies wherein a component or system is left completely unmonitored.

Section (n)(1.0): When the determination of a malfunction is based on vehicle emissions with respect to the applicable standards, both the certification and useful life standards apply (e.g., on a vehicle with less than 50,000 miles, a malfunction is to be indicated with respect to the 50,000 mile standards, whereas at higher mileages, a malfunction would be judged with respect to the 100,000 or 120,000 mile standards). An amendment to this section is proposed to clarify the definition of a malfunction in this respect.

Section (n)(8.0): A modification is proposed to modify the definition of "continuous monitoring" with respect to computer input components that are sampled for engine control purposes at relatively low rates. The amendment makes clear that manufacturers do not need to increase the sampling rate of a component solely for the purposes of monitoring.

Section (n)(11.0): A separate definition for "calculated load value" is proposed for diesel applications. The current definition is not easily applicable to diesels.

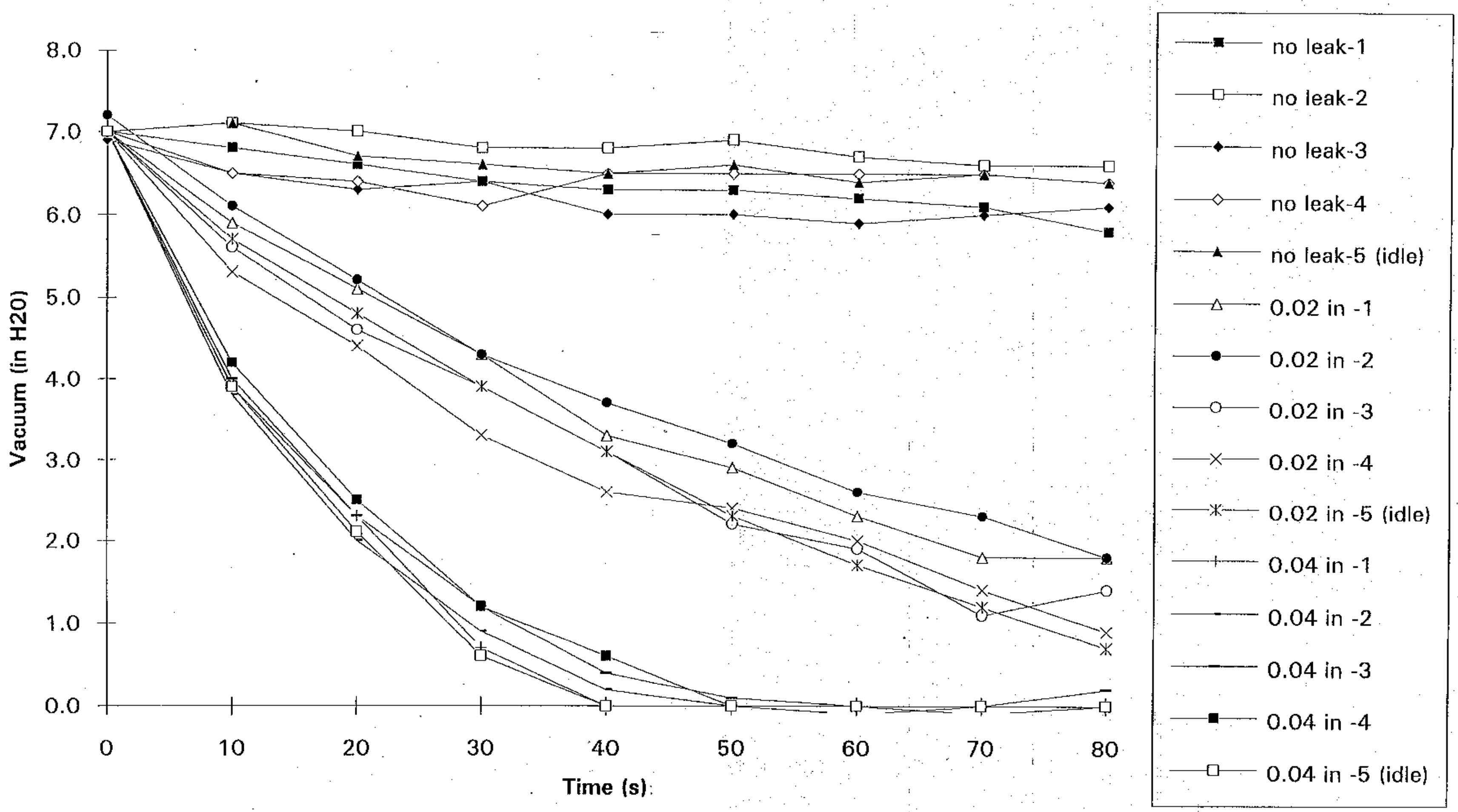
Section (n)(15.0): The staff proposes to modify the definition for diesel engines to include only engines using a compression ignition thermodynamic cycle, and not spark ignited diesel-derived engines. The latter more closely resemble conventional spark ignited engines than compression ignition engines with respect to the emission control system design.

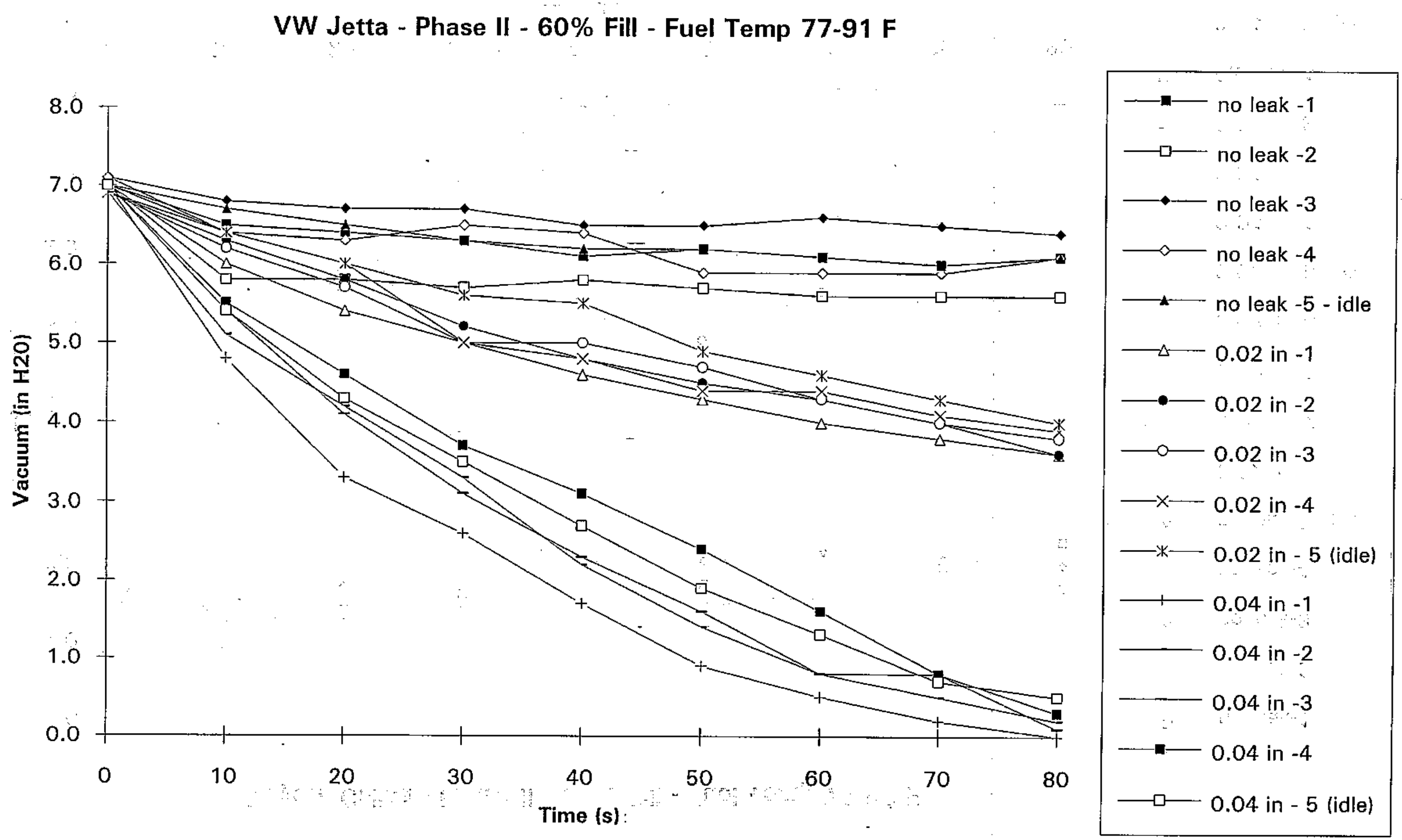
Section (n)(18.0): For the purposes of the misfire detection requirements, the staff proposes a definition for "redline engine speed" that is based on manufacturer's maximum recommended engine speed or the engine speed at which fuel cutoff occurs. Manufacturers have requested that the regulation be clarified to reflect this.

APPENDIX B

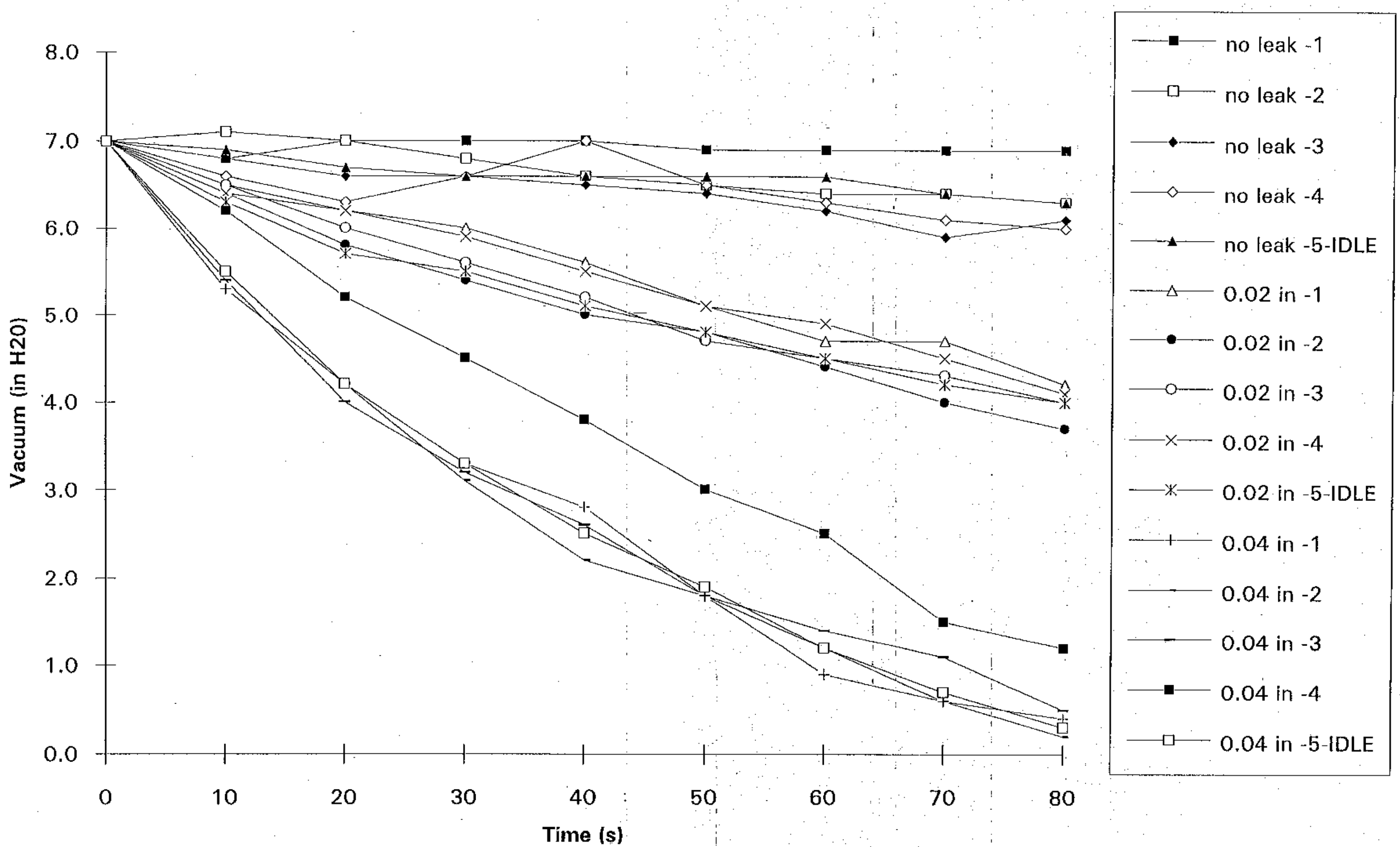
Evaporative System Leak Detection Plots

Toyota Celica - Phase II - 60% Fill - Fuel Temp 71-96 F




VW Jetta - Phase II - 60% Fill - Fuel Temp 77-91 F
Vacuum (in H20)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
10
20
30
40
50
60
70
80
Time (s)
no leak -1
no leak -2
no leak -3
no leak -4
no leak -5 - idle
0.02 in -1
0.02 in -2
0.02 in -3
0.02 in -4
0.02 in - 5 (idle)
0.04 in -1
0.04 in -2
0.04 in -3
0.04 in -4
0.04 in - 5 (idle)

Ford F150 - Phase II - 60% Fill - Fuel Temp 71-88 F



APPENDIX C

Modifications to Sections 1968.1, Title 13, California Code of Regulations

Note: These are amendments to section 1968.1, Title 13, CCR. The proposed amendments are shown in underline to indicate additions to the sections and ~~strikeout~~ to indicate deletions.

1968.1 Malfunction and Diagnostic System Requirements--1994 and Subsequent Model-Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles and Engines

(a) GENERAL REQUIREMENTS

(1.0) All 1994 and subsequent model-year passenger cars, light-duty trucks, and medium-duty vehicles shall be equipped with a malfunction indicator light (MIL) located on the instrument panel that will automatically inform the vehicle operator in the event of a malfunction of any powertrain components which can affect emissions and which provide input to, or receive output from, the on-board computer(s) or of the malfunction of the on-board computer(s) itself. The MIL shall not be used for any other purpose.

(1.1) The MIL shall be of sufficient illumination and location to be readily visible under all lighting conditions. The MIL shall illuminate in the engine-run key position before engine cranking to indicate that the MIL is functional and shall, when illuminated, display the phrase "Check Engine" or "Service Engine Soon". The word "Powertrain" may be substituted for "Engine" in the previous phrases. Alternatively, the International Standards Organization (ISO) engine symbol may be substituted for the word "Engine."

(1.2) All 1994 and subsequent model-year passenger cars, light-duty trucks, and medium-duty vehicles required to have MIL pursuant to (1.0) above shall also be equipped with an on-board diagnostic system capable of identifying the likely area of the malfunction by means of fault codes stored in computer memory. These vehicles shall be equipped with a standardized electrical connector to provide access to the stored fault codes. Specific performance requirements are listed below. A glossary of terms is contained in subsection (n)[1] ~~at the end of this section.~~

(1.3) Any reference to vehicles in this regulation shall also include medium-duty vehicles with engines certified on an engine dynamometer.

~~(1.4) Manufacturers of diesel engines utilizing computer-based electronic powertrain control systems shall submit a plan for complying with these requirements to the Executive Officer for approval at least two years prior to certification. The plan shall be approved based on monitoring all powertrain components which can affect emissions and for which reliable monitoring techniques are available at costs comparable to other engines meeting these requirements, and on meeting all other applicable requirements (e.g., storing freeze frame conditions, meeting standardization requirements, etc.).~~

[1] Unless otherwise noted, all section references are contained within this subsection of Title 13, CCR.

(1.~~5~~4) For Low Emission Vehicles (LEV), the Executive Officer shall revise the emission threshold for a malfunction on any check if the most reliable monitoring method developed requires a higher threshold to prevent significant errors of commission in detecting a malfunction.

(1.~~6~~5) For every case in which a malfunction is to be noted when an emission threshold is exceeded (e.g., emissions in excess of 1.5 times the standard), the manufacturer may perform only a functional check (defined in section (n)(16.0)) of a specific component or system if deterioration or failure of such would not cause the vehicle's emissions to exceed the emission threshold.

(1.~~7~~6) After the 1998 model year, for Non-LEVs, fulfillment of federal On-Board Diagnostic (OBD) requirements shall be deemed to be an acceptable option for the manufacturer for the purpose of meeting these requirements.

(1.~~8~~7) For 1994 and 1995 model years only, illumination of the malfunction indicator light upon detection of a malfunction shall be optional for catalyst, misfire, and complete evaporative system monitoring. MIL illumination for such vehicles shall be optional for other monitoring requirements, subject to Executive Officer approval, on the basis of use of a new monitoring strategy which is significantly different than that used previously by the manufacturer and/or which entails a high degree of sophistication in its application. Irrespective of the preceding the MIL shall illuminate on these vehicles in accordance with section 1968.1 for lack of function (see section (n)(16.0)) for electronic components/systems otherwise approved for not illuminating the MIL. Furthermore, setting fault codes for all malfunctions shall continue to conform with requirements of section 1968.1. For components/systems not requiring illumination of the MIL, manufacturers shall provide a plan for approval by the Executive Officer for reporting on the correct performance of the monitoring systems in customer use at 6 month intervals beginning from the start of production each year for at least the first three years after production. Approval of the plan shall be based on obtaining a statistically valid sample size, assuring that adequate resources are available to investigate the potential problems, and assuring that a wide variety of vehicles, operating modes, and mileage accumulation will be included in the evaluation. Should incorrect performance of the diagnostic system be determined by the Executive Officer on the basis of these reports or through other means, manufacturers shall recall the vehicles for correction of the OBD II system in accordance with Article 2.2, Title 13 CCR, or they shall submit an alternate plan for remedying the problem for approval by the Executive Officer on the basis of achieving comparable capture rates and timeliness as an official recall plan.

(1.~~9~~8) Manufacturers may employ alternate statistical MIL illumination and fault code storage protocols to those specified in these requirements, subject to Executive Officer approval based on comparable timeliness in detecting a malfunction and evaluating system performance. For strategies requiring on average between three and six driving cycles for MIL illumination, the manufacturer shall provide data and/or an engineering evaluation which adequately demonstrate that the monitoring system is equally effective and timely in detecting component deterioration. Strategies requiring on average more than six driving cycles for MIL illumination shall not be accepted.

(1.9) Regarding diagnostic system monitoring conditions and MIL illumination requirements, manufacturers are generally required to define appropriate operating conditions for monitoring, subject to the limitation that the monitoring conditions shall be encountered at least once during the first engine start portion of the applicable Federal Test Procedure (FTP) test. Upon detection of a malfunction, the MIL is to be illuminated and a fault code stored no later than the end of the next driving cycle during which monitoring occurs provided the malfunction is again detected. Until the 1997 model year, diagnostic strategies that illuminate the MIL on the basis of completing a trip (trip is defined in section (n)(16.0) of these requirements) shall be accepted. When a trip criterion is employed, upon detection of a malfunction, the diagnostic system shall store a fault code and the MIL shall be illuminated no later than the end of the next trip if the malfunction is again present.

(2.0) Manufacturers may request Executive Officer approval to disable a diagnostic system designed to meet the requirements of section (b) at ambient engine starting temperatures below twenty degrees Fahrenheit, and at elevations above eight thousand feet above sea level provided the manufacturer submits data and/or an engineering evaluation which adequately demonstrate that monitoring would be unreliable when such conditions exist. Notwithstanding, diagnostic system disablement may be requested at other ambient engine starting temperatures if the manufacturer adequately demonstrates with data and/or an engineering evaluation that misdiagnosis would occur due to the impact of such ambient temperatures on the performance of the component itself (e.g., component freezing).

(2.1) Manufacturers may disable monitoring systems that can be affected by running out of fuel (e.g., misfire detection) when the fuel level is low, provided disablement will not occur when the fuel level is above 15 percent of the nominal capacity of the fuel tank.

(2.2) For vehicles designed to accommodate the installation of Power Take-Off (PTO) units (defined in section (n)(19.0)), disablement of affected monitoring systems is permitted provided disablement occurs only while the PTO unit is active, and provided the OBD II readiness code (specified in section (e)) is cleared by the on-board computer upon activation of the PTO unit.

(b) MONITORING REQUIREMENTS

(1.0) CATALYST MONITORING

(1.1) Requirement:

(1.1.1) ~~LEVs: The diagnostic system shall individually monitor the front catalyst or catalysts (i.e., any catalyst(s) which receive engine-out untreated exhaust gas), except that front catalysts may be monitored in combination with the next catalyst downstream if it can be demonstrated that a malfunction will be indicated when the front catalyst is alone malfunctioning (see (b) (1.2.1)). Catalysts arranged in parallel with the same inlet and outlet in a single exhaust pipe shall be considered as one catalyst. A separate catalyst incorporated in series into the~~

~~same container as a front catalyst shall be considered a downstream catalyst.~~ The diagnostic system shall monitor the catalyst system for proper performance.

~~(1.1.2) If the front catalyst is a small volume catalyst (see (b)(1.2.2)), the diagnostic system shall also monitor the next catalyst downstream of the small volume catalyst either independently of, or (if the conditions in section (1.1.1) are met) in combination with, the small volume catalyst.~~

~~(1.1.3) Manufacturers may submit other monitoring strategies, subject to Executive Officer approval, based on equal timeliness and reliability in detecting a catalyst malfunction as these requirements.~~

~~(1.1.4) Non-LEVs: The diagnostic system shall monitor the catalyst system for proper performance.~~

(1.1.2) Manufacturers are not required to implement these catalyst monitoring requirements on diesel vehicles and engines.

(1.2) Malfunction Criteria:

(1.2.1) Low Emission Vehicles (see section (n)(14.0)): ~~Each monitored catalyst, or combination of catalysts, shall be considered malfunctioning when average Federal Test Procedure (FTP) total hydrocarbon (HC) conversion efficiency falls between 50 to 60 percent. The efficiency determination shall be based on an FTP test wherein a malfunction is noted when the cumulative total HC emissions measured at the outlet of the monitored catalyst(s) is more than 40 to 50 percent of the cumulative total engine-out emissions measured at the inlet of the catalyst(s). In addition, if a front catalyst is monitored in combination with a downstream catalyst, the front catalyst shall be considered malfunctioning when its efficiency has deteriorated between 40 to 50 percent from its 4000 mile average FTP total HC efficiency.~~ The catalyst system shall be considered malfunctioning when its conversion capability decreases to the point that either of the following occurs: 1) Hydrocarbon (HC) emissions exceed the applicable emission threshold specified in section (b)(1.2.2) below, or 2) the average Federal Test Procedure (FTP) Non-Methane Hydrocarbon (NMHC) conversion efficiency of the monitored portion of the catalyst system falls below 50 percent. Regarding the second criterion, the efficiency determination shall be based on an FTP test wherein a malfunction is noted when the cumulative NMHC emissions measured at the outlet of the monitored catalyst(s) are more than 50 percent of the cumulative engine-out emissions measured at the inlet of the catalyst(s).

(1.2.2) TLEV applications shall employ an emission threshold malfunction criterion of 2.0 times the applicable FTP HC standard plus the emissions from a test run with a representative 4000 mile catalyst system (125 hours of operation for medium-duty vehicles with engines certified on an engine dynamometer). The emission threshold criterion for LEV applications shall be 2.5 times the applicable FTP HC standard plus the emission level with a representative 4000 mile catalyst system. Notwithstanding, beginning with the 1998 model year, manufacturers shall phase in an emission threshold of 1.5 times the applicable FTP HC standard for all categories of low emission vehicles, which shall not include the emission level with a 4000 mile catalyst system. The phase in percentages (based on the manufacturer's projected sales volume for low emission vehicle applications) shall equal or exceed 40 percent in the 1998 model year, 70 percent in the 1999 model year, with 100 percent implementation for the 2000 model year. ULEV applications shall comply with the 1.5 times the standard emission threshold, and shall be included in the phase-in percentages specified above; however, prior to the 1998 model year, the Executive Officer shall revise the emission threshold for such vehicles if the manufacturer submits data and/or an engineering evaluation which adequately demonstrate that substantial vehicle body and/or catalyst system modifications would be necessary for this threshold to be met.

~~(1.2.2) For LEVs, each small volume catalyst (i.e., those designed with a conversion efficiency too low to be practically monitored for 50 to 60 percent average FTP total HC efficiency) monitored independently shall be considered malfunctioning when its average FTP conversion efficiency has deteriorated by between 40 to 50 percent from its 4000 mile conversion efficiency.~~

(1.2.3) Non-Low Emission Vehicles: The catalyst system shall be considered malfunctioning when its conversion capability decreases to the point that HC emissions increase by more than 1.5 times the standard over an FTP test from a test run with a representative 4000 mile catalyst system.

(1.2.4) For 1994 and 1995 model year vehicles and engines ~~LEVs and Non-LEVs~~, as an option to monitoring the catalyst during FTP driving conditions, manufacturers may monitor the front catalyst independently of, or in combination with, the next catalyst downstream. Each monitored catalyst or catalyst combination shall be considered malfunctioning when total HC conversion efficiency falls below 60 percent while in normal closed loop operation. As a guideline, the catalyst(s) should not be considered malfunctioning when its efficiency is greater than 80 percent. The efficiency determination shall be based on a steady state test wherein a malfunction is noted when the total HC emission concentration measured at the outlet of the monitored catalyst(s) is more than 20 to 40 percent of the cumulative total engine-out emissions measured at the inlet of the catalyst(s). Alternatively, if correlation with FTP emissions can be demonstrated, manufacturers may use the malfunction criteria specified in (b)(1.2.1) or (b)(1.2.3). 1994 and 1995 model year vehicles certified to this option shall incorporate FTP based monitoring no later than the 1997 model year (vehicles initially complying with section 1968.1 in the 1996 model year shall utilize an FTP based catalyst monitoring system).

(1.3) Monitoring Conditions:

(1.3.1) ~~A catalyst monitoring check shall occur at least once per trip except for vehicles utilizing steady state monitoring, which shall comply with section (1.3.2). "Trip" is defined in section (n) (5.0). This trip definition applies throughout section 1968.1.~~ The manufacturer shall define appropriate operating conditions during which monitoring shall occur, subject to the limitation that the monitoring conditions shall be encountered at least once during the first engine start portion of the applicable FTP test. However, vehicles utilizing steady state monitoring (as permitted by section (1.2.3) above), may alternatively comply with the monitoring conditions specified in section (1.3.2). The monitoring system shall operate at least once per driving cycle during which the manufacturer-defined monitoring conditions are met.

(1.3.2) If steady state efficiency is being monitored (see section (b) (1.2.4)), the manufacturer shall choose a non-closed throttle, reasonably steady speed condition for monitoring the catalyst with the constraints that the check shall (i) occur between 20 mph and 50 mph, or within an engine rpm and torque range determined by the manufacturer to be representative of medium-duty vehicle operating conditions between 20 and 50 mph steady speed conditions with a load equivalent to 50 percent of the maximum load carrying capacity, (ii) take no more than a 20 second interval to determine both that the vehicle is operating in a proper window to perform the check and to actually perform the check, and (iii) be conducted at the earliest such condition encountered after the beginning of closed-loop operation for each driving cycle. Performance of the check may be delayed after engine startup until stabilized coolant temperature is achieved and/or a suitable cumulative time interval of non-closed throttle vehicle operation has elapsed to ensure the catalyst is warmed-up for properly performing the monitoring check. The specified cumulative time interval shall begin from the first non-closed throttle operation either after achieving a stabilized coolant temperature or after engine starting and shall not exceed 180 seconds. These monitoring constraints and conditions may be altered, subject to Executive Officer Approval. Such approval shall be granted if the manufacturer submits data and an engineering evaluation justifying the need for the exception and demonstrates that the requested alteration would yield improved catalyst monitoring. "Reasonably steady" speed interval in this instance means a 20 second period where all accelerations and decelerations are of an average magnitude equivalent to 0.5 mph/second or less over any two second interval during this period. The manufacturer may abort the check if the engine operating conditions change during the check so that the vehicle exceeds the speed or acceleration/deceleration tolerances before the end of the checking interval. The manufacturer may base performance of the catalyst check upon engine RPM and load conditions equivalent to the above monitoring conditions. If a manufacturer develops a means of monitoring catalyst efficiency which cannot utilize a steady state monitoring period (e.g., examining time vs. temperature during catalyst warmup), it may present a monitoring proposal to the Executive Officer for approval based on equivalent accuracy and timeliness as the steady state monitoring protocol in detecting a malfunctioning catalyst.

(1.4) MIL Illumination and Fault Code Storage:

(1.4.1) Except as noted below, ~~upon detection of a catalyst malfunction, the diagnostic system shall store a fault code and the MIL shall be illuminated no later than the end of the next trip if the malfunction is again present.~~ upon detection of a catalyst malfunction, the MIL shall illuminate and a fault code stored no later than the end of the next driving cycle during which monitoring occurs provided the malfunction is again present.

(1.4.2) For steady state catalyst efficiency checks, upon detection of catalyst efficiency below 60 percent, the diagnostic system may perform up to two successive monitoring checks prior to informing the vehicle operator of a malfunction. These monitoring checks need not occur on the same driving cycle, but shall be performed as soon as proper monitoring conditions occur. If catalyst efficiency remains below 60 percent for the three sequential checks, a fault code shall be stored and the MIL shall then be activated.

(1.4.3) The diagnostic system shall temporarily disable catalyst monitoring when a malfunction exists which could affect the proper evaluation of catalyst efficiency.

(1.4.4) The monitoring method for the catalyst(s) shall be capable of detecting when a catalyst trouble code has been cleared (except diagnostic system self-clearing), but the catalyst has not been replaced (e.g., catalyst overtemperature approaches may not be acceptable).

(2.0) HEATED CATALYST MONITORING

(2.1) Requirement:

(2.1.1) The diagnostic system shall monitor all heated catalyst systems for proper heating.

(2.1.2) ~~In addition to the non-heated catalyst requirements in section (b) (1), the HC conversion efficiency of all heated catalysts shall each be monitored. Manufacturers may monitor heated catalysts in combination with another catalyst if it can be demonstrated that a malfunction will be indicated when the heated catalyst is malfunctioning. Otherwise, the heated catalyst shall be monitored independently. If a heated catalyst is a small volume front catalyst, the diagnostic system shall also monitor the next catalyst downstream either independently of, or (if the conditions above are met) in combination with, the small volume heated catalyst.~~ The efficiency of heated catalysts shall be monitored in conjunction with the requirements of section (b)(1).

(2.2) Malfunction Criteria:

~~(2.2.1) Pre-Start Heated Catalyst Systems: The system shall be considered malfunctioning when the designated pre-start catalyst temperature is not attained before engine starting.~~

(2.2.~~2~~1) ~~After-Start Heated Catalyst Systems~~ The catalyst heating system shall be considered malfunctioning when the catalyst does not reach its designated heating temperature within a requisite time period after engine starting. The time period is to be determined by the manufacturer subject to the requirement that the system shall detect a heating system malfunction causing emissions from a vehicle equipped with the heated catalyst system to exceed 1.5 times any of the applicable FTP standards.

(2.2.~~3~~2) Manufacturers using other heating or monitoring strategies may submit an alternate plan for approval by the Executive Officer to monitor heated catalyst systems based on comparable reliability and timeliness to these requirements in detecting a catalyst heating malfunction.

~~(2.2.4) Except as noted in section (b) (1.2.4), the diagnostic system shall use the malfunction criteria specified in section (b)(1.2.1) or section (b) (1.2.2), whichever is applicable, when monitoring the conversion efficiency of a heated catalyst.~~

(2.3) Monitoring Conditions:

~~(2.3.1)~~ Manufacturers shall define appropriate operating conditions for monitoring of the catalyst heating system, subject to the limitation that the monitoring conditions shall be encountered at least once during the first engine start portion of the applicable FTP test. The monitoring system shall operate at least once per driving cycle during which the manufacturer-defined monitoring conditions are met. ~~Pre-Start Heated Catalyst Systems: The diagnostic system shall monitor the heating system for proper operation once per trip. Manufacturers may disable the monitoring system for one engine start if during the previous driving cycle the vehicle traveled less than the equivalent of the first one mile of FTP driving.~~

~~(2.3.2) After-Start Heated Catalyst Systems: The diagnostic system shall monitor the heating system for proper operation once per trip. Manufacturers may disable the monitoring system for one engine start if during the previous driving cycle the vehicle traveled less than the equivalent of the first one mile of FTP driving.~~

~~(2.3.3) Except as noted in section (b) (1.2.4), the diagnostic system shall monitor the conversion efficiency of all heated catalysts at least once per trip.~~

(2.4) MIL Illumination and Fault Code Storage:

~~(2.4.1)~~ Upon detection of a catalyst heating malfunction, ~~the diagnostic system shall store a fault code and the MIL shall be illuminated no later than the end of the next trip if the malfunction is again present~~ the MIL shall illuminate and a fault code stored no later than the end of the next driving cycle during which monitoring occurs provided the malfunction is again present.

~~(2.4.2) For heated catalyst efficiency malfunctions, the MIL shall be illuminated, and a fault code stored according to section (b) (1.4).~~

(3.0) MISFIRE MONITORING

(3.1) Requirement: The diagnostic system shall monitor engine misfire and shall identify the specific cylinder experiencing misfire. Manufacturers may request Executive Officer approval to store a general misfire fault code instead of a cylinder specific code under certain operating conditions provided the manufacturer submits data and/or an engineering evaluation which adequately demonstrate that the misfiring cylinder cannot be reliably identified when such conditions occur. If more than one cylinder is misfiring, a separate code shall indicate that multiple cylinders are misfiring (specifying the individual misfiring cylinders under this condition is optional, however, identifying only one misfiring cylinder shall not occur when a multiple misfire code is stored).

(3.2) Malfunction Criteria: The manufacturer shall specify in the documentation provided for certification (see subsection (g) and (h) infra.) a percentage of misfires out of the total number of firing events necessary for determining a malfunction for each of the conditions listed below.

(A) The percent misfire evaluated in 200 revolution increments for each engine speed and load condition which would result in catalyst damage. Subject to Executive Officer approval, a longer interval (up to 1000 revolutions) may be employed provided the manufacturer submits data and/or an engineering evaluation which adequately demonstrate that catalyst damage would not occur due to unacceptably high catalyst temperatures before the interval has elapsed. The manufacturer shall submit in the certification documentation catalyst temperature data versus percent misfire over the full range of engine speed and load conditions. The data shall be obtained from a representative cross section of a manufacturer's engine offerings from small to large displacements. Up to three such engine evaluations shall be documented per manufacturer, though a manufacturer may submit more data if desired. An engineering evaluation shall be provided for establishing malfunction criteria for the remainder of engine families in the manufacturer's product line. The Executive Officer shall waive the evaluation requirement each year if, in the judgment of the Executive Officer, technological changes do not affect the previously determined malfunction criteria;

(B) The percent misfire evaluated in 1000 revolution increments which would cause emissions from a durability demonstration vehicle to exceed 1.5 times any of the applicable FTP standards if the degree of misfire were present from the beginning of the test. ~~If the level of misfire determined under this requirement is significantly lower for an LEV as opposed to a Non-LEV with a similar engine design, the manufacturer may request approval from the Executive Officer to use a higher percentage of misfire as the malfunction criteria for the LEV, not to exceed the level of the Non-LEV.~~ For the purpose of establishing the percent misfire, the manufacturer shall conduct the demonstration test(s) with the misfire events occurring at equally spaced complete engine cycle intervals, across randomly selected cylinders throughout each 1000 revolution increment. However, the percent misfire established shall be applicable for any misfire condition (e.g. random, continuous, equally spaced, etc.) for the purpose of identifying a malfunction. This criterion shall be used for all vehicles with engines containing the same number of cylinders as the demonstration vehicle. The number of misfires in 1000 revolution increments which was determined for the durability demonstration vehicle malfunction criterion may be used to establish the corresponding percent misfire malfunction criteria for engines with other numbers of cylinders. The malfunction criteria for a manufacturer's product line shall be updated when a new durability demonstration vehicle is tested which indicates more stringent criteria are necessary than previously established to remain within the above emission limit;

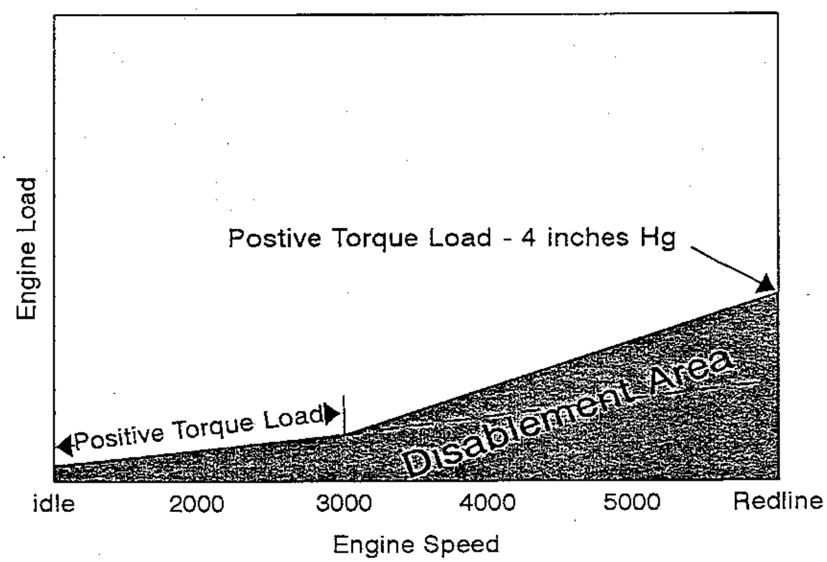
(C) The degree of misfire evaluated in 1000 revolution increments which would cause a durability demonstration vehicle to fail an Inspection and Maintenance program tailpipe emission test. This criterion shall apply to vehicles with the same number of cylinders as the demonstration vehicle. The number of misfires in 1000 revolution increments which was determined for the durability demonstration vehicle malfunction criterion may be used to establish the corresponding percent misfire malfunction criteria for engines with other numbers of cylinders. The malfunction criteria for a manufacturer's product line shall be updated when a new durability demonstration vehicle is tested which indicates more stringent criteria are necessary than previously established to ensure passing an Inspection and Maintenance test, or when the Inspection and Maintenance test is revised.

(3.3) Monitoring Conditions: ~~For 1997 and later model year vehicles, misfire shall be monitored continuously and under all positive torque engine speeds and conditions.~~

(3.3.1) ~~For pre-1997 model year vehicles,~~ Pre-1997 Model Year Vehicles: misfire shall be monitored continuously during, at a minimum, positive torque operating conditions within the range of engine speed and load condition combinations encountered during an FTP test; nonetheless, subject to Executive Officer approval, manufacturers may employ higher misfire percentage malfunction criteria ~~disable misfire monitoring~~ under specific conditions within the range of operating conditions encountered during an FTP test if the manufacturer provides data and/or an engineering evaluation which ~~can~~ adequately demonstrate that the detection of lower levels of misfire ~~monitoring is not~~ would not be reliable ~~feasible~~ for the vehicle model in question when such conditions are encountered without making fundamental engine or control unit design modifications. If the manufacturer can so demonstrate that even the detection of a higher misfire percentages is not feasible under specific FTP operating conditions, the manufacturer may request Executive Officer approval to disable the monitoring system when such conditions are encountered. ~~Further, with Executive Officer approval, the manufacturer may disable misfire monitoring when misfire cannot be distinguished from other effects when using the best available monitoring technology. The manufacturer shall present data and an engineering evaluation to the Executive Officer to justify the proposed action.~~

(3.3.2) 1997 and Later Model Year Vehicles: Manufacturers shall phase in expanded misfire monitoring conditions beginning with the 1997 model year. The phase in percentages (based on the manufacturer's projected sales volume for all vehicles and engines) shall equal or exceed 50 percent in the 1997 model year, 75 percent in the 1998 model year, 90 percent in the 1999 model year, with 100 percent implementation for the 2000 model year. Small volume manufacturers shall not be required to meet the phase-in percentages; however, 100 percent implementation of these monitoring conditions shall be required beginning with the 2000 model year. On vehicles meeting these phase-in percentages, except as provided for in section (3.3.3) below, monitoring for misfire shall be continuous and under all positive torque engine speeds and load conditions. Vehicles not meeting the monitoring conditions of this section shall meet the monitoring conditions specified in section (b)(3.3.1) above.

(3.3.3) As an exception to monitoring misfire during all positive torque operating conditions, manufacturers may disable misfire monitoring in the engine operating region bound by the positive torque line (i.e., engine load with the transmission in neutral), and the two following engine operating points: an engine speed of 3000 rpm with the engine load at the positive torque line, and the redline engine speed (defined in section (n)(18.0)) with the engine's manifold vacuum at four inches of mercury lower than that at the positive torque line. Below is a diagram of the permitted misfire detection disablement region with respect to the requirements of this section. Further, with Executive Officer approval, the manufacturer may disable misfire monitoring when misfire cannot be distinguished from other effects (e.g., rough roads, transmission shifts, etc.) when using the best available monitoring technology. The manufacturer shall present data and/or an engineering evaluation to the Executive Officer to justify the proposed action. Executive Officer approval shall be based on the extent to which monitoring is expected to be disabled in relation to the capabilities of the best available monitoring technologies as applied to other engines.



(3.4) MIL Illumination and Fault Code Storage:

(3.4.1) Except as provided below, upon detection of the level of misfire specified in subsection (3.2) (A), the MIL shall blink once per second during actual misfire conditions and remain continuously illuminated otherwise. In vehicles which provide fuel shutoff and default fuel control to prevent overfueling during misfire conditions, the MIL need not blink and may instead illuminate continuously upon detection of misfire provided that the fuel shutoff and default control shall be activated as soon as misfire is detected. Fuel shutoff and default fuel control may be deactivated only to permit fueling outside of the misfire range.

(3.4.2) Upon detection of the misfire levels specified in subsection (3.2) (B) or (C), the MIL shall be illuminated and a fault code stored no later than the end of the next driving cycle if misfire is again detected. If misfire is not detected during the second driving cycle, the MIL shall be illuminated and a fault code stored no later than the next driving cycle in which misfire is detected, unless driving conditions similar to those under which misfire was originally detected have been encountered (see section (3.4.3)) without an indication of misfire, in which case the initial temporary code and stored conditions may be erased. Furthermore, if similar driving conditions are not encountered during 80 driving cycles ~~trips~~ subsequent to the initial detection of a malfunction, the initial temporary code and stored conditions may be erased.

(3.4.3) Upon detection of misfire, manufacturers shall store the engine speed, load, and warm-up status (i.e., cold or warmed-up) under which the first misfire event was detected. A ~~trip or~~ driving cycle shall be considered to have similar conditions if the stored engine speed conditions are encountered within 375 rpm, load conditions within 10 percent, and the same warm-up status is present. With Executive Officer approval, other strategies for determining if similar conditions have been encountered may be employed. Approval shall be based on comparable timeliness and reliability in detecting similar conditions.

(3.5) MISFIRE MONITORING FOR DIESELS

(3.5.1) Requirement: Beginning with the 1998 model year, the diagnostic system on a diesel engine shall be capable of detecting the lack of combustion in one or more cylinders. The diagnostic system shall also identify the specific cylinder for which combustion cannot be detected. If the lack of combustion is present in more than one cylinder, a separate code shall indicate that multiple cylinders are malfunctioning (specifying the individual malfunctioning cylinders under this condition is optional; however, identifying one malfunctioning cylinder shall not occur when a multiple cylinder code is stored).

(3.5.2) Malfunction Criteria: A cylinder shall be considered malfunctioning when combustion cannot be detected.

(3.5.3) Monitoring Conditions: Manufacturers shall define appropriate operating conditions for monitoring, subject to the limitation that the monitoring conditions shall be encountered at least once during the first engine start portion of the applicable FTP test. The monitoring system shall operate at least once per driving cycle during which the manufacturer-defined monitoring conditions are met.

(3.5.4) MIL Illumination and Fault Code Storage: The MIL shall illuminate and a fault code shall be stored no later than the end of the next driving cycle during which monitoring occurs provided the malfunction is again present.

(4.0) EVAPORATIVE SYSTEM MONITORING

(4.1) Requirement:

(4.1.1) The diagnostic system shall verify air flow from the complete evaporative system. In addition, the diagnostic system shall also monitor the evaporative system for the loss of HC vapor into the atmosphere by performing a pressure or vacuum check of the complete evaporative system.

(4.1.2) Manufacturers may temporarily disable the evaporative purge system to perform a check.

(4.1.3) Manufacturers may request Executive Officer approval to disable or abort an evaporative system check under specific conditions (e.g., when the fuel tank level is over 85 percent of nominal tank capacity) if ~~it can be~~ data and/or an engineering evaluation are provided which adequately demonstrate~~d~~ that a reliable check cannot be made when these conditions exist.

(4.1.4) Subject to Executive Officer approval, other monitoring strategies may be used provided the manufacturer provides a description of the strategy and supporting data showing equivalent monitoring reliability and timeliness in detecting an evaporative system malfunction or leak.

(4.1.5) Implementation of this requirement is mandatory only for 1996 and later model year vehicles designed to comply with the requirements of Title 13, California Code of Regulations, Section 1976, "Standards and Test Procedures for Motor Vehicle Fuel Evaporative Emissions," for 1995 and subsequent model year vehicles.

(4.2) Malfunction Criteria:

(4.2.1) An evaporative system shall be considered malfunctioning when no air flow from the system can be detected, or when a system leak is detected that is greater than or equal in magnitude to a leak caused by a 0.040 inch diameter orifice in any portion of the evaporative system excluding the tubing and connections between the purge valve and the intake manifold.

(4.2.2) Beginning with the 1998 model year, manufacturers shall phase-in diagnostic strategies to detect system leaks greater than or equal in magnitude to a leak caused by a 0.020 inch diameter orifice. The phase-in percentages (based on the manufacturer's projected sales volume for all vehicles) shall equal or exceed 50 percent for the 1998 model year, 75 percent for the 1999 model year, and 100 percent implementation for the 2000 model year. Small volume manufacturers shall not be subject to the phase-in requirements; however, 100 percent implementation shall be required for 2000 model year.

(4.2.3) On vehicles with fuel tank capacity greater than 25 gallons, the Executive Officer shall revise the size of the orifice if the most reliable monitoring method available cannot reliably detect a system leak of ~~this~~ the magnitudes indicated above.

(4.3) Monitoring Conditions: ~~The monitoring system shall monitor the evaporative system at least once per trip.~~ Manufacturers shall define appropriate operating conditions for monitoring, subject to the limitation that the monitoring conditions shall be encountered at least once during the first engine start portion of the applicable FTP test. The monitoring system shall operate at least once per driving cycle during which the manufacturer-defined monitoring conditions are met. However, monitoring conditions may be further limited with respect to detecting leaks equivalent to a 0.020 inch diameter orifice, subject to Executive Officer approval, on the basis that the monitoring conditions will be reasonably-occurring in-use, and provided that a check for leaks equal or greater in magnitude than a 0.040 inch orifice will continue to be conducted at least once per driving cycle as indicated above. Subject to Executive Officer approval, if performance of the check causes vehicles to exceed applicable emission standards when using the best available technology, manufacturers may perform evaporative system monitoring during a steady-speed condition, as defined in section (b) (1.3.2), between 20 and 50 mph.

(4.4) MIL Illumination and Fault Code Storage:

(4.4.1) Upon detection of an evaporative system malfunction or a malfunction that prevents completion of an evaporative system check, the MIL shall illuminate and a fault code shall be stored no later than the end of the next driving cycle during which monitoring occurs provided the malfunction is again present. ~~the diagnostic system shall store a fault code and the MIL shall illuminate no later than the end of the next trip if the malfunction is again detected.~~

(4.4.2) If the diagnostic system is capable of discerning that a system leak is being caused by a missing or improperly secured fuel cap, the manufacturer may notify the vehicle operator through the use of an indicator light other than the MIL. The manufacturer is not required to store a fault code in this case. The indicator light shall conform to the requirements outlined in section (a) (1.1) for location and illumination. As another option, the manufacturer may extinguish the MIL, provided no other malfunctions have been detected, and may erase the fault code corresponding to the problem once the on-board diagnostic system has verified that the fuel cap specifically has been securely fastened. Other equivalent strategies shall be considered by the Executive Officer.

(5.0) SECONDARY AIR SYSTEM MONITORING

(5.1) Requirement: Any vehicle equipped with any form of secondary air delivery system shall have the diagnostic system monitor the proper functioning of (i) the secondary air delivery system and (ii) any air switching valve.

(5.2) Malfunction Criteria:

(5.2.1) The diagnostic system shall indicate secondary air delivery system malfunction when the flow rate falls below the manufacturer's specified low flow limit such that a vehicle would exceed 1.5 times any of the applicable FTP emission standards.

(5.2.2) Manufacturers adequately demonstrating that deterioration of the flow distribution system is unlikely may request Executive Officer approval to perform only a functional check of the system. As part of this demonstration, manufacturers shall demonstrate that the materials used for the secondary air system (e.g., air hoses, and tubing) are inherently resistant to corrosion or other deterioration. ~~In such a case,~~ If a functional check is approved, the diagnostic system shall indicate a malfunction when some degree of secondary airflow is not detectable in the exhaust system during a check.

(5.3) Monitoring Conditions: ~~The monitoring of the secondary air delivery system and the air switching valve shall occur once per trip.~~ Manufacturers shall define appropriate operating conditions for monitoring of the secondary air system, subject to the limitation that the monitoring conditions shall be encountered at least once during the first engine start portion of the applicable FTP test. The monitoring system shall operate at least once per driving cycle during which the manufacturer-defined monitoring conditions are met.

(5.4) MIL Illumination and Fault Code Storage: The diagnostic system shall store a fault code and the MIL shall illuminate no later than the end of the ~~next trip if the malfunction is again detected~~ next driving cycle during which monitoring occurs provided the malfunction is again present.

(6.0) AIR CONDITIONING SYSTEM REFRIGERANT MONITORING

(6.1) Requirement:

(6.1.1) The diagnostic system shall monitor air conditioning systems for loss of refrigerants which could harm the stratospheric ozone layer or are reactive in forming atmospheric ozone. Any sensor used for such monitoring shall itself be monitored for proper circuit continuity and proper range of operation. A provision for ensuring that a leak has been corrected before extinguishing the MIL shall be provided.

(6.1.2) Manufacturers of a model vehicle which will phase out the use of chlorofluorocarbons in its air conditioning systems by the 1996 model-year or which will use federally-approved refrigerants with substantially less atmospheric ozone depleting potential than CFC-12 need not comply with this requirement for that model.

(6.2) Malfunction Criteria: Manufacturers shall provide a monitoring strategy for approval by the Executive Officer for monitoring a refrigerant leak. The approval shall be based on timeliness and reliability in detecting a leak.

(6.3) Monitoring Conditions: ~~The diagnostic system shall monitor the air conditioning system at least once per trip.~~ Manufacturers shall define appropriate operating conditions for monitoring, subject to the limitation that the monitoring conditions shall be encountered at least once during the first engine start portion of the applicable FTP test. The monitoring system shall operate at least once per driving cycle during which the manufacturer-defined monitoring conditions are met

(6.4) MIL Illumination and Fault Code Storage: The diagnostic system shall store a fault code and the MIL shall illuminate no later than the end of the next ~~trip if the malfunction is again present~~ driving cycle during which monitoring occurs provided the malfunction is again present. The diagnostic system shall not clear a fault code and the MIL shall not turn off unless the leak has been corrected.

(7.0) FUEL SYSTEM MONITORING

(7.1) Requirement: The diagnostic system shall monitor the fuel delivery system for its ability to provide compliance with emission standards. For diesel vehicles and engines, the manufacturer shall monitor the performance of all electronic fuel system components to the extent feasible with respect to the malfunction criteria specified in section (7.2) below.

(7.2) Malfunction Criteria: The manufacturer shall establish malfunction criteria to monitor the fuel delivery system such that a vehicle's emissions would not exceed 1.5 times any of the applicable FTP standards before a fault is detected. If the vehicle is equipped with fuel trim circuitry, the manufacturer shall include as one of the malfunction criteria the condition where the trim circuitry has used up all of the trim adjustment allowed within the manufacturer's selected limit(s). Manufacturers may compensate the criteria limit(s) appropriately for changes in altitude or for temporary introduction of large amounts of purge vapor or for other similar identifiable operating conditions when they occur.

(7.3) Monitoring Conditions: The fuel system shall be monitored continuously for the presence of a malfunction.

(7.4) MIL Illumination and Fault Code Storage:

(7.4.1) For fuel systems with short-term trim only capability, the diagnostic system shall store a fault code after the fuel system has attained the criteria limit for a manufacturer-defined time interval sufficient to determine a malfunction. If the malfunction criteria limit and time interval are exceeded, the MIL shall be illuminated and a fault code stored no later than the end of the next driving cycle in which the criteria and interval are again exceeded, unless driving conditions similar to those under which the problem was originally detected have been encountered (see section (7.4.3)) without such an exceedance, in which case the initial temporary code and stored conditions may be erased. Furthermore, if similar driving conditions are not encountered during 80 driving cycles ~~trips~~ subsequent to the initial detection of a malfunction, the initial temporary code and stored conditions may be erased.

(7.4.2) For fuel systems with long-term fuel trim capability, upon attaining a long-term based malfunction criteria limit independent of, or in combination with, the short-term trim system status, the MIL shall be illuminated and a fault code stored no later than the end of the next ~~trip~~ driving cycle if the malfunction is again detected. If the malfunction is not detected during the second driving cycle, the MIL shall be illuminated and a fault code stored no later than the next driving cycle in which the malfunction is again detected, unless driving conditions similar to those under which the problem was originally detected have been encountered (see ~~sub~~section (7.4.3)) without an indication of a malfunction, in which case the initial temporary code and stored conditions may be erased. Furthermore, if similar driving conditions are not encountered during 80 driving cycles ~~trips~~ subsequent to the initial detection of a malfunction, the initial temporary code and stored conditions may be erased.

(7.4.3) Upon detection of a fuel system malfunction, manufacturers shall store the engine speed, load and warm-up status (i.e., cold or warmed-up) under which the malfunction was detected. A ~~trip or~~ driving cycle shall be considered to have similar conditions if the stored engine speed is encountered within 375 rpm, load conditions within 10 percent, and the same warm-up status is present. With Executive Officer approval, other strategies for determining if similar conditions have been encountered may be employed. Approval shall be based on comparable timeliness and reliability in detecting similar conditions.

(8.0) OXYGEN SENSOR MONITORING

(8.1) Requirement:

(8.1.1) The diagnostic system shall monitor the output voltage, response rate, and any other parameter which can affect emissions, of all primary (fuel control) oxygen (lambda) sensors for malfunction. It shall also monitor all secondary oxygen sensors (fuel trim control or use as a monitoring device) for proper output voltage and/or response rate. Response rate is the time required for the oxygen sensor to switch from lean-to-rich once it is exposed to a richer than stoichiometric exhaust gas or vice versa (measuring oxygen sensor switching frequency may not be an adequate indicator of oxygen sensor response rate, particularly at low speeds).

(8.1.2) Either the lean-to-rich or both the lean-to-rich and rich- to-lean response rates shall be checked. Response rate checks shall evaluate the portions of the sensor's dynamic signal that are most affected by sensor malfunctions such as aging or poisoning.

Manufacturers may observe the voltage envelope of the sensor when cycled at a frequency of 1.5 Hertz or greater, as determined by the manufacturer, to evaluate a slow response rate sensor (i.e. a slow sensor cannot achieve maximum and/or minimum voltage as will a good sensor given a properly chosen switching frequency and fuel step change for the check). With Executive Officer approval, manufacturers may use other voltage requirements/fuel-air switching frequencies or monitoring strategies based on a determination of accurate and timely evaluation of the sensor.

(8.1.3) For sensors with different characteristics, the manufacturer shall submit data and an engineering evaluation to the Executive Officer for approval based on showing equivalent evaluation of the sensor.

(8.1.4) For vehicles equipped with heated oxygen sensors, the heater circuit shall be monitored for proper current and voltage drop (note: a continuity check of oxygen sensors is not required). Other heater circuit monitoring strategies would require approval by the Executive Officer based on equally reliable and timely indication of malfunction as current or voltage-based monitoring.

(8.2) Malfunction Criteria:

(8.2.1) An oxygen sensor shall be considered malfunctioning when the voltage, response rate, or other criteria are exceeded and causes emissions from a vehicle equipped with the sensor(s) to exceed 1.5 times any of the applicable FTP standards, or when the criteria of sensors for use as a diagnostic system monitoring device (e.g., for catalyst efficiency monitoring) are exceeded...

(8.2.2) For heated oxygen sensors, the heater circuit shall be considered malfunctioning when the current or voltage drop in the circuit is no longer within the manufacturer's specified limits for ~~proper~~ normal operation (i.e., within the criteria required to be met by the component vendor for heater circuit performance at high mileage). Subject to Executive Officer approval, other monitoring strategy malfunction criteria for detection of heater circuit malfunctions may be used provided the manufacturer submits data and/or an engineering evaluation adequately showing monitoring reliability and timeliness to be equivalent to the stated criteria in this paragraph.

(8.3) Monitoring Conditions:

(8.3.1) For primary oxygen sensor(s) used for fuel control, the response rate and output voltage shall be monitored for malfunction before the end of the first idle period after the vehicle has commenced closed-loop operation, if the necessary checking condition for acceptable oxygen sensor(s) performance has been encountered. The performance of the sensor can only be judged acceptable by one or more of the following means: within any 20 second reasonably steady speed condition as defined in (b) (1.3.2), within any deceleration of 3 seconds or more, or during the first idle period of at least 20 seconds after closed loop operation begins (i.e., not during an acceleration condition); not withstanding, unacceptable performance can be determined at any time. Other monitoring conditions may be used provided the manufacturer provides a monitoring strategy and supporting data showing equivalent monitoring reliability and timeliness in detecting a malfunctioning sensor compared to the above monitoring conditions and the Executive Officer approves.

(8.3.2) For secondary oxygen sensors used for catalyst monitoring and/or fuel system trim, the manufacturer shall define appropriate operating conditions for response rate and/or output voltage malfunction monitoring ~~shall be monitored for malfunction~~, subject to the limitation that the monitoring conditions shall be encountered at least once during the first engine start portion of the applicable FTP test. The monitoring system shall operate at least once per driving cycle during which the manufacturer-defined monitoring conditions are met ~~per trip~~.

(8.3.3) For heated oxygen sensors, the manufacturer shall define appropriate operating conditions for malfunction monitoring of the heater circuit ~~shall be monitored for malfunction~~, subject to the limitation that the monitoring conditions shall be encountered at least once during the first engine start portion of the applicable FTP test. The monitoring system shall operate at least once per driving cycle during which the manufacturer-defined monitoring conditions are met ~~per trip~~.

(8.4) MIL Illumination and Fault Code Storage: Upon detection of any oxygen sensor malfunction, the diagnostic system shall store a fault code and the MIL shall illuminate no later than the end of the next ~~trip if the malfunction is again present~~ driving cycle during which monitoring occurs provided the malfunction is again present.

(8.5) Other (non-lambda) Oxygen Sensors:

(8.5.1) For vehicles equipped with universal exhaust gas oxygen sensors (i.e. sensors which provide an output proportional to exhaust gas oxygen concentration), the manufacturer shall define appropriate operating conditions for the diagnostic system ~~shall provide~~ to perform a response rate check (the time required to respond to a specific change in fuel/air ratio), subject to the limitation that the monitoring conditions shall be encountered at least once during the first engine start portion of the applicable FTP test. The monitoring system shall operate at least once per driving cycle during which the manufacturer-defined monitoring conditions are met. ~~per trip and an~~ The diagnostic system shall also perform an out-of-range check for which monitoring shall be continuous. For malfunctions, MIL illumination and fault code storage shall be as in (8.4).

(8.5.2) If a manufacturer utilizes other types of oxygen sensors, the manufacturer shall submit a monitoring plan to the Executive Officer for approval based on equivalent monitoring with conventional sensors.

(9.0) EXHAUST GAS RECIRCULATION (EGR) SYSTEM MONITORING

(9.1) Requirement:

(9.1.1) The diagnostic system shall monitor the EGR system on vehicles so-equipped for low and high flow rate malfunctions.

(9.1.2) Manufacturers may request Executive Officer approval to temporarily disable the EGR system check under specific conditions ~~if it can be~~ provided the manufacturer submits data and/or an engineering evaluation which adequately demonstrate~~d~~ that a reliable check cannot be made when these conditions exist.

(9.2) Malfunction Criteria: The EGR system shall be considered malfunctioning when one or both of the following occurs: (1) any component of the system fails to perform within manufacturer specifications, or (2) the EGR flow rate exceeds the manufacturer's-specified low or high flow limits such that a vehicle would exceed 1.5 times any of the applicable FTP emission standards.

(9.3) Monitoring Conditions: ~~The diagnostic system~~ Manufacturers shall define appropriate operating conditions for monitoring the EGR system, subject to the limitation that the monitoring conditions shall be encountered at least once during the first engine start portion of the applicable FTP test ~~monitor the EGR system at least once per trip~~. The monitoring system shall operate at least once per driving cycle during which the manufacturer-defined monitoring conditions are met.

(9.4) MIL Illumination and Fault Code Storage: The diagnostic system shall store a fault code and the MIL shall illuminate no later than the end of the next driving cycle during which monitoring occurs provided ~~trip if~~ the malfunction is again present.

(10.0) COMPREHENSIVE COMPONENT MONITORING

(10.1) Requirement: The diagnostic system shall monitor for malfunction any electronic powertrain component/system not otherwise described above which either provides input to (directly or indirectly), or receives commands from the on-board computer, and which: (1) can affect emissions during any reasonable in-use driving condition, or (2) is used as part of the diagnostic strategy for any other monitored system or component.

(10.1.1) Input Components:

~~(A) The diagnostic system shall monitor for malfunction any electronic powertrain component/system which can affect emissions not otherwise described above and which provides input directly or indirectly to the on-board computer.~~

~~(B)~~(A) The monitoring system shall have the capability of detecting, at a minimum, lack of circuit continuity and out of range values to ensure proper operation of the input device. The determination of out of range values shall include logic evaluation of available information to determine if a component is operating within its normal range (e.g., a low throttle position sensor voltage would not be reasonable at a high engine speed with a high mass airflow sensor reading).~~(e.g., indicating a malfunction in the case of high fuel tank pressure when the coolant temperature is low; an accelerometer output indicating continuous rough road conditions, etc.)~~.

~~(C)~~(B) Input components may include, but are not limited to, the vehicle speed sensor, crank angle sensor, knock sensor, throttle position sensor, coolant temperature sensor, cam position sensor, fuel composition sensor (e.g. methanol flexible fuel vehicles), transmission electronic components such as sensors, modules, and solenoids which provide signals to the powertrain control system (see section (b) (10.5)).

~~(D)~~(C) The coolant temperature sensor shall be monitored for achieving a stabilized minimum temperature level which is needed to achieve closed-loop operation (or for diesel applications, the minimum temperature needed for warmed-up fuel control to begin) within a manufacturer-specified time interval after starting the engine. The time interval shall be a function of starting engine coolant temperature and/or a function of intake air temperature. Manufacturers shall provide data to support specified times. The Executive Officer shall allow disablement of this check under extremely low ambient temperature conditions provided a manufacturer submits data and/or an engineering evaluation which adequately demonstrate~~ing~~ non-attainment of a stabilized minimum temperature.

(10.1.2) Output Components:

(A) The diagnostic system shall monitor output components for proper functional response to computer commands. ~~for proper functional response to each computer command, any powertrain output component/system receiving commands from the computer either directly or indirectly which can affect emissions and which is not otherwise monitored as a component/system in the above monitoring requirements.~~

(B) Components for which functional monitoring is not feasible shall be monitored, at a minimum, for proper circuit continuity and out of range values, if applicable.

(C) Output components may include, but are not limited to, the automatic idle speed motor, emission-related electronic only transmission controls, heated fuel preparation systems, the wait-to-start lamp on diesel applications, and a warmup catalyst bypass valve (see section (b) (10.5)).

(10.2) Malfunction Criteria:

(10.2.1) Input Components: Input components/systems shall be considered malfunctioning when, at a minimum, lack of circuit continuity or manufacturer-specified out-of-range values occur. ~~Additionally, the coolant temperature sensor shall be considered malfunctioning if it does not achieve a stabilized minimum temperature necessary for closed-loop operation within a manufacturer-specified time interval after starting the engine.~~

(10.2.2) Output Components: Output components/systems shall be considered malfunctioning when ~~a~~ proper functional response to ~~each~~ computer commands does not occur. Should a functional check for malfunction not be feasible, then an output component/system shall be considered malfunctioning when, at a minimum, lack of circuit continuity or manufacturer-specified out-of-range values occur.

(10.3) Monitoring Conditions: ~~Components/systems in this subsection shall be monitored continuously.~~

(10.3.1) Input Components: Input components shall be monitored continuously for proper range of values and circuit continuity. For rationality monitoring (where applicable), manufacturers shall define appropriate operating conditions during which monitoring shall occur, subject to the limitation that the monitoring conditions shall be encountered at least once during the first engine start portion of the applicable FTP test. Rationality monitoring shall occur at least once per driving cycle during which the manufacturer-defined monitoring conditions are met.

(10.3.2) Output Components: Monitoring for circuit continuity and proper range of values (if applicable) shall be conducted continuously. For functional monitoring, manufacturers shall define appropriate operating conditions during which monitoring shall occur, subject to the limitation that the monitoring conditions shall be encountered at least once during the first engine start portion of the applicable FTP test. However, functional monitoring may be conducted during non-FTP driving conditions, subject to Executive Officer approval, if the manufacturer provides data and/or an engineering evaluation which adequately demonstrate that the component does not normally function, or monitoring is otherwise not feasible, during applicable FTP test driving conditions. Functional monitoring shall occur at least once per driving cycle during which the manufacturer-defined monitoring conditions are met.

(10.4) MIL Illumination and Fault Code Storage: Upon detecting a malfunction, the diagnostic system shall store a fault code and the MIL shall illuminate no later than the end of the next driving cycle during which monitoring occurs provided ~~trip if~~ the malfunction is again detected.

(10.5) Component Determination: The manufacturer shall determine whether a powertrain input or output component not otherwise covered can affect emissions. If the Executive Officer reasonably believes that a manufacturer has incorrectly determined that a component cannot affect emissions, the Executive Officer shall require the manufacturer to provide emission data showing that such a component, when faulty and installed in a suitable test vehicle, does not have an emission effect. Emission data may be requested for any reasonable driving condition.

(c) ADDITIONAL MIL ILLUMINATION AND FAULT CODE STORAGE PROTOCOL

(1.0) MIL ILLUMINATION For all emission-related components/systems, upon final determination of malfunction, the MIL shall remain continuously illuminated (except that it shall blink as indicated previously for misfire detection). If any malfunctions are identified in addition to misfire, the misfire condition shall take precedence, and the MIL shall blink accordingly. The diagnostic system shall store a fault code for MIL illumination whenever the MIL is illuminated. The diagnostic system shall illuminate the MIL and shall store a code whenever the ~~engine control~~ powertrain enters a default or "limp home" mode of operation. The diagnostic system shall illuminate the MIL and shall store a code whenever the engine control system fails to enter closed-loop operation (if employed) within a manufacturer specified minimum time interval.

(2.0) EXTINGUISHING THE MIL

(2.1) Misfire and Fuel System Malfunctions: For misfire or fuel system malfunctions, the MIL may be extinguished if the fault does not recur when monitored during three subsequent sequential driving cycles in which conditions are similar to those under which the malfunction was first determined (see sections (b) (3.4.3) and (b)(7.4.3)).

(2.2) All Other Malfunctions: Except as noted in section (b) (6.4), for all other faults, the MIL may be extinguished after three subsequent sequential driving cycles during which the monitoring system responsible for illuminating the MIL functions without detecting the malfunction ~~trips in which the malfunction has not recurred~~ and if no other malfunction has been identified that would independently illuminate the MIL according to the requirements outlined above.

(3.0) ERASING A FAULT CODE The diagnostic system may erase a fault code if the same fault is not re-registered in at least 40 engine warm-up cycles, and the MIL is not illuminated for that fault code.

(d) TAMPERING PROTECTION Computer-coded engine operating parameters shall not be changeable without the use of specialized tools and procedures (e.g. soldered or potted computer components or sealed (or soldered) computer enclosures). Subject to Executive Officer approval, manufacturers may exempt from this requirement those product lines which are unlikely to require protection. Criteria to be evaluated in making an exemption include, but are not limited to, current availability of performance chips, high performance capability of the vehicle, and sales volume. Manufacturers using reprogrammable computer code systems (e.g., EEPROM) shall employ proven methods to deter unauthorized reprogramming which may include copyrightable executable routines or other methods. Beginning with the 1999 model year, manufacturers shall include enhanced tamper protection strategies including data encryption using methods to secure the encryption algorithm, and write protect features requiring electronic access to an off-site computer maintained by the manufacturer. Equivalent methods shall also be considered by the Executive Officer. ~~Any reprogrammable computer code system (e.g. EEPROM) shall include proven write-protect features which may include copyrightable executable routines or other methods.~~

(e) READINESS/FUNCTION CODE The on-board computer shall store a code upon first completing If a full diagnostic check (i.e., the minimum number of checks necessary for MIL illumination) of all monitored components and systems (except as noted below) has not been completed since the computer memory was last cleared (e.g., through the use of a scan tool or battery disconnect)., the manufacturer shall store a code indicating the need for additional mixed city and highway driving to complete the check. The code shall be stored in the format specified by SAE J1979 or SAE J1939, whichever applies. Both documents are incorporated by reference in sections (k)(2.0) and (k)(5.0). The diagnostic system check for comprehensive component monitoring and continuous monitoring of misfire and fuel system faults shall be considered complete for purposes of determining the readiness indication if malfunctions are not detected in these areas by the time all other diagnostic system checks are complete. If monitoring is temporarily disabled under conditions which may lead to false codes for any system, that check shall not be considered in determining diagnostic system readiness. For evaporative system monitoring, the readiness indication shall be set when a full diagnostic check has been completed with respect to the 0.040 inch orifice malfunction criteria if the monitoring conditions are constrained with respect to detection a 0.020 inch leak (see sections (b)(4.2.2) and (4.3). The diagnostic system shall also include a code or acknowledge message indicating that the diagnostic system itself is functioning properly.

(f) STORED ENGINE CONDITIONS Upon detection of the first malfunction of any component or system, "freeze frame" engine conditions present at the time shall be stored in computer memory. Should a subsequent fuel system or misfire malfunction occur, any previously stored freeze frame conditions shall be replaced by the fuel system or misfire conditions (whichever occurs first). Stored engine conditions shall include, but are not limited to, calculated load value, engine RPM, fuel trim value(s) (if available), fuel pressure (if available), vehicle speed (if available), coolant temperature, intake manifold pressure (if available), closed- or open-loop operation (if available), and the fault code which caused the data to be stored. The manufacturer shall choose the most appropriate set of conditions facilitating effective repairs for freeze frame storage. Only one frame of data is required. Manufacturers may at their discretion choose to store additional frames provided that at least the required frame can be read by a generic scan tool meeting SAE specifications established in SAE Recommended Practices on "OBD II Scan Tool" (J1978), March 1992 June, 1994, and "E/E Diagnostic Test Modes" (J1979), December 1991 June, 1994, which are incorporated by reference herein. If approval is granted to use the SAE J1939 communication protocol according to section (k)(5.0), the data shall be accessible using a scan tool meeting the J1939 specifications. If the fault code causing the conditions to be stored is erased in accordance with section (c) (3.0), the stored engine conditions may be cleared as well.

(g) DURABILITY DEMONSTRATION VEHICLE

(1.0) REQUIREMENT Each year a manufacturer shall provide emission test data obtained from a certification durability vehicle for one engine family certification durability vehicle that has not been used previously for purposes of this section. If a manufacturer does not have a certification durability vehicle available which is suitable for this demonstration, Tthe Executive Officer shall permit a manufacturer to satisfy this requirement with ~~waive this requirement if a manufacturer does not have a certification durability vehicle available which is suitable for this demonstration in a given year, provided a manufacturer submits other~~ data from a representative high mileage vehicle or vehicles (or a representative high operating-hour engine or engines) acceptable to the Executive Officer to demonstrate that malfunction criteria are based on emission performance. The Air Resources Board (ARB) shall determine the ~~demonstration vehicle~~ engine family to be demonstrated. Each manufacturer shall notify the Executive Officer prior to ~~running a California durability vehicle in order to allow possible selection as the demonstration vehicle for a given model year unless a vehicle has previously been chosen for the given model year~~ applying for certification of the engine families planned for a particular model year in order to allow selection of the engine family to be demonstrated. Demonstration tests shall be conducted on the certification durability vehicle or engine at the end of the required mileage or operating-hour accumulation. For non-LEVs, until a NOx standard applicable for more than 50,000 miles is established in California, the federal 50,000 to 100,000 mile NOx standard shall be used for demonstration purposes.

(1.1) Flexible fuel vehicles shall perform each demonstration test using 85 percent methanol and 15 percent gasoline, and gasoline only. For vehicles capable of operating on other fuel combinations, the manufacturer shall submit a plan for performing demonstration testing for approval by the Executive Officer on the basis of providing accurate and timely evaluation of the monitored systems.

(2.0) APPLICABILITY: The manufacturer shall perform single-fault testing based on the applicable FTP test cycle with the following components/systems at their malfunction criteria limits as determined by the manufacturer:

(2.1) Oxygen Sensors. The manufacturer shall conduct the following demonstration tests: The first test involves testing all primary and secondary (if equipped) oxygen sensors used for fuel control simultaneously possessing normal output voltage but response rate deteriorated to the malfunction criteria limit (secondary oxygen sensors for which response rate is not monitored shall be with normal response characteristics). The second test shall include testing with all primary and secondary (if equipped) oxygen sensors used for fuel control simultaneously possessing output voltage at the malfunction criteria limit. Manufacturers shall also conduct a malfunction criteria demonstration test for any other oxygen sensor parameter that can cause vehicle emissions to exceed 1.5 times the applicable standards (e.g., shift in air/fuel ratio at which oxygen sensor switches). When performing additional test(s), all primary and secondary (if equipped) oxygen sensors used for fuel control shall be operating at the malfunction criteria limit for the applicable parameter only. All other primary and secondary oxygen sensor parameters shall be with normal characteristics. The Executive Officer may approve other demonstration protocols if the manufacturer can adequately show comparable assurance that the malfunction criteria are chosen based on meeting emission requirements.

(2.2) EGR System: The manufacturer shall conduct only one flow rate demonstration test at the low flow limit.

(2.3) Fuel Metering System:

(2.3.1) For vehicles with short-term or long-term fuel trim circuitry, the manufacturer shall conduct one demonstration test at the border of the rich limit and one demonstration test at the border of the lean limit established by the manufacturer for emission compliance.

(2.3.2) For other systems, the manufacturer shall conduct a demonstration test at the criteria limit(s).

(2.3.3) For purposes of the demonstration, the fault(s) induced may result in a uniform distribution of fuel and air among the cylinders. Non-uniform distribution of fuel and air used to induce a fault shall not cause an indication of misfire. The manufacturer shall describe the fault(s) induced in the fuel system causing it to operate at the criteria limit(s) for the demonstration test (e.g., restricted or increased flow fuel injectors, an altered output signal airflow meter, etc.). Computer modifications to cause the fuel system to operate at the adaptive limit for malfunction shall not be allowed for the demonstration tests.

(2.4) Misfire: The manufacturer shall conduct one FTP demonstration test at the criteria limit specified in (b)(3.2)(B) for malfunction and a second demonstration test showing that the vehicle is capable of passing a California Inspection/Maintenance test when operating at the misfire criteria limit. This demonstration is not required for diesel applications.

(2.5) Secondary Air System: The manufacturer shall conduct a flow rate demonstration test at the low flow limit, unless only a functional check is permitted according to section (b)(5.2.2).

(2.6) Catalyst Efficiency:

(2.6.1) Non-Low Emission Vehicles: The manufacturer shall conduct a baseline FTP test with a representative 4000 mile catalyst followed by one FTP demonstration test using a catalyst system deteriorated to its malfunction limit. If a manufacturer is employing a steady state catalyst efficiency check in accordance with section (b)(1.2.4), demonstration of the catalyst monitoring system is not required.

(2.6.2) Low Emission Vehicles: The manufacturer shall conduct a catalyst efficiency demonstration using a catalyst system deteriorated to ~~within~~ the malfunction criteria. ~~If two substrates are integrated into the same container, only the upstream substrate shall be deteriorated for the demonstration.~~

(2.7) Heated Catalyst Systems: ~~For heated catalyst systems that use an after-start heating strategy, t~~ The manufacturer shall conduct a demonstration test where the designated heating temperature is reached at the time limit for malfunction after engine starting.

(2.8) Manufacturers may electronically simulate deteriorated components, but may not make any vehicle control unit modifications when performing demonstration tests. All equipment necessary to duplicate the demonstration test must be made available to the ARB upon request.

(3.0) PRECONDITIONING The manufacturer shall use the first engine start portion of one applicable FTP cycle for preconditioning before each of the above emission tests. If a manufacturer ~~can~~ provides data and/or an engineering evaluation which adequately demonstrate that additional preconditioning is necessary to stabilize the emission control system, the Executive Officer shall allow an additional identical preconditioning cycle, or a Federal Highway Fuel Economy Driving Cycle, following a ten-minute (or 20 minutes for medium duty engines certified on an engine dynamometer) hot soak after the initial preconditioning cycle. A cold start shall not be required prior to conducting preconditioning cycles.

(4.0) EVALUATION PROTOCOL

(4.1) ~~With the exception of short-term trim only vehicles, t~~The manufacturer shall set the system or component for which detection is to be demonstrated at the criteria limit(s) ~~from the beginning of and throughout the~~ prior to conducting the applicable preconditioning cycle(s) ~~and FTP test.~~ (For misfire demonstration, misfire shall be set at its criteria limit as specified pursuant to section (b)(3.2)(B)). If a second preconditioning cycle is permitted in accordance with section (3.0) above, the manufacturer may adjust the demonstrated system or component before conducting the second preconditioning cycle; however, the demonstrated system or component shall not be replaced, modified or adjusted after preconditioning has taken place.

(4.2) ~~For short-term trim only vehicles, the fuel system shall operate at the criteria limit from the beginning of closed-loop operation for the manufacturer-defined time interval for determining malfunction (and normally otherwise) for both the applicable preconditioning and FTP test cycles.~~ After preconditioning, the vehicle shall be operated over the first engine start portion of the applicable FTP test to allow for the initial detection of the malfunction. This driving cycle may be omitted from the evaluation protocol if it is unnecessary. If required by the demonstrated monitoring strategy, a cold soak may be performed prior to conducting this driving cycle.

(4.3) ~~For misfire demonstration, misfire shall be set at its criteria limit as specified pursuant to section (b) (3.2) (B) throughout the applicable preconditioning cycle and FTP test.~~ The vehicle shall then be operated over a full applicable FTP test.

(4.4) For all demonstrations, the MIL shall be illuminated before the hot start portion of the full FTP test in accordance with requirements of subsection (b):

(4.4.1) If the MIL does not illuminate when the systems or components are set at their limit(s), the criteria limit or the OBD system is not acceptable.

(4.4.2) Except for catalyst efficiency demonstration, if the MIL illuminates and emissions do not exceed 1.5 times any of the applicable FTP emission standards, no further demonstration shall be required.

(4.4.3) Except for catalyst efficiency demonstration, if the MIL illuminates and emissions exceed 1.5 times any of the applicable FTP emission standards, the vehicle shall be retested with the component's malfunction criteria limit value reset such that vehicle emissions are reduced by no more than 30 percent. Limit value at a minimum includes, in the case of oxygen sensors, response rate and voltage; for EGR systems, EGR flow rate; for secondary air systems, air flow rate; for short-term fuel trim- only systems, time interval at the fuel system range of authority limit; for long-term fuel trim systems, shift in the base fuel calibration; for heated catalyst systems, the time limit between engine starting and attaining the designated heating temperature (if an after-start heating strategy is used); and for misfire, percent misfire. For the OBD system to be approved, the vehicle must then meet the above emission levels when tested with the faulty components. The MIL shall not illuminate during this demonstration.

(4.4.4) For Non-LEV catalyst efficiency demonstration, if HC emissions do not increase by more than 1.5 times the standard from the baseline FTP test and the MIL is illuminated, no further demonstration shall be required. However, if HC emissions increase by more than 1.5 times the standard from the baseline FTP test and the MIL is illuminated, the vehicle shall be retested with the average FTP HC conversion capability of the catalyst system increased by no more than 10 percent (i.e., 10 percent more engine out hydrocarbons are converted). For the OBD system to be approved, the vehicle must then meet the above emission levels when re-tested. The MIL shall not illuminate during this demonstration.

(4.4.5) For Low Emission Vehicle catalyst efficiency demonstration, if HC emissions do not exceed the applicable emission threshold specified in section (b)(1.2.2) and the MIL is illuminated, no further demonstration shall be required. However, if HC emissions exceed the threshold and the MIL is illuminated, the vehicle shall be retested with average FTP HC conversion capability of the catalyst system increased by no more than 5 percent (i.e., 5 percent more engine out hydrocarbons are converted). For the OBD II system to be approved, the vehicle must then meet the above emission levels when re-tested. The MIL shall not illuminate during this demonstration. ~~if catalyst efficiency is within the malfunction criteria range over the FTP test and the MIL is illuminated, no further demonstration is required. If catalyst efficiency falls outside of the malfunction criteria range, the catalyst's efficiency shall be adjusted, or the catalyst shall be replaced with another deteriorated catalyst, and the system re-tested. If catalyst efficiency is within the malfunction criteria range over the FTP test and the MIL is not illuminated, the catalyst may be deteriorated further but not below the lower limit of the malfunction criteria range, and the system retested. If the catalyst's efficiency is below the lower limit of the malfunction criteria range and the MIL is not illuminated, the OBD system is not acceptable.~~

(4.5) If an OBD system is determined unacceptable by the above criteria, the manufacturer may re-calibrate and re-test the system on the same DDV. Any affected monitoring systems demonstrated prior to the re-calibration shall be re-verified.

(h) CERTIFICATION DOCUMENTATION: The manufacturer shall submit the following documentation for each engine family at the time of certification. With Executive Officer approval, one or more of the documentation requirements specified in this section may be waived or altered if the information required would be redundant or unnecessarily burdensome to generate:

(1) A written description of the functional operation of the diagnostic system to be included in Section 8 of manufacturers' certification applications.

(2) A table providing the following information for each monitored component or system (either computer-sensed or -controlled) of the emission control system:

i. corresponding fault code
ii. monitoring method or procedure for malfunction detection
iii. primary malfunction detection parameter and its type of output signal
iv. fault criteria limits used to evaluate output signal of primary parameter
v. other monitored secondary parameters and conditions (in engineering units) necessary for malfunction detection
vi. monitoring time length and frequency of checks
vii. criteria for storing fault code
viii. criteria for illuminating malfunction indicator light
ix. criteria used for determining out of range values and input component rationality checks

(3) A logic flowchart describing the general method of detecting malfunctions for each monitored emission-related component or system. To the extent possible, abbreviations in Society of Automotive Engineers' (SAE) J1930 "Electrical/Electronic Systems Diagnostic Terms, Definitions, Abbreviations, and Acronyms", ~~September, 1991~~ June, 1993, shall be used. J1930 is incorporated by reference herein. The information required in the chart under (2) above may instead be included in this flow chart, provided all of the information required in (2) is included.

(4) A listing and block diagram of the input parameters used to calculate or determine calculated load values and the input parameters used to calculate or determine fuel trim values.

(5) A scale drawing of the MIL and the fuel cap indicator light, if present, which specifies location in the instrument panel, wording, color, and intensity.

(6) Emission test data specified in subsection (g).

(7) Data supporting the selected degree of misfire which can be tolerated without damaging the catalyst.

(8) Data supporting the limit for the time between engine starting and attaining the designated heating temperature for after-start heated catalyst systems.

(9) For Low Emission Vehicles, data supporting the criteria used ~~by the diagnostic system for establishing a 50 to 60 percent catalyst total HC efficiency level, or a 40 to 50 percent deterioration level~~ to indicate a malfunction when catalyst deterioration causes emissions to exceed the applicable threshold specified in section (b)(1.2.2).

(10) For Non-Low Emission Vehicles, data supporting the criteria used to indicate a malfunction when catalyst deterioration leads to a 1.5 times the standard increase in HC emissions. If a steady state catalyst efficiency check is employed in accordance with section (b)(1.2.4), data supporting the criteria used by the diagnostic system for establishing a 60 to 80 percent catalyst efficiency level shall be provided instead.

(11) Data supporting the criteria used to detect evaporative purge system leaks.

(12) A description of the modified or deteriorated components used for ~~the~~ fault simulation ~~to drive the fuel system to the criteria limit(s) for demonstrating fuel system compliance with the requirements of~~ with respect to the demonstration tests specified in ~~sub~~section (g).

(13) A listing of all electronic powertrain input and output signals.

(1~~3~~4) Any other information determined by the Executive Officer to be necessary to demonstrate compliance with the requirements of this section.

(i) IN-USE RECALL TESTING PROTOCOL The manufacturer shall adhere to the following procedures for vehicles subject to in-use recall testing required by the ARB:

(1) If the MIL illuminates during a test cycle or during a preconditioning cycle, the fault causing the illumination may be identified and repaired following published procedures readily available to the public including the independent service sector.

(2) The test may be rerun, and the results from the repaired vehicle may be used for emission reporting purposes.

(3) If a vehicle contains a part which is operating outside of design specifications with no MIL illumination, the part shall not be replaced prior to emission testing unless it is determined that the part has been tampered with or abused in such a way that the diagnostic system cannot reasonably be expected to detect the resulting malfunction..

(4) Failure of a vehicle, or vehicles on average, to meet applicable emission standards with no illumination of the MIL shall not by itself be grounds for requiring the OBD system to be recalled for recalibration or repair since the OBD system cannot predict precisely when vehicles exceed emission standards.

(5) A decision to recall the OBD system for recalibration or repair will depend on factors including, but not limited to, level of emissions above applicable standards, presence of identifiable faulty or deteriorated components which affect emissions with no MIL illumination, and systematic erroneous activation of the MIL. With respect to erroneous activation of the MIL, the manufacturer may request Executive Officer approval to take action apart from a formal recall (e.g., extended warranty or a service campaign) to correct the performance of the diagnostic strategy on in-use vehicles. In considering a manufacturer's request, the Executive Officer shall consider the estimated frequency of false MIL activation in-use, and the expected effectiveness in relation to a formal recall of the manufacturer's proposed corrective action in capturing vehicles in the field. For 1994 and 1995 model years ~~only~~, on-board diagnostic system recall shall not be considered for excessive emissions without MIL illumination (if required) and fault code storage until emissions exceed 2.0 times any of the applicable standards in those instances where the malfunction criterion is based on exceeding 1.5 times any of the applicable standards. This higher emission threshold for recall shall extend up to the 1998 model year for TLEV applications (except for catalyst monitoring, for which the threshold shall extend to the 2000 model year), and to the 2000 model year for all applicable monitoring requirements on LEV and ULEV applications.

(6) Regarding catalyst system monitoring, unmonitored catalysts shall be normally aged.

(j) CONFIRMATORY TESTING The ARB may perform confirmatory testing of manufacturers' diagnostic systems for compliance with requirements of this section in accordance with malfunction criteria submitted in the manufacturer's approved certification documentation. The ARB or its designee may install appropriately deteriorated or malfunctioning components in an otherwise properly functioning test vehicle of an engine family represented by the demonstration test vehicle(s) (or simulate a deteriorated or malfunctioning component response) in order to test the fuel system, misfire detection system, oxygen sensor, secondary air system, catalyst efficiency monitoring system, heated catalyst system, and EGR system malfunction criteria for compliance with the applicable emission constraints in this section. Confirmatory testing to verify that malfunction criteria are set for compliance with emission requirements of this section shall be limited to vehicles in engine families derived from the demonstration vehicle(s). Diagnostic systems of a representative sample of vehicles which uniformly fail to meet the requirements of this section may be recalled for correction.

(k) STANDARDIZATION Standardized access to emission-related fault codes, emission-related powertrain test information (i.e., parameter values) as outlined in subsection (l), emission related diagnostic procedures, and stored freeze frame data shall be incorporated based on the industry specifications referenced in this regulation.

(1.0) Either SAE Recommended Practice J1850, "Class B Data Communication Network Interface", ~~August, 1991~~ May, 1994, or ISO 9141-2 ~~CARB~~, "Road vehicles - Diagnostic Systems - CARB Requirements for Interchange of Digital Information," February, 1994, which are incorporated by reference, shall be used as the on-board to off-board network communications protocol. All SAE J1979 emission related messages sent to the J1978 scan tool over a J1850 data link shall use the Cyclic

Redundancy Check and the three byte header, and shall not use inter-byte separation or checksums.

(2.0) J1978 & J1979 Standardization of the message content (including test modes and test messages) as well as standardization of the downloading protocol for fault codes, parameter values and their units, and freeze frame data are set forth in SAE Recommended Practices on "OBD II Scan Tool" (J1978), ~~March, 1992~~ June, 1994, and "E/E Diagnostic Test Modes" (J1979), ~~December, 1991~~ June 1994, which have been incorporated by reference. Fault codes, parameter values, and freeze frame data shall be capable of being downloaded to a generic scan tool meeting these SAE specifications.

(2.1) Manufacturers shall make readily available at a fair and reasonable price to the automotive repair industry vehicle repair procedures which allow effective emission related diagnosis and repairs to be performed using only the J1978 generic scan tool and commonly available, non-microprocessor based tools. In addition to these procedures, manufacturers may publish repair procedures referencing the use of manufacturer specific or enhanced equipment.

(2.2) The J1978 scan tool shall be capable of notifying the user when one or more of the required monitoring systems are not included as part of the OBD system.

(3.0) J2012 Part C Uniform fault codes based on SAE specifications shall be employed. SAE "Recommended Format and Messages for Diagnostic Trouble Codes" (J2012), ~~March~~ January, ~~1992~~ 1994, is incorporated by reference.

(4.0) J1962 A standard data link connector in a standard location in each vehicle based on SAE specifications shall be incorporated. The location of the connector shall be easily identified by a technician entering the vehicle from the driver's side. Any pins in the standard connector that provide any electrical power shall be properly fused to protect the integrity and usefulness of the diagnostic connector for diagnostic purposes. The SAE Recommended Practice "Diagnostic Connector" (J1962), June, 1992, is incorporated by reference.

(5.0) With Executive Officer approval, medium-duty vehicles may alternatively employ the communication protocols established in SAE Recommended Practice J1939 to satisfy the standardization requirements specified in sections (k)(1) through (k)(4) above. The Executive Officer's decision shall be based on the effectiveness of the SAE J1939 protocol in satisfying the diagnostic information requirements of Section 1968.1 in comparison with the above referenced documents.

(l) SIGNAL ACCESS

(1.0) The following signals in addition to the required freeze frame information shall be made available on demand through the serial port on the standardized data link connector: calculated load value, diagnostic trouble codes, engine coolant temperature, fuel control system status (open loop, closed loop, other; if equipped with closed loop fuel control), fuel trim (if equipped), fuel pressure (if available), ignition timing advance (if equipped), intake air temperature (if equipped), manifold air pressure (if equipped), air flow rate from mass air flow meter (if equipped), engine RPM, throttle position sensor output value (if equipped), secondary air status (upstream, downstream, or atmosphere; if equipped), and vehicle speed (if equipped). The signals shall be provided in standard units based on the SAE specifications incorporated by reference in this regulation, and actual signals shall be clearly identified separately from default value or limp home signals.

(2.0) The manufacturer shall publish in factory service manuals a normal range for the calculated load value and mass air flow rate (if available) at idle, and at 2500 RPM (no load, in neutral or park). If 2500 RPM is outside of the operating range of the engine, the corresponding data may be omitted. If the total fuel command trim is made up by more than one source (e.g. short-term trim and long-term trim), all fuel trim signals shall be available. The signals shall be provided in standard units based on the incorporated SAE specifications, and actual signals shall be clearly identified separately from default value or limp home signals. Diesel vehicles shall be exempt from this requirement.

(3.0) Oxygen sensor data that will allow diagnosis of malfunctioning oxygen sensors shall be provided through serial data port on the standardized data link. In addition, beginning with the 1996 model year (with full compliance required by the 1997 model year), for all monitored components and systems, except misfire detection, fuel system monitoring, and comprehensive component monitoring), results of the most recent test performed by the vehicle, and the limits to which the system is compared ~~(except for continuously monitored systems/components)~~ shall be available through the ~~serial data port on the standardized~~ data link ~~connector~~. For the monitored components and systems excepted above, a pass/fail indication for the most recent test results shall be available through the data link . Such data shall be transmitted in accordance with SAE J1979 (or SAE J1939, whichever applies). Alternative methods shall be approved by the Executive Officer if, in the judgment of the Executive Officer, they provide for equivalent off-board evaluation.

(m) IMPLEMENTATION SCHEDULE

(1.0) These OBD II requirements, ~~except evaporative purge system monitoring (see section (b) (4.1.5))~~ unless otherwise specified, shall be implemented beginning with the 1994 model year.

(2.0) The Executive Officer shall grant an extension for compliance with the requirements of these subsections with respect to a specific vehicle model or engine family if the vehicle model or engine family meets previously applicable on-board diagnostic system requirements and a manufacturer demonstrates that it cannot modify a present electronic control system by the 1994 model-year because major design system changes not consistent with the manufacturer's projected changeover schedule would be needed to comply with provisions of these subsections.

(2.1) The manufacturer which has received an extension from the Executive Officer shall comply with these regulations when modification of the electronic system occurs in accordance with the manufacturer's projected changeover schedule or in the 1996 model year, whichever first occurs.

(2.2) Any manufacturer requesting an extension shall, no later than October 15, 1991, submit to the Executive Officer an application specifying the period for which the extension is required.

(3.0) Small volume manufacturers as defined in (n) (13.0) shall meet these requirements by the 1996 model year.

(4.0) Manufacturers may at their discretion implement a portion of these regulations prior to the required implementation date provided that the system complies with previously applicable on-board diagnostic system requirements.

(5.0) ~~Vehicles certified to run on alternate fuels, and d~~Diesel vehicles~~,~~ shall meet these requirements by the 1996 model year. Manufacturers may request a delay in the implementation of these requirements for diesel vehicles until 1997, subject to Executive Officer approval, if it is adequately demonstrated that the delay will allow for the development of significantly more effective monitoring systems.

(5.1) Vehicles certified to run on alternate fuels shall meet these requirements by the 1996 model year. However, manufacturers may request the Executive Officer to waive specific monitoring requirements for which monitoring may not be reliable with respect to the use of alternate fuels until the 1999 model year

(5.2) Medium-duty vehicles with engines certified on an engine dynamometer may comply with these requirements on an engine model year certification basis rather than on a vehicle model basis.

(6.0) The Executive Officer may waive one or more of the requirements of these subsections with respect to a specific vehicle or engine family for which production commences prior to April 1, 1994, and which is not otherwise exempted from compliance in accordance with sections (2.0) and (2.1) above. In granting a waiver, the Executive Officer shall consider the following factors: the extent to which these requirements are satisfied overall on the vehicle applications in question, the extent to which the resultant diagnostic system design will be more effective than systems developed according to section 1968, Title 13, and a demonstrated good-faith effort to meet these requirements in full by evaluating and considering the best available monitoring technology.

(6.1) For 1995 and 1996 model year vehicles for which production is to commence subsequent to March 31, 1994, and which are not exempted from compliance in accordance with sections (2.0) and (2.1) above, the Executive Officer, upon receipt of an application from the manufacturer, may certify the vehicles in question even though said vehicles may not comply with one or more of the requirements of these subsections. Such certification is contingent upon the manufacturer meeting the criteria set forth in section (6.0) above. Manufacturers of non-complying systems shall be subject to fines pursuant to section 43016 of the California Health and Safety Code for each deficiency identified, after the second, in a vehicle model. For the third deficiency and every deficiency thereafter identified in a vehicle model, the fines shall be in the amount of $50 per deficiency per vehicle for non-compliance with any of the monitoring requirements specified in subsections (b)(1) through (b)(9), and $25 per deficiency per vehicle for non-compliance with any other requirement of section 1968.1. In determining the identified order of deficiencies, deficiencies of subsections (b)(1) through (b)(9) shall be identified first. Total fines per vehicle under this section shall not exceed $500 per vehicle and shall be payable to the State Treasurer for deposit in the Air Pollution Control Fund. Engine families in receipt of a waiver granted under section (6.0) above shall be exempt from these fines. Further, small volume manufacturers choosing to comply with these requirements in the 1995 model year shall also be exempt from these fines. For 1996 model year vehicles and engines only, failure to properly monitor multiple electronic transmission components shall be considered a single monitoring system deficiency.

(6.2) Beginning with the 1997 model year and through the 2000 model, the certification provisions set forth in section (m)(6.1) above shall continue to apply subject to the following limitations: 1) The specified fines shall apply to the second and subsequently identified deficiencies, with the exception that fines shall apply to all monitoring system deficiencies wherein a required monitoring strategy is completely absent from the OBD system, and 2) Manufacturers may not carry over monitoring system deficiencies to future model years unless it can be demonstrated that vehicle hardware modifications would be necessary to correct the deficiency, in which case the deficiency may be carried over for one model year.

(n) GLOSSARY For purposes of this section:

(1.0) "Malfunction" means the inability of an emission-related component or system to remain within design specifications. Further, malfunction refers to the deterioration of any of the above components or systems to a degree that would likely cause the emissions of an average certification durability vehicle with the deteriorated components or systems present at the beginning of the applicable certification emission test to exceed by more than 1.5 times any of the emission standards (both with respect to the certification and useful life standards), unless otherwise specified, applicable pursuant to Subchapter 1 (commencing with Section 1900), Chapter 3 of Title 13.

(2.0) "Secondary air" refers to air introduced into the exhaust system by means of a pump or aspirator valve or other means that is intended to aid in the oxidation of HC and CO contained in the exhaust gas stream.

(3.0) "Engine misfire" means lack of combustion in the cylinder due to absence of spark, poor fuel metering, poor compression, or any other cause.

(4.0) Oxygen sensor "response rate" refers to the delay (measured in milliseconds) between a switch of the sensor from lean to rich or vice versa in response to a change in fuel/air ratio above and below stoichiometric.

(5.0) A "trip" means vehicle operation (following an engine-off period) of duration and driving mode such that all components and systems are monitored at least once by the diagnostic system except catalyst efficiency or evaporative system monitoring when a steady-speed check is used, subject to the limitation that the manufacturer-defined trip monitoring conditions shall all be encountered at least once during the first engine start portion of the applicable FTP cycle.

(6.0) A "warm-up cycle" means sufficient vehicle operation such that the coolant temperature has risen by at least 40 degrees Fahrenheit from engine starting and reaches a minimum temperature of 160 degrees Fahrenheit.

(7.0) A "driving cycle" consists of engine startup, ~~vehicle operation beyond the beginning of closed-loop operation~~, and engine shutoff.

(8.0) "Continuous monitoring" means sampling at a rate no less than two samples per second. If for engine control purposes, a computer input component is sampled less frequently, the value of the component may instead be evaluated each time sampling occurs.

(9.0) "Fuel trim" refers to feedback adjustments to the base fuel schedule. Short-term fuel trim refers to dynamic or instantaneous adjustments. Long-term fuel trim refers to much more gradual adjustments to the fuel calibration schedule than short-term trim adjustments. These long term adjustments compensate for vehicle differences and gradual changes that occur over time.

(10.0) "Base Fuel Schedule" refers to the fuel calibration schedule programmed into the Powertrain Control Module or PROM when manufactured or when updated by some off-board source, prior to any learned on-board correction.

(11.0) "Calculated load value" refers to an indication of the current airflow divided by peak airflow, where peak airflow is corrected for altitude, if available. This definition provides a unitless number that is not engine specific, and provides the service technician with an indication of the percent engine capacity that is being used (with wide open throttle as 100%).

$$\text{CLV} = \frac{\text{Current Airflow}}{\text{Peak airflow (@ sea level)}} \times \frac{\text{Atm Pressure (@ sea level)}}{\text{Barometric pressure}}$$

For diesel applications, the calculated load value shall be determined by the ratio of current output torque to maximum output torque at current engine speed.

(12.0) "Medium-duty vehicle" is defined in Title 13, Section 1900 (b)(9).

(13.0) "Small volume manufacturer" shall mean any vehicle manufacturer with sales less than or equal to 3000 new light-duty vehicles and medium-duty vehicles per model year based on the average number of vehicles sold by the manufacturer each model year from 1989 to 1991. For manufacturers certifying for the first time in California, model year sales shall be based on projected California sales.

(14.0) "Low Emission Vehicle" refers to a vehicle certified in California as a Transitional Low Emission Vehicle (TLEV), a Low Emission Vehicle (LEV), or an Ultra Low Emission Vehicle (ULEV). These vehicle categories are further defined in Title 13, sections 1956.8 and 1960.1.

(15.0) "Diesel engines"~~, for the purposes of these regulations, includes diesel derived~~ refers to engines ~~and those~~ using a compression ignition thermodynamic cycle.

(16.0) "Functional check" for an output component means verification of proper response to a computer command. For an input component, functional check means verification of the input signal being in the range of normal operation, including evaluation of the signal's rationality in comparison to all available information.

(17.0) "Federal Test Procedure" (FTP) cycle or test refers to, for passenger vehicles, light-duty trucks, and medium-duty vehicles certified on a chassis dynamometer, the driving schedule in Code of Federal Regulations (CFR) 40, Appendix 1, Part 86, section (a) entitled, "EPA Urban Dynamometer Driving Schedule for Light- Duty Vehicles and Light-Duty Trucks." For medium-duty engines certified on an engine dynamometer, FTP cycle or test refers to the engine dynamometer schedule in CFR 40, Appendix 1, Part 86, section (f)(1), entitled, "EPA Engine Dynamometer Schedule for Heavy-Duty Otto-Cycle Engines," or section (f)(2), entitled, "EPA Engine Dynamometer Schedule for Heavy-Duty Diesel Engines."

(18.0) "Redline engine speed" means the manufacturer recommended maximum engine speed as normally displayed on instrument panel tachometers, or the engine speed at which fuel shutoff occurs.

(19.0) "Power Take-Off unit" refers to an engine driven output provision for the purposes of powering auxiliary equipment (e.g., a dump-truck bed, aerial bucket, or tow-truck winch).

Note: Authority cited: Sections 39600, 39601, 43013 and 43018, Health and Safety Code. Reference: Sections 39002, 39003, 43013, 43100, 43101, 43102, 43104, 43105 and 43204, Health and Safety Code.

APPENDIX D

Modifications to Sections 2030, 2031, and the incorporated certification procedures, "California Certification and Installation Procedures for Alternative Fuel Retrofit Systems for Motor Vehicles Certified for 1994 and Subsequent Model Years.

Note: The proposed amendments are shown in underline to indicate additions to the sections and ~~strikeout~~ to indicate deletions.

Amend Title 13, California Code of Regulations, Sections 2030 and 2031, to read as follows:

Article 5. Approval of Systems Designed to Convert Motor Vehicles to Use Fuels Other Than the Original Certification Fuel

2030. Liquefied Petroleum Gas or Natural Gas Retrofit Systems.

(a) Applicable Standards and Test Procedures.

The standards and test procedures for approval of systems designed to convert 1993 and earlier model year motor vehicles to use liquefied petroleum gas or natural gas fuels are contained in "California Exhaust Emission Standards and Test Procedures for Systems Designed to Convert Motor Vehicles Certified for 1993 and Earlier Model Years to Use Liquefied Petroleum Gas or Natural Gas Fuels" adopted by the State Board on April 16, 1975, as amended March 11, 1993. The standards and test procedures for approval of systems designed to convert 1994 and subsequent model year motor vehicles to use liquefied petroleum gas or natural gas fuels are contained in "California Certification and Installation Procedures for Alternative Fuel Retrofit Systems for Motor Vehicles Certified for 1994 and Subsequent Model Years," adopted by the State Board March 11, 1993, as amended ______________. At the option of the retrofit system manufacturer, the standards and test procedures for approval of systems designed to convert 1994 and subsequent model year vehicles to use liquefied petroleum gas or natural gas fuels may be used for approval of systems designed to convert 1993 and earlier model year motor vehicles to use liquefied petroleum gas or natural gas fuels in lieu of the "California Exhaust Emission Standards and Test Procedures for Systems Designed to Convert Motor Vehicles Certified for 1993 and Earlier Model Years to Use Liquefied Petroleum Gas or Natural Gas Fuels."

(b) Implementation Phase-In Schedule.

Notwithstanding subsection (a), a retrofit system manufacturer may apply "California Exhaust Emission Standards and Test Procedures for Systems Designed to Convert Motor Vehicles Certified for 1993 and Earlier Model Years to Use Liquefied Petroleum Gas or Natural Gas Fuels" to certify retrofit systems for 1994 and 1995 model-year vehicles in accordance with the following implementation phase-in schedule. Each manufacturer may certify a maximum of 85 percent of its total 1994 model-year engine family retrofit systems and 45 percent of its total 1995 model-year systems according to the requirements of these test procedures and "California Exhaust Emission Standards and Test Procedures for Systems Designed to Convert Motor Vehicles Certified for 1993 and Earlier Model Years to Use Alcohol or Alcohol/Gasoline Fuels", adopted by the State Board on April 28, 1983, as amended March 11, 1993. The remaining percentage of each manufacturer's certified 1994 and 1995 model-year engine family retrofit systems and all of 1996 and subsequent model-year engine family retrofit systems shall be certified according to "California Certification and Installation Procedures for Alternative Fuel Retrofit Systems For Motor

Vehicles Certified For 1994 and Subsequent Model Years." The percentages shall be determined from the total number of retrofit systems certified and shall be met prior to the end of the applicable calendar year. "California Exhaust Emission Standards and Test Procedures for Systems Designed to Convert Motor Vehicles Certified for 1993 and Earlier Model Years to Use Liquefied Petroleum Gas or Natural Gas Fuels" shall not be applied to certify a a retrofit system for installation on a transitional low-emission vehicle ("TLEV"), low-emission vehicle ("LEV"), or ultra-low-emission vehicle ("ULEV") or to certify a retrofit system designed to convert a vehicle to TLEV, LEV, or ULEV emission standards (as defined in Section 1960.1, Title 13, California Code of Regulations).

NOTE: Authority cited: Sections 39515, 39600, 39601 and 43006, Health and Safety Code; Sections 27156 and 38395, Vehicle Code. Reference: Sections 43000, 43004, 43006, 43008.6, 43013 and 43018, Health and Safety Code; Sections 27156, 38391 and 38395, Vehicle Code.

2031. Alcohol or Alcohol/Gasoline Fuels Retrofit Systems.

(a) Applicable Standards and Test Procedures.

The standards and test procedures for approval of systems designed to convert 1993 and earlier model year motor vehicles to use alcohol or alcohol/gasoline fuels in lieu of the original certification fuel system are contained in "California Exhaust Emission Standards and Test Procedures for Systems Designed to Convert Motor Vehicles Certified for 1993 and Earlier Model Years to Use Alcohol or Alcohol/Gasoline Fuels," adopted by the State Board April 28, 1983, as amended March 11, 1993. The standards and test procedures for approval of systems designed to convert 1994 and subsequent model year motor vehicles to use alcohol or alcohol/gasoline fuels are contained in "California Certification and Installation Procedures for Alternative Fuel Retrofit Systems for Motor Vehicles Certified for 1994 and Subsequent Model Years," adopted by the State Board March 11, 1993, as amended ____________________. At the option of the retrofit system manufacturer, the standards and test procedures for approval of systems designed to convert 1994 and subsequent model year motor vehicles to use alcohol or alcohol/gasoline fuels may be used for approval of systems designed to convert 1993 and earlier model year motor vehicles to use alcohol or alcohol/gasoline fuels in lieu of the "California Exhaust Emission Standards and Test Procedures for Systems Designed to Convert Motor Vehicles Certified for 1993 and Earlier Model Years to Use Alcohol or Alcohol/Gasoline Fuels."

(b) Implementation Phase-In Schedule.

Notwithstanding subsection (a), a retrofit system manufacturer may apply "California Exhaust Emission Standards and Test Procedures for Systems Designed to Convert Motor Vehicles Certified for 1993 and Earlier Model Years to Use Alcohol or Alcohol/Gasoline Fuels" to certify retrofit systems for 1994 and 1995 model-year vehicles in accordance with the following implementation phase-in schedule. Each manufacturer may certify a maximum of 85 percent of its total 1994 model-year engine family retrofit systems and 45 percent of its total 1995 model-year systems according to the requirements of these test procedures and the "California Exhaust Emission Standards and Test Procedures for Systems Designed to Convert Motor Vehicles Certified for 1993 and Earlier Model Years to Use Liquefied Petroleum Gas or Natural Gas Fuels," adopted by the State Board on April 16, 1975, as amended March 11, 1993. The remaining percentage of each manufacturer's certified 1994 and 1995 model-year engine family retrofit systems and all of 1996 and subsequent model-year engine family retrofit systems shall be certified according to "California Certification and Installation Procedures for Alternative Fuel Retrofit Systems For Motor Vehicles Certified For 1994 and Subsequent Model Years." The percentages shall be determined from the total number of retrofit systems certified and shall be met prior to the end of the applicable calendar year. "California Exhaust Emission Standards and Test Procedures for Systems Designed to Convert Motor Vehicles Certified for 1993 and Earlier Model Years to Use Alcohol or Alcohol/Gasoline Fuels" shall not be applied to certify a retrofit system for installation on a transitional low-emission vehicle ("TLEV"), low-emission vehicle ("LEV"), or ultra-low-emission vehicle ("ULEV") or to certify a retrofit system designed to convert a vehicle to TLEV, LEV, or ULEV emission standards (as defined in Section 1960.1, Title 13, California Code of Regulations).

NOTE: Authority cited: Sections 39515, 39600, 39601 and 43006, Health and Safety Code; Sections 27156 and 38395, Vehicle Code. Reference: Sections 43000, 43004, 43006, 43008.6, 43013 and 43018, Health and Safety Code; Sections 27156, 38391 and 38395, Vehicle Code.

State of California
AIR RESOURCES BOARD

CALIFORNIA CERTIFICATION AND INSTALLATION PROCEDURES FOR ALTERNATIVE FUEL RETROFIT SYSTEMS FOR MOTOR VEHICLES CERTIFIED FOR 1994 AND SUBSEQUENT MODEL YEARS

Note: Proposed changes to the text adopted are indicated by strike-out (deletion) and underline (addition).

Adopted: March 11, 1993
Amended:

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California Certification and Installation Procedures for Alternative Fuel Retrofit Systems for Motor Vehicles Certified for 1994 and Subsequent Model Years

1. APPLICABILITY

(a) "Certification and Installation Procedures for Alternative Fuel Retrofit Systems for Motor Vehicles Certified for 1994 and Subsequent Model Years" ("these Procedures") apply to alternative fuel retrofit systems designed for installation on gasoline- or diesel-fueled light-, medium-, and heavy-duty motor vehicles for 1994 and subsequent model years. Only these Procedures shall be used to certify a retrofit system for installation on a transitional low-emission vehicle ("TLEV"), low-emission vehicle ("LEV"), or ultra-low-emission vehicle ("ULEV") or to certify a retrofit system designed to convert a vehicle to TLEV, LEV, or ULEV emission standards (as defined in Section 1960.1, Title 13, CCR). Each manufacturer shall certify a minimum of 15 percent of 1994, 55 percent of 1995, and 100 percent of 1996 and subsequent model year engine family retrofit systems according to the requirements of these Procedures. "California Exhaust Emission Standards and Test Procedures for Systems Designed to Convert Motor Vehicles Certified for 1993 and Earlier Model Years to Use Liquefied Petroleum Gas or Nitural Gas Fuels," (for certifying liquefied petroleum gas or natural gas retrofit systems) and "California Exhaust Emission Standards and Test Procedures for Systems Designed to Convert Motor Vehicles Certified for 1993 and Earlier Model Years to Use Alcohol or Alcohol/Gasoline Fuels" (for certifying alcohol and alcohol/gasoline retrofit systems) shall be used to certify the remaining percentage of 1994 and 1995 model year engine family systems and 1993 and prior model year engine family systems, except as provided in paragraph 1.(b).

(b) A retrofit system manufacturer may as an option use these Procedures to certify alternative fuel retrofit systems designed for installation on pre-1994 model year gasoline- or diesel-fueled light-, medium-, and heavy-duty motor vehicles, with the following addition: the Executive Officer may order 25,000 mile durability vehicle testing for alternative fuel retrofit systems designed for installation on pre-1994 model year vehicles which include hardware or components other than the fuel conversion system as part of the overall retrofit system.

(c) A certification issued pursuant to these Procedures shall have the effect of a certification of an alternative fuel retrofit system pursuant to Health and Safety Code Section 43006, and shall also have the effect of an exemption issued pursuant to Vehicle Code Sections 27156 and 38395.

2. DEFINITIONS

"Alternative fuel" refers to liquefied petroleum gas, natural gas, alcohol and alcohol/gasoline fuels.

An "alternative fuel retrofit system" or "retrofit system" is a package of fuel, ignition, emission control, and engine components that are modified, removed, or added during the process of modifying a motor vehicle to operate on an alternative fuel.

"Driveability" of a vehicle refers to the smooth delivery of power, as demanded by the driver. Typical causes of driveability degradation are rough idling, misfiring, surging, hesitation, or insufficient power. Conversion from gasoline to gaseous fuels usually entails a loss of volumetric efficiency, resulting in some power loss. Normal power loss shall not be considered to be driveability degradation.

"Installer" refers to a person who installs alternative fuel retrofit systems on motor vehicles.

"Retrofit system manufacturer" or "manufacturer" refers to a person who manufactures or assembles an alternative fuel retrofit system for sale in California and requests or is granted the Executive Order certifying the alternative fuel retrofit system.

For purposes of these Procedures "useful life" is the duration, expressed in miles, of the longest durability period for the new vehicle or engine-emission standards to which the vehicle or engine was certified. (This is typically 50,000 miles for light-duty vehicles. However, as of the 1993 model year, a phase-in of new, more stringent, light-duty standards with 100,000 mile useful life requirements will begin.)

3. GENERAL REQUIREMENTS

(a) Product Specifications:

In addition to all other standards or requirements imposed, the following general requirements shall apply to all alternative fuel retrofit systems to be certified for installation on California-certified gasoline or diesel-fueled motor vehicles:

(i) Alternative fuel retrofit systems for gaseous fuels shall be equipped with a lockoff valve, actuated by an electrical or vacuum signal, preventing delivery of fuel to the carburetor, or fuel injection system, while the engine is shut down.

(ii) The driveability of a vehicle equipped with a retrofit system shall not be degraded in such a way as to encourage consumer tampering. To verify that the driveability of a retrofitted vehicle is acceptable, the Executive Officer may require that an independent laboratory evaluate driveability. The Executive Officer's determination that driveability must be evaluated shall be based on an engineering evaluation of the retrofit system described in the application for certification or on reports or observations that retrofit systems similar in design to the system for which certification is sought have caused driveabilty degradation. The cost of this evaluation shall be borne by the applicant.

(iii) If the vehicle to be retrofitted was certified with an on-board diagnostic (OBD) system pursuant to Section 1968 or 1968.1, Title 13, California Code of Regulations (CCR), the proper function of the on-board diagnostic system shall not be impaired as a result of the installation and operation of the alternative fuel retrofit system. This requirement may necessitate modification of the OBD system to prevent it from storing erroneous trouble codes (e.g., storing a code signifying faulty operation of the evaporative canister purge valve because the evaporative emission control system has been removed). All modifications to OBD components, programming or wiring, must be fully specified as parts of the retrofit system. If the retrofit system includes modifications to the OBD system, the applicant must submit an analysis showing that these modifications will not adversely affect OBD performance. <u>Notwithstanding, for 1998 and previous model year vehicles, retrofit system manufacturers may request Executive Officer approval to disable specific on-board diagnostic monitoring strategies for which monitoring may not be reliable with respect to the use of alternative fuels (e.g., oxygen sensor response rate checks). The manufacturer shall submit data and/or an engineering evaluation to justify the request.</u>

(iv) With the exception of idle speed control and throttle position control, no component or calibration of the fuel system that could affect emission performance shall be adjustable by the system installer or the vehicle's user.

(b) Emission Control Labels:

"California Motor Vehicle Emission Control Label Specifications," incorporated by reference in Title 13, CCR, Section 1965, shall apply to installations of alternative fuel retrofit systems, with the following additions:

(i) The retrofit system manufacturer shall provide a supplemental Emission Control Information label, which shall be affixed in a permanent manner to each retrofitted vehicle, in a location adjacent to the original Emission Control Information Label. If the supplemental label cannot be placed adjacent to the original label, it shall be placed in a location where it can be seen by a person viewing the original label.

(ii) The supplemental label shall clearly state that the vehicle has been equipped with an alternative fuel retrofit system designed to allow it to operate on a fuel other than gasoline or diesel, and shall identify the fuel(s) which the vehicle is designed to use. The label shall show the vehicle model year; the Executive Order number certifying the retrofit system; the retrofit system manufacturer's name, address, and telephone number; and shall state that the retrofitted vehicle complies with California emission requirements. If the retrofit system has been certified as being capable of converting the vehicle into a TLEV, LEV, or ULEV, the label shall prominently display the title, "Transitional Low-Emission Vehicle," "Low-Emission Vehicle," or "Ultra-Low-Emission Vehicle," as appropriate. The label shall also list any original parts that were removed during installation of the retrofit system, as well as any changes in tune-up specifications required for the retrofit system. In addition, the label shall show the installer's name, address, and telephone number; the date on which the retrofit system was installed; and the mileage (retrofitted vehicle odometer reading) and date at which the retrofit system warranty expires. It is not necessary for emission control labels installed with retrofit systems to be machine readable.

(iii) The retrofit system manufacturer shall provide a vacuum hose routing diagram for each retrofit system sold. The vacuum hose routing diagram shall be placed underhood in a permanent manner at a visible and accessible location and shall show modifications to the original vacuum system.

(c) Owner's Manuals:

Each retrofit system installed shall include an owner's manual containing at least the following information:

(i) a brief description of the retrofit system, including major components and their theory of operation;

(ii) the correct refueling procedure;

(iii) a listing of necessary service and service intervals, as well as tune-up data, which differ from the service requirements specified by the vehicle's or engine's original manufacturer;

(iv) the name, address, and phone number of the installer, as well as a list of the names, addresses, and phone numbers of the major dealers in California who supply parts for, or service, the retrofit system; and

(v) warranty information.

(d) Manufacturer Recordkeeping Requirement:

Manufacturers of retrofit systems shall maintain a record of the vehicle identification numbers and California license plate numbers of those vehicles on which their product has been installed. As part of this record, manufacturers shall identify the installation date and the certification number of those systems installed on each vehicle and shall identify the vehicles' owners at the time of installation, including the owners' current addresses and phone numbers at the time of installation. The retrofit system manufacturer shall supply a copy of all installation information to the Executive Officer upon request.

(e) Installer Recordkeeping Requirement:

Installers of retrofit systems shall maintain a record as specified in paragraph 3(d) and shall provide this information to retrofit system manufacturers upon request.

4. REQUEST FOR CERTIFICATION

(a) A request for certification of an alternative fuel retrofit system may be submitted by an authorized representative of the retrofit system manufacturer intending to offer the retrofit system for sale or installation in the State of California.

(b) A separate request shall be required for each model year, even though the emission standards for certifying new vehicles may be the same for consecutive model years. The request shall include all test data and other information required pursuant to these Procedures, except where other provisions of these Procedures allow carry-over or carry-across of test data from an engine family to the engine family(ies) for which certification is sought. Procedures governing carry-over and carry-across are discussed under paragraph 6, "Approval."

(c) The request for certification shall be submitted in writing, signed by an authorized representative of the retrofit system manufacturer, and shall include the following:

(i) Identification and description of the engine families for which the retrofit system to be certified is designed; the emission standards applicable to those engine families; and if applicable, a statement that the retrofit system is designed [A] to convert conventional vehicles into either TLEVs, LEVs or ULEVs, [B] to convert a TLEV into either an LEV or ULEV, or [C] to convert an LEV into a ULEV.

(ii) A complete description of the alternative fuel retrofit system, including details of the carburetor, mixer, regulator, vaporizer, or fuel injection system; the feedback mixture control system (if applicable), part number(s), calibration data, hose routing, specifications for the fuel tank, and pressure regulator; a sample of the emission control label as specified in 3.(b); a sample of the warranty statement as specified in 9(a) and (b); and all necessary modifications to the engine, emission control system, or other parts of the vehicle.

(iii) Procedures for installing and maintaining the retrofit system, including tune-up specifications and discussion of any special tools or techniques required for proper installation, maintenance, or operation.

(iv) An agreement to supply the Air Resources Board, within 45 calendar days of the Executive Officer's request, with any one or more of the vehicles used for certification testing, or to provide Air Resources Board personnel with the equipment to inspect and test such vehicles at the applicant's facility, if requested by the Executive Officer.

5. TEST PROCEDURES

(a) Description of Vehicle Categories:

For the purposes of these certification Procedures, the motor vehicle fleet is divided into three major categories:

I. Passenger cars, light-duty trucks, and medium-duty vehicles as defined in "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" (as incorporated by reference in Section 1960.1, Title 13, CCR), which were certified to an exhaust emission standard based on a chassis-dynamometer test procedure;

II. Vehicles with gross vehicle weight ratings less than or equal to 14,000 lbs and not originally certified to a chassis dynamometer-based exhaust emission standard; and

III. Vehicles with gross vehicle weight ratings greater than 14,000 lbs.

(b) Test Procedures for Vehicles in Category I:

For vehicles in Category I, the emission standards and test procedures set forth in the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" also apply to the certification of alternative fuel retrofit systems, with the following exceptions:

(i) The applicable emission standards shall be at least as stringent as the emission standards applicable to the engine families for which the retrofit systems to be certified are designed. In addition, vehicles retrofitted to operate on a given alternative fuel shall also be subject to any additional emission standards applicable to new motor vehicles that are designed to operate on the alternative fuel, and that are of the model year and vehicle class for which certification is sought. A maximum of one emission-data vehicle per engine family for which certification is sought shall be required. Where durability testing is required, a bench-test vehicle may be substituted for a durability vehicle and may also be considered an emission-data vehicle. Prior to the commencement of testing, the choice of durability vehicle or bench-test vehicle, emission-data vehicle(s) and engine(s) must be approved by the Executive Officer as being representative of the range of engine families for which certification is sought.

(ii) For the purpose of applying the provisions of the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" to certification testing of alternative fuel retrofit systems, test vehicles equipped with an alternative fuel retrofit system shall be assumed to have zero miles of mileage accumulation at the time that the retrofit system is installed. Mileage may be subsequently accumulated by driving the vehicle on the road, following a typical suburban route, or on a chassis dynamometer using the Automobile Manufacturer's Association mileage accumulation cycle (40 C.F.R., Part 86, Appendix IV, as adopted January 28, 1977).

(iii) Vehicle mileage accumulation on a durability vehicle or bench aging of retrofit system components shall be conducted to determine deterioration factors. Prior to the commencement of any emission or bench aging, the applicant's test plan must be approved by the Executive Officer. Approval of the test plan shall be contingent upon a demonstration by the applicant that bench aging produces deterioration factors at least as great as durability vehicle testing.

(iv) Bench aging conducted in lieu of vehicle mileage accumulation shall be conducted for a period of time such that the resulting deterioration of the retrofit system is equivalent to that which would occur during durability vehicle mileage accumulation over a mileage equal to the useful life of the vehicle.

(v) Vehicle mileage accumulation on a durability vehicle shall be performed in conjunction with emission testing. Before beginning vehicle mileage accumulation of the retrofit system, the system shall be installed on the durability vehicle, the vehicle shall be driven 4,000 $\pm$ 100 miles and the vehicle shall be tested using the alternative fuel. A dual-fuel retrofit system shall be emission tested using each fuel that it is capable of operating on. At the conclusion of vehicle mileage accumulation, a second emission test or series of tests shall be performed.

Alternatively, if bench aging is used to determine deterioration factors, then bench aging shall be performed in conjunction with emission testing of a bench-test vehicle. Before beginning bench aging of the retrofit system, it shall be installed on the bench-test vehicle, the vehicle shall be driven for 4,000 $\pm$ 100 miles, and the vehicle shall then be emission tested using the alternative fuel. A dual-fuel retrofit system shall be emission tested using each fuel that it is capable of operating on. After the emission tests are completed, the retrofit system shall be removed from the vehicle and subjected to bench aging. At the conclusion of bench aging, the retrofit system shall be reinstalled on the bench-test vehicle, and a second emission test or series of tests shall be performed.

(vi) For exhaust emissions of each regulated pollutant measured during the vehicle mileage accumulation or bench-test procedure, a deterioration factor shall be calculated by dividing the emission rate obtained during the second emission test by that obtained during the first. If the resulting quotient is less than one, the deterioration factor shall be assigned a value of one. The deterioration constant for evaporative emissions shall be calculated by subtracting the evaporative emissions found during the first emission test from those found during the second test. If the resulting difference is less than zero, the deterioration constant shall be assigned a value of zero.

(vii) Choices of vehicle models, engines, and transmissions for use in emission-data vehicles shall be approved by the Executive Officer as being representative of the engine families for which certification is sought, prior to the commencement of testing. Following installation of the retrofit system, the emission-data vehicle shall be driven 4,000 $\pm$ 100 miles to stabilize emission rates. After the specified mileage has been accumulated, the emission-data vehicles' exhaust and evaporative emissions, where applicable, shall be tested, using the appropriate procedure as set forth in "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles." Dual fuel vehicles shall be emission tested using each fuel that the vehicle is capable of operating on.

(viii) The deteriorated emissions of emission-data vehicles shall be calculated using the deterioration factors and constants found during vehicle mileage accumulation or bench testing. The useful life exhaust emission values are defined as the product of each emission value at 4,000 miles times the corresponding deterioration factor. For evaporative emissions, the certification emission value is equal to the sum of the emissions measured at, or extrapolated to 4,000 miles, plus the deterioration constant. The durability vehicle, bench-test vehicle, and all emission-data vehicles shall meet the applicable new vehicle useful life emission standards, as well as all applicable emission standards for intermediate mileage levels, for the vehicles' model year and fuel type(s).

(c) Test Procedures for Vehicles in Category II:

For durability, bench-test and emission-data vehicles in Category II, test vehicles shall have accumulated a total mileage greater than 4,000 miles and less than 10,000 miles with the original fuel system, prior to emission testing. If the manufacturer chooses to use the option as described in 1(b) for pre-1994 model year vehicles, then the 10,000 mile limit shall not be applicable. A test vehicle's engine and emission control system shall be equipped and calibrated as certified. The vehicle shall then be tested for exhaust and, if applicable, evaporative emissions using the test procedures set forth in the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles". The inertia weight setting shall be equal to the average of the vehicle's curb weight and gross vehicle weight rating and road load horsepower based on the frontal area of the vehicle without modifications, as determined in "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles," Section 9.b. The test results shall be defined as the baseline emission rates. After the baseline emission rates have been measured, the retrofit system shall be installed.

(i) The procedure outlined in paragraphs 5(b)(iii) through 5(b)(vi) shall be used with the following modifications: "useful life" shall equal 120,000 miles for vehicles in Category II; the durability or bench-test vehicle's emission rates of regulated pollutants measured at 4,000 ± 100 miles after the installation of the retrofit system shall not exceed 1.10 times the baseline rates; the deteriorated exhaust emissions of regulated pollutants projected to 120,000 miles shall not exceed 1.3 times the baseline emissions; and the deteriorated evaporative emissions of regulated pollutants projected to 120,000 miles shall not exceed the baseline emissions plus 0.5 grams.

(ii) When the Executive Officer determines that deterioration factors determined in paragraph 5(c)(i) may be carried across or carried over to other engine families in Category II, the representative emission-data vehicles shall be tested as specified in paragraph 5(b)(vii). Emission rates measured at 4,000 ± 100 miles after installation of the retrofit system shall not exceed 1.10 times the vehicles' baseline rates.

(d) Test Procedures for Vehicles in Category III:

Applicants requesting certification for retrofit systems for use in Category III vehicles shall submit a test plan utilizing eight mode chassis dynamometer testing to verify that the retrofit system will not cause excess emissions from engine families for which certification is sought. Test vehicles shall have accumulated a total mileage greater than 4,000 miles and less than 10,000 miles with the original fuel system prior to emission testing. If the manufacturer chooses to use the option as described in 1(b) for pre-1994 model year vehicles, then the 10,000 mile limit shall not be applicable. A test vehicle's engine and emission control system shall be equipped and calibrated as certified. The vehicle shall then be tested for exhaust emissions using the eight mode chassis dynamometer test specified in the test plan. The test result shall be defined as the baseline emission rate. After the baseline emission rate has been measured, the retrofit system shall be installed. Emission rates shall then be measured at 4,000 ± 100 miles after installation of the retrofit system using the eight mode chassis dynamometer test specified in the test plan.

(i) Subject to the Executive Officer's approval of the applicant's test plan prior to commencing testing, testing utilizing procedures other than the eight mode chassis dynamometer test shall be allowed.

(ii) Emission testing shall be conducted to determine exhaust emission rates of carbon monoxide and the sum of non-methane hydrocarbons plus nitrogen oxides. Emissions shall not exceed 1.10 times the baseline rates.

(iii) The procedures outlined in paragraphs 5(b)(iii) through 5(b)(vi) shall be used with the following modifications: "useful life" shall equal 180,000 miles for vehicles in Category III; the durability or bench-test vehicle's emission rates of CO, and the sum of non-methane hydrocarbons plus NOx measured at 4,000 $\pm$ 100 miles shall not exceed 1.10 times the baseline rates; the deteriorated exhaust emissions projected to 180,000 miles shall not exceed 1.3 times the baseline emissions; and, the deteriorated evaporative emissions projected to 180,000 miles shall not exceed baseline emissions plus 0.5 grams. For the purposes of this section, the evaporative baseline emissions shall be estimated by the manufacturer based on good engineering principles and judgment. The manufacturer's test plan shall specify the evaporative baseline emissions estimate and describe how this estimate was derived.

(iv) The Executive Officer may allow carry-across of durability data from certification bench testing of retrofit systems designed for vehicles in Categories I or II to Category III retrofit system applications, if the Executive Officer determines that the carry-across durability data will adequately represent the durability performance of the retrofit system to be certified.

(v) Applicants requesting certification for retrofit systems designed to allow Category III vehicles to operate on an alternative fuel in addition to diesel fuel shall conduct smoke opacity testing on the emission-data vehicle(s) utilizing the peak smoke opacity standards and procedures set forth in "Heavy-Duty Diesel Vehicle Smoke Opacity Test Procedure," as incorporated by reference in Title 13, CCR, Section 2182. Smoke opacity testing shall be conducted using each fuel that the retrofitted vehicle is designed to operate on. The applicable peak smoke opacity standard shall be that set for the model year for which certification is sought.

(vi) The selection of duty cycle(s) and all other aspects of the test procedure shall be subject to approval by the Executive Officer, and emission testing shall commence only after the Executive Officer has approved the test plan. The Executive Order shall be issued following review of the test data and determination that they meet the criteria specified in the test plan.

6. APPROVAL

(a) Issuance of Executive Orders:

If, after reviewing the test data and other information submitted by the retrofit system manufacturer, the Executive Officer determines that the retrofit system meets the applicable emission standards or the criteria of an approved test plan, as applicable, an Executive Order shall be issued certifying the retrofit system for sale and installation on vehicles in the engine families specified in the application. The Executive Order shall specify, if applicable, that the retrofit system is certified as [A] converting a conventional motor vehicle into a TLEV, LEV or ULEV, [B] converting a TLEV into a LEV or ULEV, or [C] converting a LEV into a ULEV.

(b) Carry-Over and Carry-Across:

Carry-over of emission test data from the previous model year to the following model year will be allowed, if the Executive Officer determines that the carry-over data will adequately represent the emissions performance of the retrofit system to be certified. Carry-across to similar engine families will also be allowed. Applications for carry-over and carry-across must be accompanied by an engineering analysis demonstrating that the emissions and durability of the retrofit system and engine family for which certification is being sought will be adequately represented by a certified retrofit system/engine family application. Applications for carry-over and carry-across will be evaluated according to the the criteria contained in EPA Advisory Circular 17F, which is incorporated herein by reference, and paragraph 4.b.4 of the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles." These include, but are not limited to, similarity of catalyst location and configuration, similarity of fuel metering system, similarity of emission control system logic and design, and similarity of any other features that may affect the durability of the retrofit system's emission performance.

7. INSTALLATION REQUIREMENTS

(a) Prior to releasing a converted vehicle to the consumer, the installer of an alternative fuel retrofit system shall submit the converted vehicle to a Bureau of Automotive Repair Referee Smog Check Station for inspection and testing.

(i) The installer of an alternative fuel retrofit system shall keep a copy of the certificate of compliance, issued by the Bureau of Automotive Repair Referee Smog Check Station, as part of the record specified in paragraph 3(e). The certificate of compliance shall contain, but need not be limited to, the following: the vehicle's identification number, the vehicle's model year and make, the date of installation, and the emissions category to which the retrofitted system is certified (i.e., conventional vehicle, TLEV, LEV, or ULEV). The original certificate of compliance shall be submitted to the vehicle owner upon the vehicle's release.

(ii) The installer of an alternative fuel retrofit system shall not release the converted vehicle to the consumer without the issuance of a certificate of compliance for the vehicle by a Bureau of Automotive Repair Referee Smog Check Station.

(iii) The installer of an alternative fuel retrofit system shall also meet the requirements of paragraph 9(c).

8. IN-USE ENFORCEMENT TEST REQUIREMENTS

(a) Manufacturers of alternative fuel retrofit systems shall, upon order by the Executive Officer, perform in-use enforcement emission testing of their products. The Executive Officer may order in-use enforcement emission testing of not more than 20 percent of a manufacturer's certified retrofit systems/engine family applications per year. If 20 percent constitutes less than one of a manufacturer's certified systems, the Executive Officer may order in-use enforcement emission testing of not more than one certified system/engine family application per year. Manufacturers shall be required to perform emission testing of not less than ten vehicles per certified retrofit system/engine family application selected by the Executive Officer for in-use enforcement emission testing. Upon order by the Executive Officer, manufacturers shall perform the applicable emission tests pursuant to the following:

(i) No vehicle shall be accepted by the manufacturer as a representative vehicle for enforcement testing unless the following criteria are met:

(1) California certified and registered.

(2) Odometer indication of less than certified useful-life mileage and vehicle age within useful-life time period.

(3) No indication of abuse (e.g., racing, overloading, misfueling, or other misuse), neglect, improper maintenance or other factors that would have an effect on emission performance.

(4) No major repair to engine or major repair of vehicle resulting from collision.

(5) Lead content of fuel sample from the vehicle tank meets applicable standards.

(6) No indication of any problem that might jeopardize the safety of laboratory personnel.

(ii) The manufacturer shall, under ARB supervision, perform diagnosis or restorative maintenance on those vehicles selected for in-use enforcement testing. The manufacturer or a laboratory approved by the Executive Officer shall (1) identify part numbers of all essential emission control system components; (2) check air filter, all drive belts, all fluid levels, radiator cap, all vacuum hoses and electrical wiring related to emission control for integrity; check fuel metering and emission control system components for maladjustments and/or tampering, and record all discrepancies; (3) check ignition system with oscilloscope and replace any defective components; i.e., spark plugs, wires, etc.; (4) check compression; (5) check and adjust engine parameters to manufacturer's specifications; and (6) perform maintenance if the vehicle is within 500 miles of scheduled maintenance service.

(iii) For vehicles in Category I, the manufacturer or a laboratory approved by the Executive Officer shall perform the applicable emission test procedures set forth in the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles." The applicable emission standards shall be the vehicle's useful life standards as well as any intermediate emission standards, as stated in the Executive Order.

(iv) For vehicles in Category II, in-use enforcement exhaust and, if applicable, evaporative emissions shall be performed using the test procedures set forth in the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles". The inertia weight setting shall be equal to the average of the vehicle's curb weight and gross vehicle weight rating and road load horsepower based on the frontal area of the vehicle without modifications, as determined in "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles," Section 9.b. For vehicles in Category III, in-use enforcement exhaust emission tests shall be performed in accordance with the test plan approved by the Executive Officer prior to certification testing of the engine family applications specified for in-use enforcement testing.

(v) The applicable exhaust emission standards for vehicles in Categories II and III shall be the baseline emission rates established during certification testing of the engine family applications specified for in-use enforcement testing times 1.3. The applicable evaporative emission standards for vehicles in Categories II and III shall be the baseline emission rates established during certification testing of the engine family applications specified for in-use enforcement testing plus 0.5 grams.

(vi) Manufacturers shall complete in-use enforcement testing within 6 months of the issuance of the in-use compliance testing order and shall submit all test data to the Executive Officer within 30 calendar days following completion of testing.

(vii) Following review of manufacturer in-use enforcement test data, the Executive Officer may conduct confirmatory in-use enforcement testing.

(b) If the results of the in-use vehicle emission tests conducted pursuant to paragraphs 8(a)(i) through 8(a)(vii) indicate that the average emissions of the test vehicles for any pollutant exceed the applicable emission standards, the entire vehicle population so represented shall be deemed to exceed such standards. Upon order by the Executive Officer, the manufacturer shall have 45 days to submit an influenced recall plan in accordance with Sections 2111 through 2121, Title 13, CCR. If no such recall plan is submitted, the Executive Officer may order corrective action including recall of the affected vehicles in accordance with Sections 2122 through 2135, Title 13, CCR. For the purpose of these Procedures, the term "manufacturer," as referenced in Sections 2111 through 2135, Title 13, CCR, shall mean "retrofit system manufacturer."

9. WARRANTY REQUIREMENTS

(a) Requirements of Manufacturers:

The manufacturer of an alternative fuel retrofit system shall warrant to the person having the vehicle retrofitted and to each subsequent purchaser of the vehicle that the alternative fuel retrofit system is designed and manufactured to conform with the applicable requirements of these Procedures and is free from defects in materials and workmanship which cause the alternative fuel retrofit system to fail to conform with the applicable requirements of these Procedures or cause damage to any part on the retrofitted vehicle. This warranty shall be effective for three years or 50,000 miles, whichever first occurs, of customer service, and shall cover the full repair or replacement costs including the costs of diagnosis, labor, and parts (including any part on the retrofitted vehicle that is damaged due to a defect in the alternative fuel retrofit system).

(b) Extended Warranty Requirements:

Each manufacturer of an alternative fuel retrofit system shall identify in its application for certification the warranted parts whose individual replacement cost, at the time of certification, exceeds the cost limit defined in paragraph 9(b)(i). The replacement cost shall include the cost of the diagnosis, parts, and labor. The costs shall be those of the highest cost metropolitan area of California. Each manufacturer shall warrant to the person having the vehicle retrofitted and to each subsequent purchaser of the vehicle that those parts identified in its application for certification as exceeding the cost limit defined in paragraph 9(b)(i) are free from defects in materials and workmanship which cause the alternative fuel retrofit system to fail to conform with the requirements of these Procedures or cause damage to any part on the retrofitted vehicle, for seven years or 70,000 miles, whichever first occurs.

(i) The cost limit shall be calculated using the following equation:

$$\text{Cost limit}_n = \$300 \times (CPI_{n-2}/121.9)$$

where:
Cost limit_n is the cost limit for the year in which the alternative fuel retrofit system is to be certified.

n is the year in which the alternative fuel retrofit system is to be certified.

CPI is the annual average consumer price index for California published by the United States Bureau of Labor Statistics.

(ii) The cost limit shall be revised annually by the Executive Officer. The highest cost metropolitan area in California shall be identified by the Executive Officer.

(iii) Each manufacturer shall submit to the Executive Officer the documentation used to identify the warranted parts required in this subsection. The documentation shall include the estimated retail parts costs, labor rates in dollars per hour, and the labor hours necessary to replace the parts.

(c) Requirements of Installers:

Each installer of an alternative fuel retrofit system shall warrant to the person having the vehicle retrofitted and to each subsequent purchaser of the vehicle that the alternative fuel retrofit system will not fail to conform with the applicable requirements of these Procedures due to incorrect installation, and that no part on the retrofitted vehicle will be damaged due to incorrect installation. Installers of alternative fuel retrofit systems shall install only those systems of a certified configuration and shall agree to indemnify the person having the vehicle retrofitted and to each subsequent purchaser of the vehicle for the cost of repair of any vehicle upon which a noncertified configuration was installed. In addition, the installer shall agree to indemnify the person having the vehicle retrofitted and to each subsequent purchaser of the vehicle for any tampering fines that may be imposed as a result of improper installation of the alternative fuel retrofit system. The warranties and agreements to indemnify shall be effective for three years or 50,000 miles, whichever first occurs, of customer service, and shall cover the full repair or replacement costs including the costs of diagnosis, labor, and parts (including any part on the retrofitted vehicle that is damaged due to incorrect installation of the alternative fuel retrofit system).

Before an installer installs an alternative fuel retrofit system, he or she shall have submitted to the ARB a sample of the warranty statement to be provided by the installer in accordance with this paragraph.