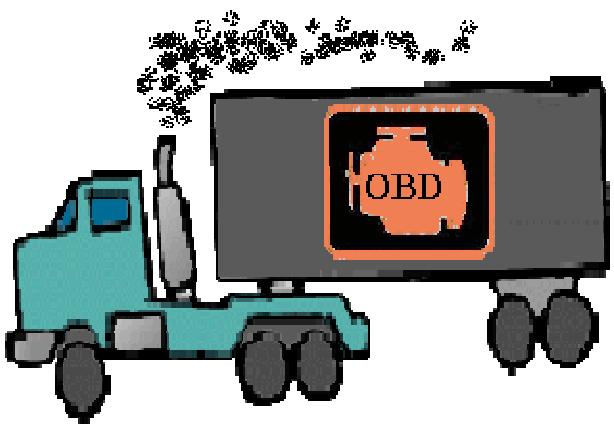
State of California
AIR RESOURCES BOARD

STAFF REPORT:
INITIAL STATEMENT OF REASONS FOR PROPOSED RULEMAKING

Technical Status and Revisions to Malfunction and Diagnostic System Requirements for Heavy-Duty Engines (HD OBD) and Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles and Engines (OBD II)

Date of Release:	April 10, 2009
Scheduled for Consideration:	May 28, 2009



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I. SUMMARY OF STAFF PROPOSAL AND RELATED POLICY ISSUES

Background

On-board diagnostic (OBD) systems are comprised mainly of software designed into the vehicle's on-board computer to detect emission control system malfunctions as they occur by monitoring virtually every component and system that can cause an increase in emissions. When an emission-related malfunction is detected, the OBD system alerts the vehicle owner by illuminating the malfunction indicator light (MIL) on the instrument panel. By alerting the owner of malfunctions as they occur, repairs can be sought promptly, which results in fewer emissions from the vehicle. Additionally, the OBD system stores important information including identification of the faulty component or system and the nature of the fault, which would allow for quick diagnosis and proper repair of the problem by technicians. This helps owners achieve less expensive repairs and promotes repairs done correctly the first time.

The California Air Resources Board (ARB) originally adopted the light- and medium-duty vehicle OBD regulation (OBD II) in 1989 for the 1996 and newer model years. As directed by the Board, the regulation has been reviewed and updated at regular updates since then. ARB also adopted separate heavy-duty OBD requirements (HD OBD) in 2005 that apply to 2010 and subsequent model year heavy-duty engines and vehicles (i.e., vehicles with a gross vehicle weight rating greater than 14,000 pounds). Again, as directed by the Board, ARB staff has been meeting with manufacturers since the original rulemaking to review progress in meeting the requirements and has identified a number of issues that necessitate amendments to the regulations.

To address the issues, staff is proposing changes to the HD OBD regulation, California Code of Regulations (Cal. Code Regs.), title 13, section 1971.1 (included as Attachment A). Further, to harmonize these changes for heavy-duty engines and for medium-duty engines, staff is also proposing changes to the OBD II regulation, Cal. Code Regs., title 13, section 1968.2 (included as Attachment B). Lastly, as ARB staff indicated during the 2005 HD OBD rulemaking process, staff is proposing adoption of a HD OBD enforcement regulation, Cal. Code Regs., title 13, section 1971.5 (included as Attachment C), which would establish enforcement procedures and requirements.

Summary of Proposed Amendments

A summary of the issues and technical amendments is provided below while detailed explanations of each of these issues and amendments are provided in sections II through VII of this report. Of the proposed amendments to the HD OBD and OBD II regulations, many have been largely agreed upon between ARB and manufacturers based on various discussions and meetings, and include the following:

- Clarifying storage and erasure of permanent fault codes.
- Revising in-use monitoring frequency tracking for the particulate matter (PM) filter monitor.

- Revising the definition of “idle” for several tracking requirements.
- Revising diesel fuel system monitoring requirements for non-common rail systems.
- Revising the diesel PM filter monitor malfunction thresholds for 2010-2012 model years.
- Delaying some monitoring requirements for catalyzed PM filters and diesel NMHC converting catalysts to the 2013 model year.
- Deleting the monitoring requirement for MIL circuit faults.

Staff is also proposing amendments to the HD OBD requirements for gasoline engines to be consistent with those already required in the OBD II regulation, including the following:

- Requiring detection of air-fuel ratio cylinder imbalance failures.
- Clarifying the gasoline primary and secondary oxygen sensor monitoring requirements.

In addition to these proposed amendments, there are a few issues that ARB and manufacturers have not completely agreed upon. While manufacturers have expressed concerns with them, staff believes that they are necessary to ensure the integrity of the OBD systems. These amendments include:

Monitoring of transmission vehicle speed sensors
At the manufacturers' request, the HD OBD regulation currently excludes transmission components from the system unless the manufacturer specifically uses such a component for other monitors (e.g., uses transmission vehicle speed sensor to enable/disable PM filter monitoring). However, manufacturers have now indicated they need to use the vehicle speed input from the transmission but do not want to thoroughly monitor the vehicle speed sensor itself or to cover it under the emission warranty if it fails. Fundamentally, staff disagrees and stands behind the OBD policy—if a component is used for monitoring something else, the component itself must be monitored to ensure the integrity of the whole system. Deviation from this policy would allow development of non-robust system designs in which certain components (e.g., speed sensor) could fail and disable monitoring of more crucial emission controls (e.g., PM filter), and yet go undetected and uncorrected for indefinite periods of time.

NOx catalyst emission thresholds
Another issue is the malfunction threshold for NOx converting catalysts such as selective catalytic reduction (SCR) systems. Currently, manufacturers are required to detect a catalyst fault before tailpipe emissions exceed 0.5 g/bhp-hr NOx on 2010 engines with a NOx standard of 0.2 g/bhp-hr. Manufacturers have argued such a level is infeasible given current NOx sensor technology and that the threshold should be raised to 0.8 g/bhp-hr. After meeting with manufacturers, sensor suppliers, and analyzing what little data is available, ARB believes some increase is warranted although it is not convinced that the current NOx sensor capability necessitates raising the threshold as high as manufacturers have requested. Consequently, it is proposing a new threshold of 0.6 g/bhp-hr. ARB staff has identified several possible monitoring strategies that could be done with current NOX sensor technology and still meet the

proposed threshold. Additionally, manufacturers have not provided any data supporting their proposed threshold.

AECD tracking

Another proposed amendment of concern to heavy-duty manufacturers is the requirement to track in-use activity of auxiliary emission control devices (AECDs) that adversely affect emissions (emission-increasing AECDs, or EI-AECDs). Light- and medium-duty diesel manufacturers made similar arguments against tracking EI-AECDs when it was first adopted in the OBD II regulation in 2006. Then and now, manufacturers have argued that the OBD regulation is not the appropriate place for this requirement, that confidentiality would be compromised, and that the requirement would impose a large resource burden. Staff finds these arguments to be unsubstantiated and that this requirement is necessary to ensure that these EI-AECDs are active as infrequently as possible in-use (to minimize any associated adverse emission impact) and are implemented equitably by all manufacturers. In the OBD II regulation, staff modified its initial proposal to address or eliminate manufacturer concerns and the same amendments are now being proposed for the HD OBD regulation.

In addition to the above issues, there are three issues where staff and industry have stronger disagreements. These 'issues of controversy' involve provisions of the new enforcement regulation, aging requirements for demonstration testing, and accounting for emissions from infrequent regeneration events (e.g., PM filter regenerations) when calibrating.

Enforcement regulation

Manufacturers have objected to provisions within the newly-proposed HD OBD enforcement regulation (§1971.5) citing lack of legal authority and resource limitations. Specifically, the proposal requires manufacturers to perform testing on a limited number of their own engines after they have reached high mileage to ensure that OBD monitors are working properly. Since these requirements would require manufacturers to remove engines and emission controls from actual in-use vehicles and to emission test each threshold monitor on an engine dynamometer, manufacturers have argued that ARB has no authority to adopt requirements beyond certification and that this would impose significant added workload and costs that should instead be borne by ARB. Staff disagrees as ARB has clear authority to adopt enforcement test procedures to ensure its regulations are met and there is no restriction that such procedures are limited to items that are conducted prior to certification or limited to those carried out only by ARB. Further, performing these procedures would be a condition for certification and would be used to ensure engines are compliant with the other certification requirements consistent with other ARB regulations that require manufacturer compliance testing. Under the procedures, ARB would also have the authority to perform enforcement testing but given the complexity, expense, and lack of an ARB facility capable of such engine dynamometer emission testing, it is expected that ARB will be heavily reliant on the self-testing done by manufacturers for enforcement purposes. Manufacturers on the other hand, have the facilities and expertise to test their own engines and emission controls as it is already a necessary part of development, calibration, and certification.

Regarding workload and costs to perform such testing, ARB is proposing manufacturers test 1-3 engines per year (depending on the number of engine families sold by the engine manufacturer) and has done a cost analysis (see section XI.) for this testing. Staff's analysis found the increased costs to be less than $2 per engine produced by a typical manufacturer (or less than 0.01 percent of the engine retail cost). Given that the testing would not typically be conducted until three to four years after the engine is first sold, staff also believes that testing resources (personnel, lab availability, etc.) will be adequately available and will not infringe upon the testing needed for 2010 or 2013 model year calibration workloads. Further, ARB investigated cheaper alternatives to engine dynamometer testing such as screening engines using portable emission measurement systems while the engine is still in the vehicle or using chassis (vehicle) dynamometers to determine if further testing is warranted. Unfortunately, several complications were encountered that, at this time, render such screening infeasible. Staff has discussed this with industry and, given that the first engines would not likely be tested until the 2013 calendar year, has indicated that it is still open to alternative testing suggestions that may be taken into consideration in a future regulatory update.

Demonstration Testing

An essential element of the current regulation requires manufacturers to perform demonstration testing prior to certification. Depending on the size of the manufacturer, manufacturers would have to perform a series of emission tests on 1-3 engine families per year to confirm a subset of OBD monitors are calibrated correctly (e.g., that a fault is detected before emissions exceed 2.0 times the tailpipe standards). While this 'spot-check' testing is done on a prototype engine prior to certification, manufacturers and staff have disagreed as to the level of aging that is needed on the engine and emission controls for this testing. Staff has proposed amendments that would require a manufacturer, by 2016, to develop and validate aging procedures that would allow them to rapidly simulate high mileage and do the demonstration testing on a complete system (engine and emission controls) that is aged to the equivalent of full useful life (the point up to which the tailpipe emission standards apply such as 435,000 miles for the heaviest engines). Manufacturers have instead proposed that they be allowed to age only portions of the emission controls (specifically, the aftertreatment) and not age the engine or other emission controls. Further, they have proposed that they be required to age to a much lower mileage point and 'extrapolate' or project likely emission levels from there. They argue that staff's proposed requirement that they validate their aging cycles by gathering data on actual in-use high mileage engines is unnecessary. Staff disagrees, having found that because diesel engines and emission controls are becoming more and more complex, staff's proposal is the only way to accurately determine how high emissions will be when a fault occurs. Accordingly, manufacturers should be required to generate high-mileage systems that represent both the engine and emission controls in that it is the only way to ensure that a manufacturer's aging procedure produces aged systems similar to those of engines in-use.

Infrequent Regeneration Adjustment Factors (IRAFs)

For normal tailpipe certification, manufacturers are currently required to include the emissions from infrequent regeneration events, such as a PM filter regeneration that may happen every 300 miles, and account for such emissions by averaging them out over the frequency with which they occur. For example, an event that happens once every ten FTP emission tests would be spread out over all ten so that $1/10^{th}$ of the increase is added to each individual test before being compared to the emission standard. Similarly, when calibrating for OBD emission threshold monitors (e.g., NMHC catalyst conversion efficiency faults that must be detected before emissions exceed 2.5 times the FTP standard), manufacturers are required to assess the impact of the fault on their baseline calculated IRAF so that a fault is detected before the emissions exceed the threshold including accounting for these infrequent regeneration events. Much concern has been raised by manufacturers about the current requirements to account for IRAFs when calibrating HD OBD systems including the necessity of it and especially the cost and resources to do so. Staff and manufacturers made progress towards a common ground by agreeing to account for IRAFs primarily by using engineering analysis and/or data to estimate modifications to the baseline IRAFs rather than full rigorous development of new IRAFs for each malfunction. However, staff and manufacturers have disagreed on how best to implement such engineering judgment/allowances in the regulation. The current proposal requires manufacturers to develop and submit their estimates to ARB and for ARB to approve the estimates upon the manufacturer providing data and/or engineering evaluation demonstrating the procedure used to develop the estimates is consistent with good engineering judgment. The manufacturers, however, have argued that they are unsure as to what constitutes good 'enough' engineering judgment to be accepted by ARB. Manufacturers have proposed modifications that would limit the number of monitors they would have to investigate or develop separate IRAFs for because they are concerned that staff will be unreasonable or disagree as to what is good engineering judgment. This argument seems specious in that sound engineering judgment underlies a number of OBD decisions that ARB must make and has not previously been a significant issue of controversy. This includes determining what kind of malfunction is most likely to yield the highest emissions for a given threshold-based monitored component and deciding what kind of driving cycle will reveal the highest emission increase to determine whether a component even needs to be functionally monitored. What matters most in all engineering evaluations is that the analysis and data used in arriving at the decision are documented and well-founded. Further, in the case of IRAF adjustment factors, should an engineering evaluation ultimately contain a flaw that isn't easily anticipated by the manufacturer or ARB and results in higher than expected regeneration emission impacts during in-use compliance testing, the proposed heavy-duty OBD enforcement regulation provides relief in two forms. First, through the 2012 model year, ARB will use the adjusted IRAF estimated by the manufacturer at the time of certification for determining compliance even if testing of in-use engines shows the estimate to be wrong. Second, the ARB will not consider a system noncompliant if it is caused by something that could not have been reasonably foreseen by the manufacturer.

Emission and cost impacts

Emission benefits, costs, and cost-effectiveness were calculated when the HD OBD regulation was originally adopted in 2005. While the proposed amendments to the HD

OBD regulation do not materially alter the previously calculated values, changes to the base emission inventory in the last few years has necessitated new calculations. The proposed HD enforcement regulation also adds new costs that have not previously been considered. The new analysis has found the lifetime HD OBD emission benefits including the amendments would be 165 pounds of ROG, 2000 pounds of NOx, and 14 pounds of PM per heavy-duty engine. It has further found that, including the proposed amendments, the HD OBD requirements result in a $132.39 increase in retail price of the engine plus an additional $1.97 for the new enforcement regulation. When combined with an estimated $496 increase in emission repair costs for items that previously would have gone undetected and uncorrected, the cost-effectiveness of the HD OBD program would be $0.15 per pound of ROG + NOx and $22.50 per pound of PM. Both values compare favorably with the cost-effectiveness of other recently adopted regulations. Further details of the emission benefit, costs, and cost-effectiveness calculations are in sections X. and XI.

Recommendation

ARB staff recommends that the Board adopt the amendments to the OBD II and HD OBD regulations and adopt the HD OBD enforcement regulation as proposed in the Initial Statement of Reasons.

II. TECHNICAL STATUS UPDATE AND PROPOSED REVISIONS TO HEAVY-DUTY OBD MONITORING REQUIREMENTS

A. INFREQUENT REGENERATION ADJUSTMENT FACTORS

Diesel emission control technology has been rapidly evolving in recent years to allow engines to achieve compliance with lower tailpipe standards. However, some of the new emission controls do not work in a traditional manner of continuously reducing emissions. Instead, these components effectively reduce emissions for some amount of time and then temporarily require an alternate mode of operation to renew/regenerate the component before it can resume effectively reducing emissions. Two examples of such emission controls are the particulate matter (PM) filter, which typically requires an active regeneration event every 300 to 500 miles to burn off the accumulated soot, and an oxides of nitrogen (NOx) adsorber, which periodically requires a desulfurization event. When these infrequent, but periodic, events occur, tailpipe emissions can increase dramatically and exceed the allowable tailpipe standards. Accordingly, the tailpipe standards require diesel engine manufacturers to account for these infrequent emission increases and include them as part of their emission measurement when determining compliance with the tailpipe standard. Since these events occur infrequently, the emission test procedures define a method for manufacturers to account for the additional emissions by taking into account the frequency of the events, the magnitude of emission increase of the event, and the duration of the event. For a simple example, take a regeneration event that is active once within every ten emission tests, causes an emission increase of 1.3 grams per brake-horsepower hour (g/bhp-hr) NOx, and takes less than one emission test to complete. The emission test procedures would require one-tenth of the 1.3 g/bhp-hr increase, or 0.13 g/bhp-hr, to be added to emission test results obtained without the event, and this total would be compared to the tailpipe emission standard. This method allows the excess emissions generated during the infrequent event to be spread out across all emission tests between successive events and to provide a representative average emission level from the vehicle. Manufacturers are all aware of these provisions and have been performing such measurements as part of their certification process since they began using emission controls with infrequent regeneration events.

Within OBD, there are several malfunctions that are required to be detected prior to emissions exceeding defined tailpipe levels (e.g., prior to emissions exceeding 2.0 times the standard). Because infrequent regeneration events do affect overall emissions from the vehicle, the OBD regulation also requires diesel engine manufacturers to account for these events when calibrating diagnostics that are tied to defined emission levels. Further, the presence of the malfunction itself can affect the regeneration event (in frequency, duration, or even magnitude of emission increase) so manufacturers are currently required to take those effects into account and calibrate such that the average emission level from the engine, including adjustments for infrequent regeneration events with a malfunction present, is at or below the required OBD malfunction threshold. However, engine manufacturers have requested this requirement to account for impacts on infrequent regeneration adjustment factors when calibrating OBD monitors (§1968.2(d)(6.2)) be eliminated or changed.

First, manufacturers have argued that the additional testing time and resources to properly determine the adjustment factors are significant and costly. Second, the tailpipe emission certification process already ensures the emission solution is robust and includes the emission impact of the infrequent regeneration processes. Thus, they argue, there is little added benefit in determining unique infrequent regeneration adjustment factors (IRAFs) for each OBD malfunction. Accordingly, they have asked staff to eliminate the requirement to account for changes in IRAFs due to threshold parts and to either ignore IRAFs altogether or to allow the certification IRAFs to be applied instead. ARB, however, does not agree with the manufacturers' position and is not proposing elimination or modification of this requirement.

Manufacturers have indicated it takes substantial test time and resources to establish IRAFs for tailpipe certification and repeating that process for each OBD threshold would be an enormous task. ARB staff, however, believes manufacturers would not need to repeat the entire process to determine what, if any, impact the presence of a malfunctioning component will have on IRAFs. The costs and resources necessary should be very limited, requiring only a small amount of additional resources and emission testing (if needed), and should be nowhere near the level of effort required to generate the baseline factors for tailpipe certification. For this reason, staff's cost analysis apportioned only a small amount of resources to the specific task of determining unique IRAFs. The engineers that are carrying out calibration of OBD malfunctions (which involves iterative emission testing with a varying degree of a malfunctioning part) must have a detailed understanding of the engine and interactions between various components, especially in cases where a component is malfunctioning. This knowledge is necessary to design a robust diagnostic that will comprehend these interactions and still make correct decisions. This is the very same type of knowledge staff expects manufacturers to use to determine if there is an impact to the adjustment factors that warrants further analysis or testing to identify the magnitude of the change to the baseline factors. Specifically, the baseline factors would only be affected if the implanted malfunction causes significantly higher PM accumulation rates in the PM filter (such that active regeneration would be triggered more frequently) or causes emissions during an actual regeneration event to be significantly different. Staff expects manufacturers to be able to reasonably estimate whether either of those two cases is likely and, for those that are, use existing or additional emission test data to determine the impact. The baseline factors would then be scaled accordingly.

Manufacturers have argued that they conduct lengthy test processes to accurately quantify the interval between regeneration events for tailpipe certification and repeating such tests would be a costly use of resources. However, it is not expected that a manufacturer would have to implant the fault and continue testing until a regeneration event occurs to be able to make that determination. Manufacturers would be able to reasonably extrapolate the impact using shorter test intervals by looking at data captured during the iterative emission testing being done for the OBD threshold calibration. As an example, by gathering data of the PM filter loading (e.g., by looking at engine-out PM emissions or more likely, the rate of accumulation for the various regeneration triggers) during testing with an implanted malfunction and comparing it to baseline testing, manufacturers would be able to determine if the malfunction is likely going to lead to more frequent or less frequent regeneration and by how much. Such data would be sufficient to determine the necessary adjustment to the baseline frequency factor. For those malfunctions that the manufacturer has determined are likely to have an impact on regeneration emissions themselves, manufacturers may have to carry out an additional test with a malfunctioning component present and regeneration active and compare the results to the baseline to determine the magnitude of the adjustment to the baseline factors. However, even this 'additional' test may likely be encountered during the normal calibration of the OBD threshold or could be intrusively triggered by inserting a loaded PM filter or altering the regeneration triggers to force the regeneration to happen while the faulty part is installed. As the manufacturer applies similar strategies and controls across its product line, this process would likely be refined even further to make capturing the necessary data an automatic step during the calibration process and thus, virtually eliminate the need for any additional testing.

Some manufacturers have suggested they would encounter substantial additional testing to develop adjusted IRAFs in spite of staff examples of how the process could be shortened using engineering judgment. Manufacturers claim that they cannot be sure their own engineering judgment is "good enough." They believe that, to ensure emissions are below required IRAF-based OBD thresholds with a faulty component present, nothing short of full-scale testing could be used. Manufacturers have even proposed modifications that would limit the number of monitors they would have to investigate or develop separate IRAFs for because they are concerned that staff will be unreasonable or disagree as to what good engineering judgment consists of. This argument seems specious, however, since a great deal of OBD decisions require sound engineering judgment to be applied - from determining what kind of malfunction is most likely to yield the highest emissions for a given threshold-based monitored component to deciding what kind of driving cycle will reveal the highest emission increase to determine whether a component even needs to be functionally monitored. What matters most is that the analysis and data used in arriving at the adjusted IRAF are documented and well-founded. Should an estimating methodology contain a flaw that isn’t easily anticipated, leading to higher than expected regeneration emission impacts during in-use compliance testing or some other reasonably non-anticipated effect takes place, the proposed heavy-duty OBD enforcement regulation (§1971.5) provides relief in that ARB may not consider a system noncompliant if it is caused by something that could not have been reasonably foreseen by the manufacturer.

In OBD, there are several malfunction thresholds that require calibration to ensure malfunctions are detected before they exceed prescribed emission limits. These malfunctions may affect engine-out emission levels or aftertreatment performance (e.g., conversion efficiency of pollutants) which, in turn, can alter the regeneration frequency or emission levels during a regeneration event much more than when all components in the system are operating normally. Therefore, the manufacturers’ position that the baseline tailpipe emission certification process already accounts for the emission impact of the infrequent regeneration processes is incorrect. Without re-determining the frequency or measuring the new emission levels, a manufacturer cannot verify that the total emissions from the vehicle, on average, will be at or below the required OBD threshold levels when a fault is detected. For example, if manufacturers were not required to adjust the IRAF for a malfunctioning oxidation catalyst when calibrating the oxidation catalyst monitor, the manufacturer would likely be able to calibrate the system to only detect a fault when an oxidation catalyst was completely missing since the impact of the catalyst on emissions during non-regeneration is generally very small. However, during a regeneration event, where emission levels can be 10 or more times above the emission standard with a properly operating system, a missing catalyst can cause those emissions to be substantially higher still. One manufacturer reported to ARB that emissions were so high during a regeneration event with a malfunctioning catalyst that they were unable to measure the results in their emission test cell. The manufacturers’ suggested approaches of applying the baseline IRAFs and/or not taking into account the higher emissions would lead to a much higher emission level in the real world before a malfunctioning catalyst would be detected.

After further discussions with engine manufacturers, the manufacturers have generally agreed to the need to account for IRAFs when calibrating malfunction thresholds, but have proposed language that imposes substantial limitations on what is required of manufacturers, attempts to define what data is good enough and acceptable for approval, and sets timelines for approval of a manufacturer’s IRAFs. Specifically, manufacturers proposed that the number of emission threshold monitors for which they would be required to obtain new data to support the IRAF estimations be limited (e.g., maximum of two to four monitors), regardless of how many monitors actually impact need new IRAF estimations. Additionally, they proposed that ARB be required to approve the IRAFs at least six months before the manufacturer's target approval date for the OBD system or one month after they submitted the IRAF estimations and data for review and approval, and proposed that they be allowed to carry-over the IRAF estimations for up to three model years if errors were found in the estimation between the time of IRAF approval and the target OBD approval date. Staff does not believe any of the proposed modifications are appropriate and the manufacturers concerns are unfounded. As noted above, there are many aspects of emission regulations and compliance (and engine design, for that matter) that rely on manufacturers using sound engineering judgment. Further, the OBD staff has a demonstrated history of working with manufacturers for well over 10 years and the OBD program could not be where it is now if the staff was unreasonable with manufacturers on the eve of certification or could not reach common ground on what constitutes good engineering judgment. Artificially limiting the number of monitors for which a modified IRAF needs to be calculated when it is known that other monitors definitively adversely effect emissions in-use is also inappropriate. Manufacturers that define robust emission control solutions that are tolerant of faults will have fewer monitors that affect IRAFs while those that define less robust solutions may have more adverse interactions when components deteriorate. Limiting the number of monitors that have to be accounted for would reward those with inferior design solutions and result in higher in-use emissions when faults occur relative to those that design robust solutions.

B. DIESEL FUEL SYSTEM MONITORING

The regulation currently requires diesel manufacturers to continuously monitor for fuel system pressure control malfunctions. While some manufacturers have implemented common rail fuel systems, which can readily be monitored continuously for pressure malfunctions, others have expressed concerns that fuel pressure monitoring cannot be done continuously for non-common rail systems such as electronically controlled, mechanically actuated, unit injector systems . Based on the current design of the unit injector system, where fuel pressure is generated within each individual injector as opposed to via a high-pressure fuel pump as used in a common-rail system, the only method identified by the manufacturers to continuously monitor the fuel pressure would be to add a pressure sensor in each injector, which may not be a practical solution. Manufacturers contend there are no other viable solutions for continuous fuel pressure monitoring for unit injector systems. Manufacturers indicate, however, that they can monitor for fuel pressure faults by running an intrusive monitor once per trip under constrained conditions and believe such a monitor will be able to robustly detect all faults that would affect fuel pressure. Accordingly, manufacturers have asked ARB to change the regulation to only require monitoring to be conducted once per trip on non-common rail systems.

It is important to achieve proper fuel pressure in a diesel engine to maintain low emission levels. Continuous monitoring of the fuel pressure would ensure that if there was a problem, even it if only affected a portion of the engine operating conditions or if it had a varying impact (e.g., a big impact in some regions and a small impact in other regions), it would reliably get detected as long as operation in impacted regions was encountered. Conversely, with a once-per-trip monitor that only runs under a subset of engine operating conditions, only faults that impact the region where monitoring occurs will be reliably detected.

However, ARB does agree that it would be very difficult, if possible, to continuously monitor the fuel pressure on unit injector systems or fuel systems that achieve injection fuel pressure within the injector or increase pressure within the injector (e.g. in the injector of an amplified common rail system) given their current design, and is thus proposing to not require continuous fuel pressure monitoring for these systems. Proper fuel pressure, however, is still critical for emissions and staff is concerned about different faults that may only impact specific regions of the engine operating conditions. As a compromise, staff is proposing a change that would allow once per trip monitoring of fuel pressure, but manufacturers would be required to demonstrate that the diagnostic (or diagnostics) can detect all failure modes which would lead to a fuel pressure problem within the entire range of engine operating conditions and before emissions exceed the OBD malfunction thresholds. A manufacturer would be required to submit details of their system and a failure analysis, such as a failure mode and effects analysis, identifying all possible failure modes and the effect each has on fuel pressure across the entire range of engine operating conditions. If different faults can cause pressure problems in exclusive regions (e.g., some only affect idle and some only affect off-idle), the manufacturer would be required to implement more than one diagnostic or enable the diagnostic in various operating conditions to cover the regions where faults could occur and use logic to ensure such faults are robustly detected.

In addition to the above proposal, based on discussions with some manufacturers working on their fuel pressure control monitors, ARB has identified an area where further clarification would be beneficial. Specifically, manufacturers have asked questions about whether they should be using a single injector fault or a fault that equally affects all cylinders when calibrating the fuel pressure, quantity, and timing monitors to the OBD thresholds. Staff generally tries to pick a reasonable compromise between calibrating for all possible combinations of failures and a manageable number of combinations. Therefore, staff is proposing that for fuel pressure, quantity, and timing monitoring for systems that have single component failures which could affect a single injector (e.g., systems that build injection pressure within the injector that could have a single component pressure fault caused by the injector itself), manufacturers would be responsible for calibrating for both a single cylinder fault that causes the system to reach the malfunction criterion as well as a fault that equally affects all cylinders such that the malfunction criterion is reached starting in the 2013 model year. Staff believes this represents reasonable coverage for failures in use, be it a gradual deterioration or fault that affects all cylinders virtually equally or a more severe degradation or malfunction of a single injector that by itself causes such an emission increase. For systems that achieve injection pressure outside of the injector (e.g., common-rail systems), staff is proposing that for fuel quantity and timing monitoring, manufacturers would be required to calibrate for both a single cylinder fault and a fault that equally affects all cylinders, while for fuel pressure monitoring, manufacturers would only be required to calibrate for a fault that equally affects all cylinders. Staff's rationale for the difference in fuel pressure monitoring is that systems like a common-rail system achieve injection pressure independent of the individual injectors and are unlikely to have a pressure fault affecting a single cylinder (but are still susceptible to quantity or timing faults that would affect a single cylinder or all cylinders equally).

Staff is also proposing modifications to the MIL illumination and fault code storage protocol for fuel pressure control monitoring that are similar to the current requirements for gasoline fuel system monitoring. Specifically, the regulation would require fault detection to be more robust to failures that only occur within specific operating conditions by using similar conditions for maturing and clearing of faults. The use of similar conditions, which include engine speed, load, and warm-up status, provides for more consistent detection of faults that are routinely present in some operation conditions (e.g., high load) but are not present in others (e.g., idle). Manufacturers have indicated that they are controlling fuel pressure to substantially different levels during various engine operating conditions and staff is concerned that, as a result, faults are more likely to have inconsistent impacts across the engine speed and load map. Absent the use of similar conditions, a fault that is present every time high load conditions are encountered and absent every time idle is encountered could go for extended periods of time where the fault is detected and subsequently erased based solely on driver behavior. Similar conditions would only allow such a fault to be matured or erased under high load conditions and provide for more consistent detection. These modifications would apply to 2013 and subsequent model year engines.

C. DIESEL EXHAUST GAS RECIRCULATION (EGR) SYSTEM MONITORING

Staff is proposing amendments to the monitoring requirements that would clarify the requirements for various types of EGR systems. Currently, the monitoring requirements were written with the premise that the system would have direct feedback-control of EGR flow, as staff had believed that almost all manufacturers would use such systems. However, based on discussions with manufacturers as they review their plans for 2010 and later engines, the monitoring requirements needed to be modified to account for a broader range of systems. Examples include control systems that technically use closed-loop control of other parameters such as fresh air flow or cylinder intake air concentration and control EGR flow to achieve the desired target instead of direct closed loop control of EGR flow. As detection of emission-related faults of these systems is important, regardless of whether or not they are directly feedback controlled, staff proposed amendments to the malfunction criteria for these monitors to indicate a fault tied to the "expected" EGR flow, rather than solely referring to the "commanded" EGR flow.

Staff is also proposing amendments regarding EGR catalysts. Several manufacturers have implemented or proposed configurations which utilize a dedicated catalyst in the EGR system to convert hydrocarbons or soluble organic fractions (SOFs) prior to the exhaust gas being routed through the EGR cooler or valve. Manufacturers have indicated this catalyst reduces fouling of the cooler and/or valve, thereby prolonging the durability and performance of the EGR system. While manufacturers have argued that back to back tests comparing the emissions of a system with and without such a catalyst will show no measurable emission increase, they have acknowledged that a malfunction of the catalyst will eventually lead to higher emissions as the cooler and/or valve become fouled, reducing the effectiveness of the cooler or restricting flow through the system. Eventually, such fouling will cause an EGR cooler or flow fault to be detected but it is unclear how long higher emissions may be present or how much more rapidly a failed catalyst will cause subsequent failure of the cooler or valve. To avoid these excess emissions, the proposed amendments would require monitoring of EGR catalysts beginning with the 2013 model year. Staff believes that the current monitoring requirements would already require monitoring of this catalyst under the ‘other emission control’ section but discussions with manufacturers have indicated that this technology may also be phased out in the next few years as manufacturers determine such a part is not necessary. While it has not generally been acceptable to add an emission control component and have it be unmonitored, staff believes a deviation from policy until the 2013 model year is appropriate for several reasons. Such reasons include failure of the catalyst does not immediately lead to an emission increase but rather a more rapid deterioration of another emission component, the other emission component (EGR cooler and/or EGR valve) is monitored and will eventually set a fault once its performance is compromised, and the component appears to be used by very few manufacturers in the interim but will not likely be used long term. Most manufacturers have systems that do not use this component and either do without it altogether, or in some limited cases, use the normal catalyst and/or PM filter in the exhaust to perform this function by putting the inlet to the EGR system further down the exhaust stream and after the catalyst or PM filter. In cases where such designs prevail, the additional leadtime until 2013 will allow manufacturers to transition to such designs.

Additional proposed changes to the EGR system monitoring requirements are discussed under section II.T. (Emission Control Strategies) below.

D. DIESEL BOOST PRESSURE CONTROL SYSTEM MONITORING

For diesel boost pressure control systems, staff is proposing changes to account for systems that are not equipped with variable geometry turbochargers (VGT) systems. Currently, only VGT systems are monitored for slow response failures (e.g., malfunctions that cause the VGT itself to take longer than expected to achieve the desired VGT position.). Discussions with manufacturers have identified that malfunctions that cause the system to take longer to achieve desired boost levels can affect emissions, regardless of the boost hardware architecture. Accordingly, staff is broadening the slow response malfunction criteria to apply to all boost systems, regardless of whether the system uses a VGT, and to make the criteria based on the response of the system to achieve the actual boost rather than on the response of one of the individual actuators to achieve a certain position. It should be noted that most manufacturers have indicated that slow response boost failures rarely could get bad enough that they would cause emissions to exceed the OBD threshold and thus, are subject only to a functional monitor. Further, most manufacturers are able to demonstrate that the under and over boost monitors meet the definition of a functional check for slow response by demonstrating they detect induced response failures with such diagnostics before emissions are too high. This proposed requirement, however, will ensure that any manufacturer who has a larger sensitivity to slow response boost malfunctions will be required to detect faults before emissions exceed the prescribed threshold levels.

Similar to the proposed amendments for EGR system monitoring, staff is also proposing amendments to the monitoring requirements that would attempt to clarify the requirements for various types of boost pressure control systems. Currently, the monitoring requirements were written with the premise that all systems would have direct feedback-control of boost pressure, as staff had believed that almost all manufacturers would use such systems. However, based on discussions with manufacturers as they review their plans for 2010 and later engines, the monitoring requirements needed to be modified to account for a broader range of systems. Examples include open loop boost pressure systems or control systems that technically use closed-loop control of other parameters such as fresh air flow or cylinder intake air concentration and control boost pressure to achieve the desired target instead of direct closed loop control of boost pressure. As detection of emission-related faults of these systems is important, regardless of whether or not they are directly feedback controlled, staff proposed amendments to the malfunction criteria for these monitors to indicate a fault tied to the “expected” boost pressure, rather than solely referring to the “commanded” boost pressure.

Additional proposed changes to the boost pressure control system monitoring requirements are discussed under section II.T. (Emission Control Strategies) below.

E. DIESEL NON-METHANE HYDROCARBON (NMHC) CONVERTING CATALYST MONITORING

The regulation currently requires diesel engine manufacturers to design the OBD system to detect an NMHC catalyst malfunction when the catalyst conversion capability decreases to the point that NMHC emissions exceed 2.5 times the applicable standard for 2010 model year engines. However, if a catalyst malfunction does not result in emissions exceeding this threshold, the regulation allows the manufacturer to detect a malfunction when the catalyst has no detectable amount of NMHC conversion capability. Monitoring of NMHC conversion performance is also required for catalyzed PM filters, with monitoring similarly required at 2.5 times the applicable standard or, if emissions cannot exceed that level, for complete failure of the NMHC-catalyzing function. The regulation also currently requires manufacturers to monitor the NMHC catalyst for its ability to perform other emission-related functions. Specifically, monitoring is required to ensure that the catalyst performance is sufficient to provide an exotherm necessary for PM filter regeneration and, if applicable, to generate a desired feedgas (e.g., nitrogen dioxide (NO_2)) to promote better performance in a downstream aftertreatment component (e.g., for higher NOx conversion efficiency in a selective catalytic reduction (SCR) system).

With respect to NMHC-converting catalyst monitoring, engine manufacturers are concerned that total failure of NMHC catalysts will push emissions over the threshold and force them to implement threshold monitors. Furthermore, they do not believe that there is any monitoring technology that can robustly detect anything other than a completely failed NMHC catalyst. Lastly, they believe the current requirement of determining and applying an adjusted IRAF when determining the emission level of a malfunctioning catalyst exacerbates this problem by requiring them to detect a less degraded catalyst. Accordingly, manufacturers have asked ARB to raise the threshold to 4.0 times the NMHC standard and remove the requirement to develop and apply an adjusted IRAF so that manufacturers would very likely only have to implement functional monitors.

Staff, however, does not agree with the manufacturers' assessment of the current monitoring technology, and is not proposing any changes to the current malfunction thresholds. Staff believes that there are currently feasible methods to perform threshold monitoring of the NMHC catalyst. For discerning a good from bad catalyst, manufacturers have primarily focused on whether the catalyst can generate a sufficient exotherm and have concluded that a catalyst is either able to produce a sufficient exotherm (and thus, is perfectly adequate) or it is unable to produce a sufficient exotherm (and thus, is completely failed). Manufacturers have concluded from such analysis that there is no level of catalyst degradation between perfectly adequate and completely failed and that an exotherm monitor can only discern those two states. However, in talking with suppliers and individual manufacturers, catalysts do indeed have intermediate levels of deterioration that cause increases in light-off temperature and lower conversion efficiencies. By looking more closely at the catalyst behavior during active regeneration (e.g., by investigating how much time and/or fuel is needed to generate an exotherm, tracking the actual temperature rise from the exotherm versus the expected, and using better temperature sensors), manufacturers may be able to better determine the characteristics exhibited as an NMHC catalyst degrades (even if it is still capable of eventually getting to a high enough exotherm to achieve regeneration of the PM filter). As an alternate approach, there are at least two light-duty manufacturers that are planning on monitoring the catalyst during a cold start. Often combined with an accelerated catalyst light-off strategy similar in concept to what many gasoline manufacturers use, this monitoring approach tracks the light-off and/or temperature rise characteristics to evaluate the catalyst during intrusive actions intended to bring the catalyst up to the desired temperature quickly after a cold start.

Along with improved monitoring approaches, manufacturers have the ability to reduce the emission impact associated with a malfunctioning catalyst. For example, engine-out NMHC emission levels have a direct impact on the emission levels from a malfunctioning NMHC catalyst. The lower the engine-out emissions, the lower the tailpipe emissions for a given level of degraded catalyst. In addition to looking into reducing engine-out emissions, manufacturers can also look into reducing emissions during a regeneration event. Manufacturers have generally indicated that without an NMHC catalyst, baseline tailpipe NMHC emissions are very close to the NMHC standard (still under in some cases, slightly over in others) and nowhere near the OBD malfunction criteria of 2.5 times the standard. However, when an active regeneration of the PM filter occurs and the NMHC catalyst is degraded or non-functional, emissions can be very high. Accordingly, when defining the level of degraded catalyst that reaches the OBD malfunction threshold (e.g., 2.5 times the standard), the emissions during the PM filter regeneration are the primary emission contributors. Because manufacturers are required to account for changes in regeneration emissions in the form of an adjusted IRAF, the 'threshold' NMHC catalyst is almost exclusively defined by the impact on regeneration emissions. The more infrequent the regenerations or the smaller the emission increase during regeneration, the more tolerant the system is of a degraded catalyst before the OBD malfunction criterion is reached. Again, manufacturers have the ability to directly reduce the emission impact associated with a malfunctioning catalyst by minimizing emissions during a PM filter regeneration event. Manufacturers that have less refined control strategies for regeneration (e.g., injecting fixed quantities of fuel regardless of the observed temperature rise/reaction of the catalyst) will have higher associated emissions while those that more closely regulate the regeneration event can take quicker action to terminate or reduce fueling when the expected reaction does not occur. At least two manufacturers have taken this approach to be able to meet a lower tailpipe emission level with a degraded catalyst that their catalyst monitor is able to identify as a malfunction.

Similar to their argument for NMHC converting catalyst monitoring, manufacturers have also asked for the 2010 model year threshold to be raised from 2.5 to 4.0 times the standard for catalyzed PM filter NMHC conversion monitoring to ensure that only a functional check would be needed. Staff has been talking with suppliers and individual manufacturers regarding the use and monitoring of catalyzed PM filters. While there is no consistent trend in industry, many are looking at catalyzed PM filters and acknowledging that the incremental cost of a catalyzed PM filter is not insignificant. As such, those that are using catalyzed PM filters are doing so because they are realizing actual benefits. Most have stated that it simply 'helps out' with regeneration without being able to quantify the actual impact. Discussions with others indicate that the catalyzed coating leads to higher levels of passive regeneration at lower exhaust temperatures, helps convert hydrocarbon (HC) and carbon monoxide created during an active regeneration, and can help generate NO_2 feedgas for downstream SCR systems. Again, given the importance of these tasks and manufacturers' acknowledgment that they are spending extra money to have these functions, it is appropriate that monitoring be required. If the reasoning behind having the catalyzed coating is the impact on passive regeneration, then this function should be able to be monitored by looking at regeneration frequency or rate of soot loading increase under conditions where high levels of passive regeneration are expected. At least one heavy-duty manufacturer believes that there will be a detectable difference in active regeneration frequency between a PM filter with and without the catalyzed coating and is designing their 2010 monitor to detect this. However, staff acknowledges that manufacturers are scrambling to finish their systems for the 2010 model year and many are behind schedule on OBD development because the emission calibrations are not finalized. The success of the monitoring approaches outlined above may be highly dependent on the actual catalyst configuration, significance of the catalyst loading on the PM filter, and regeneration strategy (especially reliance on high levels of passive regeneration). Accordingly, staff is proposing to delay the monitoring requirements of the catalyst function of catalyzed PM filters until the 2013 model year to give manufacturers more time to refine their systems, optimize regeneration strategies, and better investigate the impacts of the catalyzed PM filter.

For monitoring of the NMHC catalyst's ability to generate a desired feedgas used to improve performance of a downstream aftertreatment component, manufacturers have indicated that insufficient knowledge exists about what property of the catalyst causes the desired feedgas and thus have argued that there is no feasible or known method to verify that such function is still properly operating. Further, manufacturers have indicated that the impact of such a failure is decreased efficiency of the downstream aftertreatment component (e.g., SCR system). Accordingly, manufacturers have asked ARB to eliminate the requirement to directly verify the NMHC catalyst generates sufficient feedgas for other components and to instead rely on monitoring of the downstream component (e.g., SCR system) to detect a failure if the impact is large enough to cause emissions to exceed the OBD malfunction criteria.

However, the manufacturer's claim that they have insufficient knowledge about the mechanism of the catalyst that creates the desirable feedgas is not supported. Staff has met with various suppliers to the manufacturers who have indicated that they understand the properties of the catalyst extremely well and alter specific components to achieve the feedgas generation the manufacturers are asking for. In most cases, the catalyst is being used to oxidize nitric oxide (NO) to NO_2 to increase the relative NO_2 levels, which can help oxidize soot in a PM filter (leading to higher levels of passive regeneration of the PM filter or more effective active regenerations) and, perhaps more importantly, can improve NOx conversion efficiency in an SCR system. Using a catalyst to generate such a feedgas is not that new of a technology as there are even retrofit devices certified by ARB for use on older model year diesel engines that take advantage of these catalyst properties. Further, discussions with suppliers indicate that this catalyst function is likely to be the first to deteriorate and would not be accompanied with a substantial change in the catalyst's HC conversion efficiency or ability to generate an exotherm. As such, staff believes that being able to determine whether the catalyst is still performing this function is essential and is concerned that a failure of this function will not likely be detected by the NMHC catalyst monitoring strategies mentioned above.

The manufacturers' proposal would require the failure of this function to be detected only if it alone causes the SCR system conversion efficiency to drop so far that it exceeds the OBD thresholds for the SCR system (approximately 2.5 to 3.0 times the standard). Staff does not believe this is an acceptable solution because, while failure of this NMHC catalyst property will lead to decreased SCR NOx conversion efficiency and likely higher tailpipe NOx levels, it is not expected to cause a large enough impact to exceed the SCR catalyst threshold. Under this scenario, this NMHC catalyst property could be completely non-functional, tailpipe emissions will be increased by some amount, and the system will continue to operate without any indication to the operator that a malfunction has occurred. Further, if the SCR system itself eventually degraded enough that the combined impact of the upstream catalyst and the SCR catalyst efficiency exceeded the threshold and illuminated the MIL, technicians would likely only replace the SCR catalyst components to extinguish the MIL. This repair sequence would result in essentially a partial repair—emissions would never be returned to the levels they were at when the upstream catalyst was also properly functioning. At this time, the most promising monitoring technology for verifying this function of the catalyst is some form of an SCR system NOx conversion efficiency evaluation to detect lower than expected conversion efficiencies in the absence of the proper feedgas. One heavy-duty manufacturer has indicated its intent to detect such a malfunction by evaluating the NOx conversion efficiency across the SCR system during specific operating conditions. If successful, this manufacturer would be able to detect a fault when this property of the NMHC catalyst was gone but the SCR system was still operating properly.

If the catalyst's ability to generate NO_2 also has a significant impact on PM filter regeneration, another possible monitoring approach would involve evaluation of PM filter regeneration characteristics. In cases where the catalyst is used to promote high levels of passive regeneration, manufacturers may be able to identify a malfunction when backpressure or other soot loading measures indicate much higher loading than expected if passive regeneration was working correctly. Given the importance of proper feedgas generation to PM filter regeneration and/or proper SCR system NOx conversion efficiency and the information from suppliers that this catalyst property will likely deteriorate first, staff is not proposing to adopt the changes suggested by the manufacturers. However, staff acknowledges that the monitoring approach of looking at SCR system conversion efficiency does ultimately rely on SCR system configuration and NOx sensor accuracy and is concerned that the monitor resolution may be insufficient in the 2010 timeframe. Additionally, for monitoring approaches looking at PM filter regeneration, the ability to discern properly operating systems from malfunctioning systems may be highly dependent on the manufacturer's catalyst configuration and regeneration strategy. Accordingly, staff is proposing to delay functional monitoring of proper feedgas generation until the 2013 model year. This additional leadtime should provide manufacturers the ability to better understand the catalyst properties used to generate the feedgas, optimize and refine catalyst configurations and PM filter regeneration strategies, and gain experience with NOx sensors and SCR systems to investigate areas where feedgas generation is expected to be high or have a substantial impact on conversion efficiency and focus on those regions for possible monitoring approaches.

Additionally, to be consistent with the recent OBD II regulation update, staff is proposing to add specific language detailing the requirements for manufacturers to functionally monitor an NMHC-converting catalyst used to prevent ammonia slip downstream of an SCR system. Under the current regulation, all NMHC-converting catalysts have to be monitored but specific details were only provided for the most common types of catalysts such as catalysts used to generate an exotherm for PM filter regeneration or catalyzed PM filters. As has been traditionally done in the OBD regulatory updates, as new emission control technologies become more defined, staff adds more specific language to clarify the requirements that apply to that technology. This often removes the need for manufacturers to submit a monitoring plan (e.g., as is required in the 'other emission controls' section) and gives clear direction to manufacturers as to what is expected.

Staff is also proposing modifications to the emission thresholds manufacturers are required to calibrate NMHC catalyst monitors to. Currently, the HD OBD regulation requires manufacturers to detect an NMHC-converting catalyst malfunction before emissions exceed a specific NMHC emission threshold because staff thought that, in every case, NMHC emissions would be the dominant pollutant affected by a degraded NMHC catalyst system. However, as manufacturers finalize their designs for 2010, staff has observed a tremendous amount of variation in emission control solutions including many cases where the interactions of various emission controls and strategies cause previously unanticipated results. In some cases, a malfunction of a NMHC emission control component has caused a rather large increase in NOx emissions. As an example, a degraded NMHC catalyst can lead to more frequent or extended PM filter regeneration events. And, some manufacturers disable NOx controls during a PM filter regeneration event. Accordingly, more frequent and longer PM filter regeneration events lead to more operation with NOx controls disabled and significantly higher NOx emission levels. Thus, even though the root failure is of a component intended to reduce NMHC emissions, the in-use emissions impact may actually be dominated by NOx emissions. As the intent of OBD is to ensure malfunctions of emission components are detected before tailpipe emission levels of any criteria pollutant are too high, it would be inappropriate to allow excess emissions of one pollutant solely because the malfunctioning emission control is 'primarily' intended to control another pollutant. Thus, staff is proposing to require manufacturers to detect catalyst malfunctions before a specific NOx threshold is exceeded in addition to the currently-required NMHC threshold. Specifically, starting with the 2013 model year, manufacturers would be required to detect a fault before NMHC emissions exceeded 2.0 times the applicable standard or NOx emissions exceeded the applicable NOx standard by more than 0.2 g/bhp-hr, whichever occurs first. It is still expected in the vast majority of cases that the NMHC emission threshold will be the dominant factor when detecting malfunctioning NMHC converting catalyst systems. However, in the rare case that a manufacturer's particular design has other interactions or synergistic effects that cause NOx emissions to substantially increase, this change will ensure that a fault is detected before NOx emissions are substantially higher.

F. DIESEL OXIDES OF NITROGEN (NOx) CONVERTING CATALYST MONITORING

The regulation currently requires diesel manufacturers to monitor the NOx catalyst(s) for proper conversion capability and to detect a catalyst malfunction before NOx emissions exceed the applicable NOx standard by more than 0.3 g/bhp-hr for the 2010 model year. The regulation also requires engines equipped with SCR systems or other catalyst systems that utilize an active/intrusive reductant injection to monitor these systems for proper performance. Manufacturers have expressed concern that the current NOx sensor technology will not provide the accuracy at low concentration levels necessary for OBD monitoring of the SCR catalyst. According to manufacturers, a fresh production NOx sensor currently has a tolerance of +/- 6 parts-per-million (ppm) while an aged NOx sensor currently has a tolerance of +/- 15 ppm. Further, they indicated that the average NOx emissions over the federal test procedure (FTP) transient cycle would have to be roughly 20 ppm to meet the 0.2 g/bhp-hr NOx tailpipe standards for 2010 while concentrations would be roughly 50 ppm at the OBD threshold of 0.3 g/bhp-hr above the standard. Therefore, using an aged +/- 15 ppm NOx sensor to robustly discern a properly operating system at 20 ppm (that could read as high as 35 ppm) from a malfunctioning system at 50 ppm (that could read as low as 35 ppm) would not provide sufficient separation to be feasible. Based upon a paper assessment of the NOx sensor capability as an SCR monitoring device, manufacturers have indicated that to meet the 2010 model year requirements, an aged NOx sensor's accuracy would need to be about +/- 5 ppm, and that a sensor with such an accuracy will not be available in time to meet the 2010 requirements. Thus, manufacturers have asked staff to relax the OBD malfunction threshold for the 2010 model year to a level of 0.6 g/bhp-hr (or 60 ppm) above the NOx tailpipe standard instead of 0.3 g/bhp-hr (or 30 ppm) above the NOx tailpipe standard.

ARB is not convinced that the current NOx sensor capability necessitates raising the SCR catalyst monitor threshold as high as manufacturers have requested. Manufacturers have not provided engineering test data from actual calibrations to support their assessment of SCR monitoring capability, even after staff sent specific requests for this supporting data, and have based their claims primarily on a paper assessment using 'average' concentrations over an entire emission test. Average concentrations generally are not very helpful in determining technical feasibility as an SCR catalyst diagnostic would typically be constrained to run under very specific operating conditions where the best separation between good and bad exists. It is expected that a degraded SCR catalyst would not lead to universally higher NOx emissions throughout the emission test but rather to larger increases during very specific conditions (e.g., accelerations, higher load cruises) and actual concentrations are only relevant during those specific conditions. Based on very limited data received, it appears that degraded catalysts do indeed affect emissions most in specific operating conditions where expected NOx concentrations are higher and current sensor accuracy is less of an issue. ARB does, however, believe that some interim relief is needed to address some remaining uncertainties with NOx sensor durability and separation at high mileage and is proposing to raise the OBD malfunction threshold to 0.4 g/bhp-hr (or 40 ppm) above the NOx tailpipe standard for the 2010 through 2012 model years (concurrently, this same threshold will also apply for 2010 through 2012 model year NOx sensor performance monitoring). Based on the manufacturers' over-simplified analysis, this would require discerning a 20 ppm system (reading as high as 35 ppm) from a 60 ppm system (reading as low as 45 ppm). As explained below, manufacturers should be able to be more selective when monitoring is conducted to provide even more separation than this.

In addition to improved NOx sensors not being available for 2010, some manufacturers have argued that the OBD malfunction threshold for SCR catalyst monitoring should be raised more than the proposed 0.4 g/bhp-hr above the NOx tailpipe standard due to the effects of the surrounding exhaust heat on the electronic NOx sensor module tolerance. Manufacturers have stated that the sensor supplier will only warrant an accuracy of +/- 18 ppm when NOx sensor module temperatures exceed an upper limit. Staff has considered this point but does not agree that the OBD malfunction threshold for SCR catalyst monitoring should be raised any higher for this reason. Staff believes most manufacturers will be able to design or configure an aftertreatment system to avoid exposing the electronic NOx sensor module to such excessive temperatures under the vast majority of vehicle operation and to keep the NOx sensor module within the supplier's specifications. During rare extreme conditions when high temperatures cannot be avoided (e.g. particulate matter filter regeneration), manufacturers can disable the SCR catalyst monitor in these limited regions by using parameters within the OBD system to identify these extreme conditions. Staff considers it unacceptable to design a system that encounters these excessive temperatures in the majority of vehicle operation thereby preventing the SCR catalyst monitor from having a reasonable in-use monitoring frequency.

Despite some manufacturers' claims that improved NOx sensors are needed to monitor the SCR system, other manufacturers have identified different monitoring strategies that utilize current NOx sensor technology to successfully monitor the SCR catalyst. Most of these strategies rely upon monitoring the SCR catalyst only under normally occurring conditions where NOx concentrations are higher. Staff has been shown data indicating that sustained periods of operation above the 'average' 20 ppm NOx concentrations with a properly functioning SCR system are occurring during both the FTP transient cycle and the supplemental emission test (SET) cycle on engines designed to meet the 2010 NOx standard. Some manufacturers have provided data showing sustained periods of operation above 60 ppm NOx concentrations that naturally occur during the SET cycle, usually during transient conditions from high load to lower load conditions. At higher NOx concentrations (greater than 60 ppm), the accuracy of the NOx sensor is not as critical (e.g., an accuracy of +/- 15 ppm has less relative influence if you are measuring a concentration of 60 ppm instead of 20 ppm for good system) and can provide sufficient separation between a good catalyst and a threshold catalyst.

Manufacturers could design their SCR monitors to run when these higher NOx concentrations are either occurring naturally or created intrusively. Staff has data from a manufacturer that demonstrates the ability to intrusively increase the NOx output of an engine by decreasing exhaust gas recirculation (EGR) under specific engine operating conditions to run other emission-related diagnostics. Therefore, staff believes it is feasible to use the concept of intrusively increasing engine out NOx emissions and to calibrate an SCR catalyst monitor that will both be able to monitor the catalyst with currently available NOx sensors and be within the proposed OBD thresholds. An example of how this could be done is by defining specific engine operating conditions and intrusively reducing EGR flow to temporarily increase inlet (and outlet) SCR catalyst

NOx concentrations. While intrusive diagnostics that increase emissions are generally avoided, the negative emission impact of intentionally increasing NOx to the SCR catalyst could be minimized by appropriately increasing reductant injection dosing to the SCR catalyst such that properly operating systems still result in low SCR outlet NOx concentrations while malfunctioning systems would show larger relative outlet levels due to the decreased conversion efficiency and increased inlet levels.

In addition to monitoring only at higher NOx levels, alternative methods of monitoring the SCR catalyst conversion efficiency may be available. Staff believes it is feasible to intrusively perform SCR catalyst monitoring by temporarily disabling or altering reductant injection to optimize conditions for catalyst monitoring. Manufacturers have argued that they cannot afford to perform such intrusive strategies because of the negative emission consequence of reduced/disabled reductant injection. However, staff has data from an SCR system showing reductant injection being completely disabled temporarily with no adverse emission impact due to the reductant storage properties of an SCR catalyst. This data suggests that there may be a possibility to infer SCR catalyst NOx conversion efficiency by measuring reductant storage capability if the two parameters can be correlated. Such a strategy would require disabling the dosing and watching for a reaction in the rear NOx sensor. If the sensor saw an increase in NOx soon after disablement, it would indicate poor reductant storage (and potentially correlate to poor NOx conversion efficiency). If the sensor did not see an increase in NOx after some amount of time, the system could conclude the catalyst was working correctly and resume reductant delivery. This strategy offers the potential to avoid any negative emission consequence during monitoring of the SCR catalyst while the catalyst is good by terminating the monitor before any NOx breakthrough has occurred.

Lastly, the HD OBD regulation requires manufacturers to detect a NOx converting catalyst malfunction before emissions exceed a specific NOx emission threshold. Originally, staff thought that, in every case, NOx emissions would be the dominant pollutant affected by a degraded NOx catalyst system such as SCR. However, as mentioned in section II.E. for NMHC converting catalysts, staff has observed a tremendous amount of variation in emission control solutions including many cases where the interactions of various emission controls and strategies cause previously unanticipated results. As the intent of OBD is to ensure malfunctions of emission components are detected before tailpipe emission levels of any criteria pollutant are too high, it would be inappropriate to allow excess emissions of one pollutant solely because the malfunctioning emission control is ‘primarily’ intended to control another pollutant. Thus, staff is proposing to add language to ensure that NOx converting catalyst malfunctions are detected before NOx or NMHC emissions, whichever happens first, exceed specified levels. It is still expected in the vast majority of cases that the NOx emission threshold will be the dominant factor when detecting malfunctioning NOx converting catalyst systems like SCR. However, in the rare case that a manufacturer’s particular design has other interactions or synergistic effects that cause NMHC emissions to substantially increase, this change will ensure that a fault is detected before NMHC emissions exceed 2.0 times the applicable standard. To ensure any manufacturer with such a rare interaction has sufficient leadtime to calibrate properly, the proposed NMHC threshold would not be applicable until the 2013 model year.

G. DIESEL NOx ADSORBER MONITORING

The HD OBD regulation currently requires manufacturers to detect NOx adsorber malfunctions before emissions exceeded a specific NOx threshold. Similar to the proposed NOx converting catalyst monitoring revisions mentioned above and for the same reasons, staff is also proposing to require manufacturers to detect NOx adsorber malfunctions before a specific NMHC threshold is exceeded in addition to the currently-required NOx threshold. Specifically, starting with the 2013 model year, manufacturers would be required to detect a fault before NOx emissions exceeded the applicable NOx standard by more than 0.2 g/bhp-hr or NMHC emissions exceeded 2.0 times the applicable standard.

Additionally, staff is proposing language similar to what is currently required for NMHC and NOx converting catalyst monitoring regarding malfunction criteria determination with multiple adsorbers. Specifically, in order to determine the proper OBD malfunction threshold for the NOx adsorber, manufacturers would be required to progressively deteriorate or “age” the adsorber to the point where emissions exceed the malfunction threshold. The method used to age the adsorbers must be representative of real world adsorber deterioration under normal and malfunctioning operating conditions. For engines with aftertreatment systems that utilize multiple adsorbers, determining the OBD malfunction threshold becomes more complex since aging effects of the adsorber are dependent on many factors, including the locations of the adsorbers relative to the other aftertreatment technologies and the synergism between each component in the system. While a “one-size-fits-all” aging process that accurately represents every possible aftertreatment configuration is ideal, the diesel aftertreatment system designs are not yet at a level of stabilization (i.e., not yet limited in variation of configurations) to define such a process. Thus, until then, staff would require manufacturers to submit a system aging and monitoring plan to the Executive Officer for review and approval of the monitoring strategy, malfunction criteria, and aging process. Executive Officer approval would be based on the representativeness of the adsorber system aging to real world adsorber deterioration under normal and malfunctioning operating conditions, the effectiveness of the monitor to pinpoint the likely area of malfunction, and verification that each adsorber component is functioning as designed.

H. DIESEL PARTICULATE MATTER (PM) FILTER MONITORING

The heavy-duty OBD regulation currently requires the OBD system to identify malfunctions of the PM filter when the filtering capability degrades to a level such that tailpipe emissions exceed a specific threshold. For the 2010 through 2015 model year engines, the threshold is the highest of the following thresholds: 0.05 g/bhp-hr as measured from an applicable emission test cycle (i.e., FTP or supplemental emission test (SET)) or the applicable standard plus 0.04 g/bhp-hr (e.g., 0.05 g/bhp-hr for a standard of 0.01 g/bhp-hr).

Heavy-duty engine manufacturers have expressed concern that the current threshold is too stringent and is not technically feasible for the 2010 model year time frame. They contend that the current status of technology cannot support such a threshold. When ARB originally adopted the current requirement in 2005, staff proposed that improved differential pressure sensors and refined soot-loading models should allow manufacturers to comply with the above thresholds by the 2010 model year. Manufacturers insist that current differential pressure sensors cannot measure pressures with the accuracy necessary to comply with the required thresholds in the given timeframe and that there are a number of uncontrolled variables that affect the accuracy of soot-loading models, such as a “lack of rigid control of fuel specifications” and the increased usage of biodiesel fuels that cannot be accounted for in the models. Additionally, part-to-part variability of PM filters increases the uncertainty of the pressure sensor correlation with the emission threshold. In order to achieve the current emission thresholds for PM filter monitoring, manufacturers believe PM sensors are necessary. However, these sensors are not expected to be available in the 2010 time frame.

ARB staff agrees that some relief is needed for these initial years of PM filter monitoring implementation based on discussions with manufacturers about their progress in meeting the monitoring requirements. Thus, staff is proposing to raise the PM filter threshold for the 2010 through the 2012 model year engines to 0.07 g/bhp-hr as measured from an applicable emission test cycle (i.e., FTP or SET) or the applicable standard plus 0.06 g/bhp-hr (e.g., 0.07 g/bhp-hr for a standard of 0.01 g/bhp-hr). Staff believes the increase of the emission threshold by up to 40 percent will sufficiently address manufacturers’ concerns on the technical feasibility of meeting the threshold. Two medium-duty diesel engines are already capable of detecting PM filter malfunctions below 0.07 g/bhp-hr and others are expected to meet these same levels soon. Additionally, two heavy-duty engine manufacturers have indicated that they are on track to detect malfunctions prior to PM emissions exceeding 0.05 g/bhp-hr but do not yet have final calibration data to conclusively demonstrate it.

Additionally, heavy-duty diesel manufacturers will have the added knowledge gained from three years of equipping engines with PM filters prior to introducing monitors in 2010 that comply with the 0.07 g/bhp-hr threshold. Staff projects that this additional experience should provide manufacturers the opportunity to further refine versions of the technology and components they currently use for the PM filter diagnostic such as soot loading models and differential pressure sensors. In general, the diagnostics typically involve a comparison of the expected differential pressure derived from the soot-loading model and the actual measured differential pressure sensor across the PM filter. If the measured differential pressure is too small compared to the modeled differential pressure, a malfunctioning PM filter can be determined. However, if the soot loading model and/or the differential pressure sensor are not accurate, it is difficult to discern a good PM filter from a bad one because the differential pressures for the good and bad filters would overlap. As a result, only higher thresholds can be monitored with a crude soot loading model. With improvements to soot loading models and differential pressure sensors, staff believes that most heavy-duty manufacturers will be able to reliably identify malfunctioning PM filters at the proposed 0.07 g/bhp-hr PM threshold in the 2010 timeframe.

In addition to improving the monitoring stringency, more accurate soot loading models would allow manufacturers to operate their PM filter diagnostic more frequently than is currently possible with crude soot models. Under certain engine operating conditions such as driving with a clean PM filter (i.e., a PM filter clear of soot) or low exhaust flow rates, it may be difficult to discern a good PM filter from a bad PM filter, especially with a crude soot model. To compensate for the shortcomings of their soot models, some manufacturers have proposed monitoring the PM filter only under high speeds and loads and only during a limited manufacturer-specified period following a PM filter regeneration event. As a result, in-use monitoring frequency may be low for such strategies and may have difficulty complying with the in-use monitoring frequency requirements. However, if a more accurate soot loading model is utilized, monitoring can be achieved at a variety of PM soot loads, thereby increasing the monitoring frequency of the diagnostic and potentially improving the separation between a malfunctioning and good PM filter. Improvements to differential pressure sensors will also have a similar positive effect on PM filter monitoring. Therefore, further refinement of soot-loading models and differential pressure sensors would reduce much of the diagnostic measurement variation manufacturers are concerned about and allow monitoring at the proposed 0.07 g/bhp-hr level under a variety of operating conditions that are encountered frequently during in-use driving.

Manufacturers can also directly impact the level of emissions with a malfunctioning PM filter by varying engine out emissions. Directionally, the lower the engine out PM emissions, the lower the tailpipe PM level will be when a fault is detected. Staff has seen great variance in the levels of engine out PM level from manufacturers as they each seek to optimize in different areas. Unfortunately, some manufacturers have chosen to optimize for other factors with little to no consideration on diagnostic monitoring capability and, as a result, those manufacturers are struggling. Other manufacturers that did include OBD capability or impacts in the final emission solution and calibration appear to be able to detect malfunctions at much lower PM levels.

Other areas for improving the diagnostic's accuracy include reducing the manufacturer tolerances in the engine, reducing the part-to-part variability of the backpressure characteristics of the PM filters, and correcting for the backpressure variations of PM filters caused by manufacturing tolerances. Generally, any improvements to aspects that reduce the variation of PM output of the engine or the backpressure characteristics of the PM filter would reduce diagnostic error. Manufacturers could demand tighter tolerances from their suppliers to reduce the variation in these parts to improve the accuracy of the diagnostic. While deviations in back pressure are probably not critical for the durability or trapping performance of the PM filter, they likely will be critical for diagnostic purposes. Sizing of the PM filter itself also plays a role in the backpressure levels and manufacturers are expected to still be gaining experience from the field to define the optimum characteristics to improve monitoring capability.

Regarding manufacturer's concerns on fuel specification variation and increased usage of biodiesel fuels causing uncertainty in the soot loading models, staff agrees that consistent fuel quality is an important aspect in ensuring accurate modeling of the soot loading. However, diesel fuel quality in the United States is consistent in quality and will deliver consistent performance on diesel vehicles. In order to sell diesel fuel, fuel producers must demonstrate that various constituents of their candidate fuel meet certain specifications, including sulfur content, aromatics, and lubricity, and that tailpipe emissions from using the fuel on a known engine do not exceed emissions of that emitted from a reference fuel on the same engine. Additionally, ARB has a fuel enforcement program where fuel inspectors conduct frequent, unannounced inspections of refineries, service stations, distribution and storage facilities, and other facilities to ensure California diesel fuel is of a consistent quality. Lastly, staff acknowledges that biodiesel fuels have been shown to reduce exhaust PM emissions and thereby affect the accuracy of soot loading models if its usage is unaccounted for. However, staff believes that biodiesel usage is still very small in California (less than 0.1%) and its effect on PM soot loading models is not significant in the more common forms available (i.e., B2 or two percent biodiesel content). If higher blends of biodiesel fuel do affect the robustness of the PM filter diagnostics, manufacturers can continue to do what they do today and limit their usage by specifying limits on biodiesel fuels which may be safely used to avoid voiding the engine warranty on parts that can be damaged by its usage, such as the PM filter, fuel injectors, seals, and rubber gaskets. Further, the uncertainties introduced by fuels would have a larger impact on soot loading models as the soot loading increases towards full. However, most manufacturers constrain monitoring to the period shortly after a regeneration event. Even if manufacturers extend the interval and/or wait until some minimum amount of soot is accumulated to achieve better separation between a good and malfunctioning PM filter, it is expected that manufacturers would still limit the loading to the lowest soot loading levels where they can achieve robust monitoring and where the uncertainties introduced by low levels of fuel variation should have minimal impact.

As for PM sensors, staff agrees with industry that these sensors will not be commercially viable for the 2010 timeframe. However, PM sensor manufacturers are making progress and are continuing their development work towards developing a commercial product capable of meeting the 2013 model year PM filter thresholds. For the 2010 model year, as mentioned above, considering that some medium-diesel engine manufacturers are currently achieving the proposed 0.07 g/bhp-hr PM filter emission threshold without PM sensors for the 2007 model year, staff believes that heavy-duty diesel engine manufacturers should also be capable of meeting this threshold in the 2010 timeframe utilizing conventional technology (i.e., PM filter soot modeling and differential pressure sensors).

In addition to the proposed amendment mentioned above, staff is also proposing changes to the malfunction criteria for PM filter frequent regeneration monitoring. Currently, the regulation requires manufacturers to indicate a frequent regeneration fault before emissions exceed 2.0 times the NMHC emission standards. However, in discussions with manufacturers and review of submitted emission data, NOx emissions have often increased significantly during PM filter regenerations. Depending on the manufacturer's strategy, some NOx emission controls may be temporarily disabled or otherwise scaled back during regeneration events leading to a substantial NOx increase. In some cases, it appears that NOx emissions may be more affected than NMHC emissions as more frequent or extended regeneration events leads to more frequent and longer periods of reduced NOx control. Thus, staff is proposing to require manufacturers to indicate a fault before emissions exceed 2.0 times the NMHC standards or the applicable NOx standard by more than 0.2 g/bhp-hr, whichever occurs first, starting with the 2013 model year.

Lastly, manufacturers have expressed concern about the current requirements for monitoring the NMHC conversion capability of catalyzed PM filters. Staff addressed this issue in section II. E (Diesel NMHC Converting Catalyst Monitoring) above.

I. DIESEL EXHAUST GAS SENSOR MONITORING

The HD OBD regulation currently details specific monitoring requirements for air-fuel ratio sensors and NOx sensors, while for other exhaust gas sensors such as PM sensors, manufacturers are required to submit a monitoring plan for ARB approval. PM sensors are less developed than NOx sensors, and thus, less is certain about the important characteristics of PM sensors relative to their use in emission control or their proper use as monitoring devices. However, staff has had discussions with sensor suppliers about PM sensor development and is encouraged by the early findings. Further, staff has held discussions with these suppliers about the need for diagnostics, and staff expects that basic diagnostics such as circuit checks, out-of-range values, and heater functionality will be easily implemented. For sensor response or other such characteristics, manufacturers may need to implement strategies similar to those being developed for NOx sensors and may require intrusive operation to verify sensor readings or response during known exhaust concentration conditions (e.g., during deceleration events where fueling is shut-off). Thus, staff is proposing to require manufacturers to monitor the PM sensors to the same specific requirements as those currently required for NOx sensors.

J. GASOLINE FUEL SYSTEM MONITORING

An important part of the emission control system on gasoline vehicles is the fuel system. Proper delivery of fuel is essential to maintain stoichiometric operation, maximize catalytic converter efficiency, and minimize tail pipe emissions. As such, the OBD regulations have always required fuel system malfunctions to be detected when the fuel system cannot maintain emissions below a specific threshold (e.g., 1.5 times the standards).

Recent field testing of light- and medium-duty vehicles has revealed in-use fuel system-related malfunctions that OBD II systems generally cannot identify but which can cause emissions to exceed malfunction thresholds with no detection of a malfunction. ARB and manufacturers investigated this problem and found the cause to be cylinder-to-cylinder differences or imbalances in the air-fuel ratio that are not properly corrected by the fuel control system. As stated, this type of malfunction or system deterioration can have a significant impact on emissions. The imbalances can be caused by fuel injector variation, unequal airflow into the cylinders, or uneven EGR distribution across the cylinders. In many cases, the front oxygen sensor, which is located in the manifold collector and is used for feedback fuel control, does not equally sense all cylinders and may cause the feedback fuel control system to be blind or overly sensitive to specific cylinders. This can result in improper fuel system corrections (i.e., the fuel system under-compensates or overcompensates for the imbalance) and higher emissions without detection of a malfunction.

As this failure mode was not previously identified in the OBD II regulation, staff recently amended the OBD II regulation to include detection of this malfunction, and is currently proposing the same amendments to the HD OBD regulation. The staff is proposing that manufacturers be required to detect an air-fuel cylinder imbalance in one or more cylinders that causes the fuel delivery system to be unable to maintain emissions below a specified emission level. To provide manufacturers sufficient leadtime to comply with the new requirements, staff is proposing a phase-in during the 2014-2016 model years with a malfunction threshold of 3.0 times the standards, with all engines required to meet the final threshold of 1.5 times the standards in the 2017 model year.

The staff is proposing a different phase-in schedule for vehicles equipped with certain types of EGR systems that have been found to be more prone to causing cylinder imbalance as the system deteriorates. The staff is proposing cylinder imbalance malfunctions be detected on all 2014 and subsequent model year engines equipped with EGR systems that have separate flow delivery passageways (internal or external) that deliver EGR flow to individual cylinders (e.g., an EGR system with individual delivery pipes to each cylinder).

There are a number of monitoring strategies that may be used to detect cylinder imbalances. Monitoring of these types of failures may be accomplished by evaluating the front and/or rear oxygen sensor signals. During in-use testing of vehicles with cylinder imbalance malfunctions by ARB staff, one vehicle had a cylinder imbalance caused by intake valve deposits. The valve deposits caused an EGR effect in that cylinder that resulted in a rich air-fuel ratio relative to the other cylinders. Coincidentally, the oxygen sensor was oversensitive to the malfunctioning cylinder and the fuel system overcompensated by leaning out all the cylinders yielding an overall lean bias for the engine. The lean bias caused NOx emissions to significantly exceed the emission standards. The vehicle manufacturer analyzed the vehicle using special engineering tools to obtain a high-speed signal from the oxygen sensors. With the high speed data, the manufacturer observed that front oxygen sensor signal was noisy (i.e., there were rich spikes in the exhaust signal due the relatively rich air-fuel ratio in the cylinder that had the valve deposits). The noisy signal was an indicator that something was wrong with the system. Fuel system monitors generally use filtered or slower speed oxygen sensor signals to determine the average fuel system error caused by malfunctions that uniformly affect all cylinders. Therefore, typical fuel system monitors would not detect a noisy sensor as malfunctioning fuel system behavior. However, monitoring of the high-speed signal of the front sensor for this kind of behavior could be used to detect a cylinder imbalance fault. Additionally, the rear oxygen sensor signal also could show signs of cylinder imbalance. In the example discussed above, the rear oxygen sensor indicated a lean signal throughout the emission test cycle. However, depending on the fuel control strategy and the catalyst and sensor configuration, analysis of the rear sensor alone may not be sufficient for cylinder imbalance monitoring, nor would analysis of the rear oxygen sensor fuel control values be sufficient to cover all cases. (Monitoring of the downstream fuel control values will therefore remain a separate requirement in the regulation.)

Staff is also proposing additional language regarding engines that employ engine shutoff strategies (e.g., hybrid buses that shut off the engine at idle) that was not comprehended in the current regulation. The HD OBD regulation currently requires manufacturers to detect fuel system malfunctions where the system fails to enter closed-loop operation within a certain time after engine start, which does not specifically address engines that can implement engine shutoff and restarts multiple times within the same driving cycle. Thus, staff is proposing to require manufacturers to detect fuel system malfunctions for these engines when the system fails to enter closed-loop operation within a certain time after every engine restart.

Lastly, a minor change was made to harmonize with the light- and medium-duty regulation regarding secondary oxygen sensor fuel system monitors. Specifically, an allowance was added for manufacturers to eliminate the use of similar conditions for such monitors upon demonstration that the system only operates in sufficiently constrained conditions that there is no technical need to use similar conditions to ensure robust detection of faults.

K. GASOLINE MISFIRE MONITORING

The staff is proposing to modify the gasoline misfire monitoring requirements in the HD OBD regulation to limit the monitoring of misfire during flare downs to just those occurring during positive torque conditions. Staff recently amended the OBD II regulation with the same change due to manufacturers' arguments that, while there were no outside influences acting on the engine during the flare-down, the engine may be in negative torque and misfire monitoring accuracy could be affected.

The HD OBD regulation currently requires manufacturers to monitor for misfire from no later than the end of the second crankshaft revolution after engine start. Similar to the issue for gasoline fuel system monitoring above, the language does not specifically address engines that employ engine shutoff strategies (e.g., hybrid buses that shut off the engine at idle) and can restart the engine multiple times within the same driving cycle. Thus, staff is proposing to require manufacturers to monitor for misfire no later than the end of the second crankshaft revolution after every engine restart.

L. GASOLINE SECONDARY AIR SYSTEM MONITORING

Secondary air systems are used on vehicles to reduce cold start exhaust emissions and typically consist of an electric air pump, hoses, and a check valve(s) to deliver outside air to the exhaust system upstream of the catalytic converter(s). The HD OBD regulation currently requires manufacturers to monitor the “air flow” delivered by the secondary air system and, in cases where there are more than one delivery hose (e.g., one to each side, or bank, of a V-6 engine), to verify that the proper amount of air is delivered through each hose. Industry, however, questioned the necessity of monitoring the air flow to each bank of the engine in cases where complete blockage of air delivery to one bank does not affect emissions. Thus, the staff is proposing modified language to exempt detection of flow to both banks if the manufacturer can show that complete blockage of air delivery to one bank does not cause a measurable increase in emissions.

M. GASOLINE EVAPORATIVE SYSTEM MONITORING

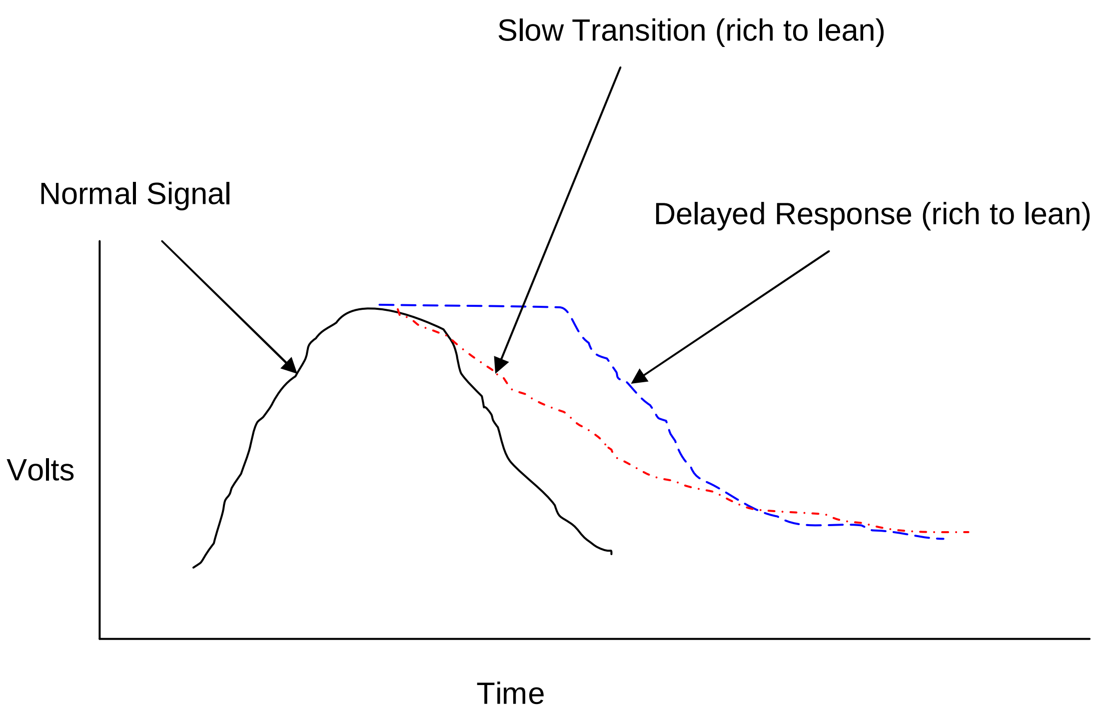
The HD OBD regulation currently requires monitoring of the complete evaporative system for vapor leaks to the atmosphere as well as verification of proper function of the purge valve. Traditionally, vehicles have used a single purge path to purge vapor from the system to the engine. However, some newer engines, especially turbo-charged engines, have implemented two paths to ensure sufficient purge during boost operation. For vehicles that rely on the proper function of both paths to maintain in-use emission levels, the requirement has been clarified to ensure that both purge paths are monitored.

N. GASOLINE EXHAUST GAS SENSOR MONITORING

The HD OBD regulation currently details specific monitoring requirements for “exhaust gas sensors,” with monitoring requirements split for exhaust gas sensors that are considered “primary” sensors versus “secondary” sensors. The OBD II regulation, by contrast, currently details specific monitoring requirements for oxygen sensors (conventional and wide-range or universal sensors), while manufacturers using other types of exhaust gas sensors (e.g., NOx sensors, PM sensors) are required to submit a monitoring plan for Executive Officer approval. Considering gasoline engines are generally not expected to utilize other exhaust gas sensors as much as oxygen sensors and to be consistent with the OBD II regulatory language, staff is proposing to modify the gasoline exhaust gas sensor monitoring language in the HD OBD regulation to detail specific requirements for oxygen sensors and require manufacturers to submit a plan for other exhaust gas sensors.

Additionally, as is currently required in the OBD II regulation, staff is proposing to clarify what is expected of manufacturers when developing response rate monitors for primary oxygen sensors. Specifically, manufacturers would be required to detect both asymmetric malfunctions (i.e. faults that affect only the lean-to-rich response rate or only the rich-to-lean response rate) and symmetric malfunctions (i.e., faults that equally affect both the lean-to-rich and rich-to-lean response rates). These response rate faults include faults that affect the response either by delaying the initial reaction of sensor to an exhaust gas change (e.g., "delayed" response) or by delaying the transition from a rich reading to a lean reading (or vice-versa) (e.g., "slow transition") (see Fig. 1 below). In previous years, while all light- and medium-duty manufacturers were currently capable of detecting each of these types of faults, not all of them had rigorously calibrated the monitors to ensure proper detection of the faults before emissions exceed 1.5 times the standards. Accordingly, staff recently amended the OBD II regulation, and is currently proposing for the HD OBD regulation, to identify the failure modes for response that should be considered by manufacturers in calibrating the response diagnostic. Under the proposal, manufacturers would be required to consider six different response fault conditions when determining the worst case failure mode necessary for calibration: asymmetric lean-to-rich delayed response, asymmetric rich-to-lean delayed response, asymmetric lean-to-rich slow transition, asymmetric rich-to-lean slow transition, symmetric delayed response, and symmetric slow transition. Manufacturers would be expected to determine an appropriate response monitor threshold(s) to ensure that all response failures are detected prior to exceeding 1.5 times the standards. Further, beginning in the 2013 model year, manufacturers would be required to submit data and/or documentation demonstrating that they have used a calibration method that ensures that these criteria have been satisfied.

Fig. 1: O2 Sensor Deterioration Sketch



Results from testing in-use light- and medium-duty gasoline vehicles by ARB staff have also reinforced the need for more rigorous monitoring of the secondary sensors used to monitor the catalyst for proper operation. For secondary oxygen sensors, the HD OBD regulation currently requires the diagnostic system to detect a fault, to the extent feasible, when the secondary oxygen sensor is no longer reliable for monitoring. Given the location of the sensor downstream of the catalyst, stringent monitoring of the sensor has been difficult to achieve or isolate from other effects (e.g., oxygen storage in the catalyst). Accordingly, staff had been accepting fairly simple “activity” diagnostics in light- and medium-duty OBD II vehicles that verify minimal operation of the sensor as acceptable monitoring techniques. Unfortunately, in-use vehicles with deteriorated secondary oxygen sensors and deteriorated catalysts were found to have high emissions and no MIL illumination. Staff found that replacement of the secondary oxygen sensor resulted in the diagnostic system being able to detect the malfunctioning catalyst and illuminate the MIL. Ideally, manufacturers’ secondary oxygen sensor monitors should be able to detect and illuminate the MIL for this fault (i.e., detect a malfunction for deteriorated sensors that cannot robustly detect a “threshold” catalyst). However, before the OBD II regulation was recently amended, very few manufacturers had monitors that met this ideal situation. Most monitors had a gap in the degree of sensor deterioration between where the sensor is no longer sufficient for catalyst monitoring and where the sensor itself can be detected as malfunctioning. Considering that catalyst fault codes are a significant percentage of the failures found in high-mileage cars in I/M programs, the staff believed the OBD II regulation needed to be modified to make manufacturers better understand what is expected of the secondary oxygen sensor monitors and to avoid problems like these in the future. Further, recent improvements in monitoring techniques for the rear sensor were identified that enable more stringent monitoring of the sensor as well as improved monitoring techniques for the catalyst monitor that are less sensitive to secondary sensor performance degradation.

Thus, staff recently amended the OBD II regulation to require better monitoring of the secondary sensors to ensure “sufficient” sensor performance for other monitors, and is currently proposing the same amendments for the HD OBD regulation. Specifically, the proposed amendments would require the OBD system be designed such that the worst-performing acceptable secondary sensor is able to detect the best-performing unacceptable system or component (e.g., catalyst) that uses the secondary sensor for monitoring. In other words, in the case of the catalyst monitor, the worst-performing secondary oxygen sensor that could “pass” the secondary sensor monitor should be able to detect a deteriorated catalyst that just barely “fails” the catalyst monitor (i.e., a catalyst deteriorated right to the threshold). If the OBD system is technically unable to meet this requirement, manufacturers would be required to submit a plan detailing how they will ultimately close the gap, and the proposed amendments would prescribe the minimum acceptable level of monitoring required of secondary oxygen sensors in the interim. Specifically, the OBD system would be required to detect a slow rich-to-lean response malfunction of the sensor during a fuel shut-off event (e.g., deceleration fuel cut event). This monitor would be required to monitor the response time during the following periods: (1) from a rich condition (e.g., 0.7 Volts) at the start of fuel shut-off to a lean condition (e.g., 0.1 Volts) expected during fuel shut-off conditions, and (2) the response time of the sensor in the intermediate sensor range (e.g., from 0.55 Volts to 0.3 Volts). In order to develop a robust monitor, manufacturers would need to isolate the sensor response from catalyst effects and transport time as much as possible. Some manufacturers do not use fuel shut-off during deceleration to the degree or frequency that is necessary for the monitoring defined above. Therefore, in developing the proposed diagnostics, some manufacturers would have to make changes to their fuel control strategies to ensure that fuel shut-off is initiated from a rich condition (i.e., a sensor voltage that is greater than voltages necessary to make the response time measurements defined above) and occurs with sufficient in-use frequency to meet the minimum required monitoring frequency specified in the regulation.

To allow time for manufacturers to make these changes across their product lines, the proposal would require all 2013 and subsequent model year engines to meet this requirement. The OBD system would be required to track and report the in-use monitoring frequency of this monitor starting with the 2013 model year. Additionally, prior to certification of 2013 model year engines, the manufacturers would be required to submit a comprehensive plan demonstrating the their efforts to minimize any gaps remaining between the worst-performing acceptable sensor and a “sufficient” sensor.

O. COLD START EMISSION REDUCTION STRATEGY MONITORING

In order to meet the standards, manufacturers have to use emission control strategies to minimize emissions during and after a cold engine start. The vast majority of emissions from gasoline engines during an FTP emission test are generated during the short period after engine start before the catalytic converter “lights off” (i.e., reaches the operating temperature where it begins to achieve high conversion efficiency). In order to minimize these cold start emissions, manufacturers use special strategies to maximize the heat transferred through the exhaust to the catalytic converter to accelerate light off. The most common elements of cold start strategies are modifications to engine speed and ignition timing. The idle speed is increased over the speed that is normally used, or is necessary, for a start-up. Increased idle speed increases exhaust mass flow. Ignition timing is also retarded from normal timing which makes the engine run less efficiently. Retarded ignition timing increases the exhaust temperature and further increases exhaust mass flow. Combined, the two elements generate hotter exhaust temperatures and more thermal mass that can be used to accelerate the light off of the catalyst. Staff required the monitoring of these cold start strategies in light- and medium-duty vehicles in 2002. The cold start monitoring requirements have been a difficult requirement for staff to administer. It requires a detailed disclosure by the manufacturers on how their cold start strategy works. At the same time, it requires an in depth understanding by both ARB staff and the manufacturers’ staff of how malfunctions, drivers’ actions, and vehicle operating conditions (e.g., fuel quality) can affect the proper execution of the cold start strategy.

In reviewing the cold start monitoring strategies that manufacturers implemented in the OBD II systems, the staff has concluded that, in some cases, the monitors did not sufficiently ensure that the cold start strategies are successfully executed. For example, some monitors evaluated the combined effects of idle speed and ignition timing and only detected a malfunction when both elements (i.e., engine speed and ignition timing) of the emission reduction strategy have failed. The staff believes this is an inappropriate way to design the monitor because the OBD II system will not detect a malfunction until two failures have occurred. Other manufacturers have calibrated their monitors such that a malfunction will not be detected until the performance of the cold start system has deteriorated beyond what is required for normal warmed-up engine operation. For example, most manufacturers require increased idle speed during cold start. Some manufacturers, however, have implemented malfunction thresholds for the cold start monitor that require the engine speed to be less than the normal warmed up idle speed for a malfunction to be detected. While such an approach does indeed verify that the engine starts and idles, it does not verify that some amount of increased idle speed was achieved during the cold start.

To address these issues, the staff amended to the cold start monitoring requirements in the OBD II regulation to ensure more consistent implementation of the requirements by all manufacturers. Specifically, the staff added language that described more specific malfunction criteria for the elements of the cold start monitoring strategy, requiring the OBD II system to detect a malfunction if either of two malfunction criteria is satisfied.

For the first malfunction criterion, the OBD II system is required to detect a cold start malfunction if any single commanded element of the cold start strategy does not properly respond to the commanded action while the cold start strategy is active. A cold start strategy element has proper cold start response if the following conditions are satisfied: (i) the element responds by a robustly detectable amount; (ii) the element responds in the direction of the desired command; and (iii) the magnitude of response is above and beyond what the element would achieve on start-up without the cold start strategy active. For example, if the cold start strategy commands a higher idle engine speed, a fault must be detected if there is no detectable amount of engine speed increase above what the system would achieve without the cold start strategy active. For elements involving spark timing (e.g., retarded spark timing), the monitor may verify final *commanded* spark timing in lieu of verifying actual *delivered* spark timing.

For the second malfunction criterion, the OBD II system is required to detect a cold start malfunction when any failure or deterioration of the cold start emission reduction control strategy causes a vehicle's emissions to be equal to or above 1.5 times the applicable FTP standards. For this requirement, the OBD II system is required to either monitor all elements of the system as a whole (e.g., measuring air flow and modeling overall heat into the exhaust) or the individual elements (e.g., increased engine speed, commanded final spark timing) for failures that cause vehicle emissions to exceed the emission malfunction threshold.

Staff is currently proposing these same modifications to the gasoline cold start emission reduction strategy monitoring requirements in the HD OBD regulation. Additionally, the staff is requiring heavy-duty diesel engines to monitor for malfunctions of the cold start emission reduction strategies. While not yet prevalent in heavy-duty engines, some light-duty diesel manufacturers have implemented such strategies and some heavy-duty manufacturers have indicated such strategies are being considered to reduce emissions shortly after engine start-up. The proposed amendments would ensure such strategies are monitored for proper operation when and if they are implemented.

P. ENGINE COOLING SYSTEM MONITORING

The heavy-duty OBD regulation requires manufacturers to monitor cooling systems for malfunctions that affect emissions or other diagnostics. Engine manufacturers often modify engine operation strategies based on engine coolant temperature (ECT) and utilize it to enable other OBD diagnostics. Malfunctions resulting in improper engine temperature regulation may disable OBD diagnostics, reduce OBD monitoring frequency, cause changes in engine and emission control operation, and cause an increase in vehicle emissions. Therefore, ARB has required cooling systems to be monitored to detect malfunctions if either of the following occurs: (i) the ECT does not reach the highest temperature required by the OBD system to enable other diagnostics, or (ii) the ECT does not reach a warmed-up temperature within 20 degrees Fahrenheit of the engine manufacturer's nominal thermostat regulating temperature. Since engine manufacturers are responsible for designing their own OBD monitors, they have direct control over the first criteria by limiting how high they specify the enable temperature used for other monitors. Manufacturers that choose to design emission solutions that are less sensitive to temperature (or work effectively earlier in warm-up) and design diagnostics that are robust at lower warm-up temperatures can directly reduce the stringency of this monitor.

Nonetheless, engine manufacturers have expressed difficulty in meeting these requirements primarily because the engine may be used in a variety of vehicles and with various other devices that affect the warm-up of the engine. Other than the assurance that there is sufficient cooling capacity at peak engine loads, historically, few constraints have been placed on vehicle manufacturers (i.e., truck builders) and thus, there is significant variance in the engine warm-up characteristics in individual vehicles. Due to this variety, engine manufacturers have commented that they cannot properly distinguish normal warm-up behavior from malfunctioning warm-up behavior. To address these concerns, manufacturers have proposed several modifications to the regulation they believe would make cooling system monitoring more feasible in the 2010 timeframe. One such request involves a change that would allow cooling system monitors to take longer to make pass or fail decisions, spanning many more trips than the two-trip strategy currently allowed for decision making. Specifically, manufacturers have asked permission to only illuminate the MIL if a fault is detected on six consecutive trips. Engine manufacturers believe a 6-in-a-row monitoring strategy will effectively filter out abnormal drive patterns or anomalies in vehicle operation that may cause the system to occasionally be delayed in warm-up or not warm-up, yet they would still eventually detect a fault for systems with a true fault.

ARB staff disagrees with the engine manufacturers' request to use a longer statistical filter to detect faults because it does not adequately address the issue; these strategies simply allow for more time on less than sufficiently robust monitors hoping that false fails will not occur often enough or that the driver will not frequently or repeatedly engage in what they consider ‘abnormal driving patterns.’ A more appropriate solution is for engine manufacturers to better define enable conditions or the modeled coolant temperature to either account for or disable the monitor during such ‘abnormal’ driving conditions if an accurate pass/fail decision cannot be made. While this can result in less frequent monitoring and must be balanced with maintaining reasonable monitoring frequency under the breadth of conditions encountered in the real world, designing (or allowing) a monitor to run under conditions where it may make an incorrect decision is always inappropriate as it can lead to erroneous decisions in-use and undermine technician and vehicle operator confidence in the OBD system. Accordingly, staff will not be proposing a change to the currently required 2-in-a-row detection strategy.

Engine manufacturers have also requested that cooling system monitoring be disabled/desensitized on engine starts with ambient or starting temperatures below 60 degrees Fahrenheit. They believe this allowance will help reduce calibration burden and constrain monitoring to temperatures where truck cabin heat or other sources would be used minimally and would have less impact on delaying proper warm-up. The heavy-duty OBD regulation currently allows engine manufacturers, with Executive Officer approval, to use alternate malfunction criteria and/or monitoring conditions that are a function of temperature at engine start on engines that do not reach the temperatures specified in the malfunction criteria when the thermostat is functioning properly. Similarly, light- and medium-duty vehicles are given relief for engine starting temperatures below 50 degrees Fahrenheit and several engine manufacturers have used this provision for select vehicles (e.g., primarily vehicles with very large passenger compartments). ARB has recognized vehicle operation in California at temperatures below 50 degrees Fahrenheit is limited and accordingly, most ARB emission standards only apply down to 50 degrees Fahrenheit. However, the amount of vehicle activity in the temperature range from 50 to 60 degrees Fahrenheit is expected to be substantial in California, so monitoring to a less rigorous threshold in this temperature region could affect a substantial fraction of vehicle activity. As stated before, engine manufacturers have some control over the stringency of this monitor, as they have the ability to calibrate their OBD systems to use lower enable temperatures for appropriate monitors and still be robust in detecting faults. Thus, while ARB agrees that engine manufacturers should be allowed to desensitize the thermostat monitor on lower engine start temperatures, ARB is proposing to allow this on engine starts with temperatures below 50 degrees Fahrenheit, not 60 degrees Fahrenheit.

Citing the difficulty in accounting for heat sinks, engine manufacturers have also requested that cooling system monitoring be limited to detection of malfunctions in which the thermostat is fully stuck open, irrespective of what temperature is or is not achieved. Manufacturers feel that simply verifying the thermostat is not fully stuck open would greatly simplify the monitoring process and allow manufacturers to design for a range of applications, ensuring some minimum capability on all applications. ARB, however, disagrees and believes failures that prevent proper warm-up for emissions and diagnostics need to be detected regardless of the failure mode (e.g., fully stuck open, partially stuck open, leaking, opening too early).

Engine manufacturers would also be required to monitor for failures which cause the ECT to cool back down below diagnostic enablement temperatures after they have been reached (e.g. monitoring to ensure temperatures stay above thresholds after they are initially reached). In certain situations, an idling vehicle with a malfunctioning thermostat and low airflow across the engine bay can reach warmed-up temperatures and pass thermostat monitoring yet when the vehicle reaches higher speeds, additional cooling is introduced across the radiator and engine block, lowering the ECT below the temperature necessary for other OBD diagnostics. This situation could effectively disable all diagnostics that require off-idle operation without being detected as a cooling system fault as well as cause an increase in emissions in some instances (e.g., activation of low temperature AECDs that disable emission control functions, fall below optimal operating temperature windows for exhaust aftertreatment). The proposed revisions to the regulation include specific language identifying this malfunction and requiring monitoring for 2016 and subsequent model years. Staff has proposed longer leadtime for this specific requirement because of manufacturers' previously stated concerns that they have insufficient control over truck builders with regards to equipping the engine with devices that prolong warm-up or cool the engine back down. By waiting until 2016 model year, manufacturers will have time to implement OBD across all engines and truck builders will become more aware of the choices they make and their impacts on proper operation of the OBD system. In some cases, this monitoring requirement could effectively impose design restrictions on the engine cooling system and force manufacturers to be more proscriptive in restricting what truck builders can and cannot add to an engine to remain in compliance. While this may be unfavorable, allowing truck builders to add equipment that effectively disables many OBD monitors and/or causes an engine to run below normal operating temperatures (and with an associated increase in emissions) is not an acceptable long term path for achieving and maintaining low emissions in-use. In some cases, a manufacturer may need to make design changes or include additional control strategies to ensure an engine stays above a minimum operating temperature under normal ambient conditions and the additional leadtime should allow manufacturers to investigate alternatives and/or implement such features. Further, as with other required thermostat monitoring, manufacturers will have the ability to constrain monitoring to operating conditions where they can robustly determine if the system is passing or failing and exclude conditions (e.g., very cold temperatures, very low speed driving) where such decisions cannot be made.

Engine manufacturers have also expressed interest in allowing vehicle manufacturers some ability to calibrate their own cooling system criteria in order to properly account for appropriate heat/work losses in the final vehicle configuration. In recognizing the difficulty of engine manufacturers to calibrate for every type of vehicle the engine is likely to be used in, ARB believes giving vehicle manufacturers some capability to select between various calibration parameters to best match the specific vehicle configuration would be a workable solution. This would allow the OBD system to be better optimized for the specific truck configuration while still allowing vehicle manufacturers a wide range of authority in what they add to the system and how it impacts vehicle warm-up. While ARB feels this is a reasonable approach, engine manufacturers will need to take appropriate actions to ensure vehicle manufacturers are given proper instruction on how to determine the proper calibration to select and are not allowed to just default to one that would be inappropriate. Further, engine manufacturers are ultimately held responsible for OBD compliance in-use and inappropriate selection by vehicle manufacturers could result in enforcement action against the engine manufacturer.

Q. CRANKCASE VENTILATION (CV) SYSTEM MONITORING

During the engine combustion process, some exhaust gases can escape past the pistons into the crankcase and subsequently to the atmosphere. The CV system is used to contain these exhaust gases (also known as “blow-by”) and typically directs them to the intake to be re-routed through the engine. The CV system generally consists of a crankcase vapor outlet hose (through which the exhaust gas is directed from the crankcase to the intake ducting typically upstream of the compressor), and a CV valve to control the flow through the system. Many diesel systems also include a filter and/or oil separator to reduce the amount of oil and/or particulate matter that exits the CV system. As with CV systems on gasoline vehicles, staff believes the likely cause of CV system malfunctions and excess emissions is improper service or tampering of the CV system. These failures include misrouted or disconnected hoses, and missing or improperly installed valves, filters, or oil separators. Of these failures, hose disconnections on the vapor vent side of the systems and/or missing valves can cause emissions to be vented to the atmosphere.

For vehicles with diesel engines, the HD OBD regulation currently requires manufacturers to submit a plan for Executive Officer approval of the monitoring strategy, malfunction criteria, and monitoring conditions prior to introduction on a production vehicle. Executive Officer approval is based on the effectiveness of the monitoring strategy to monitor the performance of the CV system to the extent feasible with respect to the proposed malfunction criteria detailed in the current regulation, which essentially requires the OBD system to monitor for disconnections between the crankcase and the CV valve and between the CV valve and the intake ducting.

Instead of continuing to use the provision to require manufacturers to submit a monitoring plan for ARB approval, the staff is proposing to apply essentially the same monitoring requirements that are currently being required for gasoline vehicles and for light- and medium-duty diesel vehicles. Thus, the staff is proposing that manufacturers be required to monitor the CV system for disconnections between the crankcase and the CV valve and between the CV valve and the intake ducting. Regarding disconnection between the CV valve and the crankcase, detection would likely be significantly more difficult, and could require additional hardware such as a pressure switch to ensure flow in the system. However, in order to facilitate cost-effective compliance, the staff proposes to exempt manufacturers from detecting this type of disconnection if certain system design requirements are satisfied. Specifically, manufacturers can be exempted from monitoring in this area if the CV valve is fastened directly to the crankcase in a manner that makes technicians more likely to disconnect a monitored portion of the system (e.g., the line from the valve to the intake ducting provided this line is monitored)) during service or if disconnection of the CV valve results in a rapid loss of oil such that the vehicle operator is certain to respond and have the vehicle repaired. Staff believes that this would eliminate most of the disconnected hose and valve events because technicians who do not reconnect the intake ducting hose when the service procedure is completed will be alerted to a diagnostic fault or oil leak that will lead the technician back to the improperly assembled component.

Under the existing certification requirements for diesel engines, manufacturers are allowed to implement open CV systems (i.e., systems that release crankcase vapors to the atmosphere without routing them to the intake ducting or to the exhaust upstream of the aftertreatment) if the manufacturer accounts for the crankcase emissions to the atmosphere in the tailpipe certification values. Such systems have additional risk for emission failures because a malfunctioning filter or oil separator will result in much dirtier gases being vented directly to atmosphere instead of being routed into the engine. For these systems, the proposal would still require manufacturers to submit a monitoring plan for Executive Officer approval.   The plan would be approved based on the effectiveness of the proposed monitor to detect disconnections and malfunctions in the system that prevent proper control of crankcase emissions (e.g., if the system is equipped with a filter to reduce crankcase emissions to the atmosphere, the OBD system shall monitor the integrity of the filter).

In general, diesel engine manufacturers would be required to meet design requirements for most of system in lieu of actually monitoring many of the hoses for disconnection. Specifically, the proposed regulation would allow for an exemption for any portion of the system that is resistant to deterioration or accidental disconnection and not subject to disconnection during any of the manufacturer’s repair procedures for non-CV system repair work. These safeguards should eliminate most of the disconnected or improperly connected hoses while allowing manufacturers to meet the requirements without adding any additional hardware solely to meet the monitoring requirements. Where monitoring is required between the CV and the intake ducting, it is possible to use monitoring strategies similar to those used on gasoline vehicles. For example, if the components of the CV system are properly sized, a disconnected line will cause a large source of unmetered air to be inducted into the engine which can be detected by EGR or intake air mass flow rationality monitoring.

R. COMPREHENSIVE COMPONENT MONITORING

One of the most important elements of the OBD system is that it requires comprehensive monitoring of all electronic powertrain components or systems that either can affect emissions or are used as part of the OBD diagnostic strategy for another monitored component or system. This includes input components such as sensors and output components or systems such as valves, actuators, and solenoids. Monitoring of all these components is essential since their proper performance can be critical to the monitoring strategies of other components or systems.

However, as engines and vehicles have become increasingly sophisticated, there has been a proliferation of electronic components much beyond the traditional electronic powertrain components that existed when OBD was started. Many of these components are peripheral components not related to fuel or emission control of the engine. Yet, by the most stringent of interpretations, these ancillary components could be considered subject to OBD because they are powertrain-related and could affect emissions indirectly by increasing electrical demand or load on the engine when malfunctioning.

In order to keep OBD systems containable and focused on identifying the powertrain components more directly related to fuel or emission control, the staff is proposing changes to the heavy-duty OBD regulation similar to those recently added to the OBD II regulation to exclude certain types of powertrain components. Specifically, the proposed changes would exclude components that are driven by the engine or can increase emissions only by increasing electrical demand or load on the engine and are not related to fuel or emission control. Examples of such excluded components could include electric power steering systems or intelligent vehicle charging systems.

Additionally, while hybrid powertrain components are subject to monitoring, the current regulation does not have very specific guidelines aimed at hybrid components, and some manufacturers have been unsure as to how to design their hybrid component diagnostics to be acceptable under the regulation. Ideally, the regulation would provide specific performance and diagnostic requirements for each and every hybrid component. Unfortunately, hybrids are still rapidly evolving and neither the staff nor manufacturers have developed sufficient experience to detail monitoring requirements for all hybrid components that would properly comprehend how they are used in all applications. Thus, the staff has proposed the inclusion of general guidelines specifying that monitoring would be required for (1) all components/systems used as part of the diagnostic strategy for other monitored component/systems, (2) all energy input devices to the electrical propulsion system, and (3) battery charging system performance, electric motor performance, and regenerative braking performance, and has added a provision that would require manufacturers to submit a monitoring plan for ARB’s review and approval.

Manufacturers have expressed concerns about the specific requirement in the HD OBD regulation to monitor both the MIL and the wait-to-start lamp for circuit continuity malfunctions (e.g., burned out bulbs). Specifically, manufacturers have argued that, as engine builders/suppliers, they do not have control over the instrument panels and driver displays selected by truck builders in the final vehicle. In many of those systems, the warning lights are directly wired and controlled by the instrument panel itself, not the engine control unit (ECU), and it would require instrument panel changes and/or added hardware or software in the instrument panel to diagnose the lights and send that information back to the engine ECU. As another option, manufacturers would need to provide for and require that these warning lamps be directly hardwired to the engine ECU to ensure enough information is available to diagnose the circuits. Further, manufacturers have indicated a strong trend in industry to change from incandescent bulbs to light emitting diode (LED) technology for the warning lamps. Manufacturers have argued that LEDs are much less susceptible to burned out bulb failures, leaving only circuit faults to the LED as a likely failure mode. In some cases, the LEDs are directly attached to circuit boards, virtually eliminating any hardwiring. Lastly, one manufacturer has indicated that given the nature of an LED and its extremely low current draw levels, certain failure modes within the LED itself are not technically feasible to detect.

Staff's original intent for monitoring the wait-to-start lamp was different from the rationale for monitoring the MIL. For the wait-to-start lamp, monitoring has always been required in light-duty from the start of OBD II implementation. If this lamp does not function properly, a vehicle operator may crank the engine too soon, causing increased emissions from extended cranking or failed crank attempts before the engine is finally started. Further, if the lamp malfunctioned, the MIL would be illuminated to indicate the need for repair. Based on the potential for direct emission impact, staff is not proposing any changes to the requirements for wait-to-start lamp monitoring. For MIL monitoring, however, the rationale for monitoring was to simplify roadside or other inspections of heavy-duty vehicles. Rather than requiring an inspector to shut off the engine and enter the vehicle cab to visually look for the proper function of the MIL (and record that observation somehow), the intent was the entire inspection could be automated and all necessary information could be downloaded electronically via a scan tool. However, the presence of a non-functional MIL does not necessarily need to be considered in a roadside type inspection. Unlike the wait-to-start lamp, a malfunction of the MIL by itself does not lead to a direct emission impact. And, unlike other malfunctions that result in MIL illumination, a malfunction of the MIL itself prevents the MIL from illuminating, thereby largely eliminating the chance for the driver to be alerted and take appropriate action. If other emission-related faults are present, the data downloaded at inspection will properly indicate the fault data and lead to correct pass/fail decisions. Given the minimal additional benefit for roadside inspection and the reduced opportunity for a driver to voluntarily notice and take corrective action for a failed MIL, staff is proposing to eliminate the requirement to monitor the MIL for circuit malfunctions in the HD OBD regulation.

Heavy-duty manufacturers have also expressed concern for potential monitoring of vehicle speed sensors located in the transmission. Manufacturers have indicated that the vehicle speed sensor may be needed to enable certain monitors, such as idle misfire monitoring. However, similar to the argument about the MIL and wait-to-start lamp monitoring, manufacturers have argued that, as engine builders/suppliers, they do not have control over the components in the transmission, including the vehicle speed sensor. Thus, manufacturers originally asked to be exempted from monitoring the vehicle speed sensor even though they would be using that sensor to enable other OBD monitors. After being told that would be unacceptable, manufacturers submitted an alternate plan that would including partial monitoring and MIL illumination for the vehicle speed sensor but would still require special handling as they wanted to exclude vehicle sensor failures from emission warranty, they wanted to exclude other transmission components from monitoring even though they were used to monitor the vehicle speed sensor itself, and they wanted to exclude disclosure and the review and approval process by ARB for these additional diagnostics. Staff, however, disagrees with manufacturers' proposal. Staff believes if the manufacturer uses the vehicle speed sensor signal from the transmission to enable an OBD monitor, the manufacturer must monitor the sensor as required under the comprehensive component monitoring requirements (including monitoring of components used to monitor the vehicle speed sensor itself, MIL illumination and proper fault handling upon fault detection, and disclosure of such diagnostics to ARB for review and approval). Further, the emission performance warranty is clear that all items that turn on the MIL are subject to emission warranty and other provisions such as warranty reporting. Manufacturers have indicated that one transmission supplier in particular has informed them that they are prohibited from using information from their transmission for OBD purposes. Given that, there are still several options available to manufacturers including using alternate transmission suppliers (which will likely result in this transmission supplier reconsidering its position if its products are unable to be used with any heavy-duty engine). Other options including installing a dedicated vehicle speed sensor that is under the control of the engine manufacturer or using sources other than the transmission for vehicle speed information. Staff, however, still believes the best solution would be to have the transmission supplier provide a raw, undefaulted vehicle speed signal to the engine controller so that the engine controller could perform all of the necessary diagnostics. While this would still subject the vehicle speed sensor in the transmission to warranty requirements, this would avoid drawing other transmission components into the OBD system.

Additionally, for 2013 and subsequent model year heavy-duty engines, manufacturers would be required to monitor fuel control system components (e.g., injectors, fuel pumps) that have tolerance compensation features implemented in hardware or software during production or repair procedures. Examples of these include individually coded injector-to-injector tolerances and fuel pumps that use in-line resistors to correct for differences in fuel pump volume output. Some manufacturers have indicated they are currently using or are planning to use such components to achieve more consistent emission performance from cylinder to cylinder and would be reliant on proper assembly as well as on repair technicians to properly reprogram engine computers with the right coding upon fuel system component replacement in the field (e.g., a new injector). Staff is concerned that such systems are more prone to erroneous or incomplete repairs and will result in undetected increases in emission levels. Accordingly, monitoring of such systems will be required to ensure that mis-assembly, erroneous programming, or incomplete repair procedures that result in incorrect adjustments being applied will be detected.

S. EMISSION-RELATED COMPONENT FAILURE MODES

The heavy-duty OBD regulation requires manufacturers to monitor “emission-related” components and systems that can either affect emissions or other OBD monitors. For major emission-related components or systems, functional monitors are generally required if a specific failure does not cause emissions to increase above the OBD emission threshold. For other emission-related input or output electronic components like sensors or valves, they are required to be monitored as completely as possible, regardless of the emission impact of individual failure modes of the component. This generally includes monitoring for circuit/out-of-range, rationality high and low, and functional faults.

Manufacturers have expressed concerns with these requirements. Specifically, while the regulation specifies the components and systems that are required to be monitored, it does not distinguish between emission-related and non-emission-related “failure modes” of these components and systems. Manufacturers have indicated they should not have to monitor for specific failure modes of a component or system that do not impact emissions or other OBD monitors and believe the regulation language should be modified to allow manufacturers to be exempt from monitoring of these specific failure modes. For example, if a valve can only affect emissions when stuck closed, manufacturers argue they should not also have to detect stuck open failures.

ARB staff, however, disagrees. Allowing regulation language that would exempt monitoring of specific failure modes would only lead to many more discussions and arguments between manufacturers and ARB staff regarding whether or not a specific failure mode does indeed affect emissions during any reasonable in-use driving condition. One area of contention could be the specific driving conditions or driving cycle under which the emission impact of the specific failure mode should be evaluated. A failure mode that does not cause any emission increase during cruising conditions, for example, may cause a considerable increase in emissions during higher load driving. Manufacturers would have to run many test cycles to determine which driving conditions would indeed impact emissions. Additionally, considering the many applications one engine can be used in, manufacturers would need to determine if the failure mode that does not affect emissions in one application (e.g., a bus that mostly experiences city driving) could affect emissions in another application (e.g., trucks that run mostly on the freeways). Another area of contention could be the actual impact of the specific failure mode on other OBD monitors. For example, a manufacturer may consider a particular failure mode to be non-emission-related because, in addition to not resulting in any emission increase, the failure mode would not directly cause the disablement of any of the OBD monitors. However, this failure mode may indirectly affect another component of the vehicle such that certain enable conditions of other OBD monitors may be harder to meet (e.g., a failure mode of one component could indirectly slow down the increase of the engine coolant temperature, thereby delaying enablement of other monitors tied to engine coolant temperature). This would require a lot of analysis and testing on the part of the manufacturer and ARB staff to rule out all these indirect consequences and to consider which other OBD monitors may be affected. For the few failure modes that may fall under such an exemption, the amount of workload required to determine if these failure modes are indeed exempt would be huge. It should also be noted that, under the current policy, manufacturers are not required to add any additional hardware just to accomplish monitoring of all failures—monitoring of all failures is limited to monitoring that is technically feasible.

Thus, ARB is maintaining its current policy to require the complete monitoring of emission-related components and systems. A component that is experiencing a failure mode that does not have an emission impact or affect other OBD monitors is still clearly a malfunctioning component. If a repair technician sees an emission-related component experiencing this failure mode but with no MIL illuminated, this may cause confusion with the technician, which would undermine the confidence of the OBD system in the field. With the heavy-duty OBD regulation requiring the complete monitoring of these components, the extra workload to distinguish emission-related failure modes from non-emission-related failure modes will not be necessary and the confidence in OBD in the field will be sustained.

T. EMISSION CONTROL STRATEGIES

Based on recent meetings with manufacturers, staff has concerns that manufacturers are not designing OBD systems to monitor certain aspects of the emission control system, especially those that are not "specifically" identified in the regulation. The intent of OBD systems is to detect virtually any malfunction that leads to an emission increase yet staff is discovering some manufacturers have additional emission controls or strategies that they have not readily disclosed to the OBD staff nor been considered when developing diagnostics. Staff is proposing amendments to reiterate and clarify that, if there is an emission control strategy being used by the engine, manufacturers should be monitoring this strategy for proper operation to the extent possible. Such monitoring should include faults that disable, prevent, or delay the strategy from properly operating and faults that cause the strategy to reach adaptive or authority limits and be unable to achieve the desired goal under conditions where it should be able to achieve them. In most cases, this will include monitoring of input components that are used to enable the strategy or as feedback for feed-forward information, output components that are controlled by the strategy to achieve the desired goal, and the overall function of the strategy itself.

In addition to proposed language in the other emission controls section and the comprehensive component sections for input and output components, staff proposed specific language for the EGR and boost monitors to further address this issue. The diesel EGR and boost pressure monitoring requirements include malfunction criteria tied to the system being unable to achieve proper closed loop control (e.g., not entering closed-loop control when it was expected to, reaching control limits when it should not have). These requirements could be interpreted as only applying if the system has direct feedback control of EGR flow or boost pressure (e.g., to a target EGR flow or boost pressure level). However, as mentioned above in sections II.C. and II.D. for diesel EGR and boost pressure control system monitoring, some manufacturers are using control systems with slightly different target parameters in lieu of EGR flow or boost pressure as staff originally anticipated (e.g., modify or control EGR flow not to achieve a target EGR flow rate but to achieve a target air-fuel ratio). Accordingly, these alternate systems should be similarly monitored for failures that affect proper closed loop operation. Staff is thus proposing to require manufacturers to submit a monitoring plan for ARB's review and approval. This would allow manufacturers and ARB staff to evaluate the technology and determine an appropriate level of monitoring that is both feasible and consistent with the closed-loop monitoring requirements for the EGR and boost pressure control systems and would ensure that manufacturers cannot avoid monitoring of critical emission control systems simply by creating a new control parameter name.

U. OTHER PROPOSED AMENDMENTS

Staff is proposing modifications to better define “continuous” monitoring for several monitors in the HD OBD regulation. Currently, the regulation defines “continuously” in the context of monitoring conditions for comprehensive component circuit and out-of-range monitors but not in the context of monitoring for other major monitors. Accordingly, this definition doesn’t apply for monitors such as diesel fuel pressure control monitoring and EGR system feedback control monitoring, which are also required to be monitored “continuously.” As these systems are typically continuously controlled, staff believed monitoring “continuously” was appropriate. However, staff acknowledges that there typically are conditions where control is not being done (e.g., shortly after engine start-up) and that there are conditions where robust monitoring could not be done (e.g., monitoring for too low EGR flow faults when EGR is commanded closed) and that continuous monitoring may not have been the most appropriate term. When used in the context of these monitors, staff intended for manufacturers to design the monitors to run virtually all the time except during conditions where robust fault detection is not possible. To avoid further confusion, staff modified the monitoring conditions requirement for these monitors to more explicitly state that.

III. PROPOSED REVISIONS TO OBD II REGULATION

At the request of medium-duty diesel manufacturers in order to maintain consistency between the HD OBD and OBD II diesel requirements, staff is proposing to carry over almost all of the proposed diesel-related changes mentioned above for the HD OBD regulation to the OBD II regulation, applying them to medium-duty diesel vehicles. The engines used in medium-duty diesel vehicles are often the same or similar to engines that also go in heavy-duty vehicles, are built and certified primarily by heavy-duty manufacturers, and often use the heavy-duty certification procedures as is currently allowed. Accordingly, the staff believes harmonization of the requirements is largely appropriate. The light- and medium-duty OBD II regulation is scheduled to begin a biennial review later this calendar year and further revisions for light-duty vehicles will be considered then. However, to avoid an interim mismatch in the requirements between the HD OBD regulation and the OBD II regulation, the changes that are applicable to medium-duty diesels are being proposed jointly. In some cases, the changes to medium-duty diesels involve clarification of requirements that are also applicable to light-duty diesels and will apply to both light- and medium-duty. However, modifications to specific emission threshold values (e.g., the interim higher threshold values for some diesel monitors) are proposed only for medium-duty vehicles and will not be applied to light-duty diesels. Any revisions to light-duty diesel emission thresholds will be considered and brought to the Board during the biennial review of the light-duty regulation scheduled to begin later this year. The specific proposed changes to the OBD II regulation can be found in Attachment B.

Additionally, staff is proposing one change to the gasoline monitoring requirements in the OBD II regulation concerning the phase-in schedule for primary oxygen sensor response rate monitoring data submission. Currently, manufacturers are required to submit data and/or engineering analysis to demonstrate that their oxygen sensor monitors are able to detect all asymmetric and symmetric response rate malfunctions with a phase-in starting with the 2010 model year. However, recent discussions with manufacturers indicate that more time is needed to meet this requirement. Thus, staff is delaying the start of the phase-in from the 2010 model year to the 2011 model year, with all vehicles required to meet this requirement for the 2013 and subsequent model years.

IV. PROPOSED REVISIONS TO HEAVY-DUTY OBD STANDARDIZATION REQUIREMENTS

A. REFERENCE DOCUMENTS

The staff is proposing amendments that would update the list of SAE and ISO documents that are incorporated by reference into the HD OBD regulation. As is common practice with technical standards, industry periodically updates the standards to add specification or clarity. The current HD OBD regulation incorporates the 2005 version of technical standard SAE J1939 and associated documents. The proposal would update the regulation to incorporate the most recently adopted versions of each applicable part of SAE J1939.[1] The proposed amendments would also incorporate the most recently adopted versions of several other SAE (i.e., SAE J1930, J1979, J2012, and J2403) and ISO documents (i.e., ISO 15765-4). Several other SAE standards are currently being prepared for ballot and adoption. As these documents are only updated every few years, staff will monitor the progress of adoption of these updates and include them in this rulemaking (through staff suggested changes presented at the Board Hearing) if they are adopted within time. Furthermore, the staff is proposing to incorporate two additional SAE technical standard documents to the HD OBD regulation. Specifically, the staff is proposing to add: (1) SAE J1699-3 – “OBD II Compliance Test Cases”, May 2006; and (2) SAE J2534-1 – “Recommended Practice for Pass-Thru Vehicle Programming”, December 2004. SAE J1699 and SAE J2534-1 are currently used by light- and medium-duty vehicle manufacturers for production engine/vehicle evaluation (PVE) testing of standardized requirements, and are expected to be used for PVE testing of heavy-duty engines (§1971.1(l)(1)) that use the ISO 15765-4 protocol.

B. PERMANENT FAULT CODES

The HD OBD regulation currently requires the OBD system to store a “permanent” fault code for an emission-related fault in non-volatile memory that can only be erased if the

[1] Staff had not yet obtained the SAE J1939 documents at the time this staff report was published. ARB will make these documents available as soon as it receives them, and will reference them and make them available for comment in a subsequent 15-Day Notice.

monitor responsible for setting that fault code has run and passed enough times to confirm that the fault is no longer present. These fault codes are intended to address fraudulent inspection issues where vehicle owners or technicians could erase the emission-related fault information, including the fault codes, through a battery disconnection or by a scan tool command without repairing the fault.

There have been a number of questions as to how specifically the OBD system would erase a permanent fault code, specifically after a clearing of all other fault information (through a battery disconnection or a scan tool clear command) and for continuous monitors versus monitors subject to the minimum in-use performance ratio requirements (e.g., once-per-trip monitors). For monitors that are designed to run continuously, including monitors that must wait until similar conditions are satisfied (e.g., misfire and fuel system monitors), there has been uncertainty about when a permanent fault code should be cleared since a continuously running monitor makes multiple pass/fail decisions throughout the driving cycle. Further, for monitors requiring similar conditions to be satisfied prior to extinguishing a MIL, there has been uncertainty since there is no requirement to store similar conditions in NVRAM along with the permanent fault code and thus, no way to know if similar conditions have been satisfied or not. Recently adopted language in the OBD II regulation requiring implementation of permanent fault codes included language that clarified the protocol under which the fault codes could be erased to ensure consistent implementation by all manufacturers and consistent methods for repair technicians to prepare vehicles for re-inspection by clearing permanent fault codes, and staff is currently proposing for the same amendments for the HD OBD regulation. The proposed amendments would require that the permanent fault code be erased only after the vehicle has been operated on a driving cycle in which both the monitor has run and passed without any indication of a malfunction and the criteria similar to those for a general denominator (§1971.1(d)(4.3.2)(B)) have been satisfied (with the exception that the general denominator conditions require ambient temperatures above 20 degrees Fahrenheit or below 8000 feet in elevation). This would ensure that the vehicle has been operated for a sufficient period of time to reasonably detect a recurrence of the malfunction but does not unnecessarily delay erasure of permanent fault codes. By eliminating the dependency on ambient temperature and altitude, the driving conditions can easily be met throughout California and the nation, regardless of location or seasonal temperatures. Further, in the special case of erasing a permanent fault code for a monitor that uses similar conditions following a code clear event, this eliminates the need for manufacturers to store similar conditions in NVRAM and actually prohibits manufacturers from using similar conditions to erase the permanent fault code. While this creates the possibility that a permanent fault code may be erased before the vehicle encounters similar conditions to those in which the malfunction was originally detected, this is a reasonable compromise since generic scan tools are not capable of reading similar conditions information, and repair technicians would be unable to determine how to operate the vehicle to erase a permanent fault code - a situation that would be unacceptable for inspection programs.

C. ACCESS TO ADDITIONAL DATA THROUGH A GENERIC SCAN TOOL

Currently, manufacturers are required to report certain "real-time" data parameters in a format that a generic scan tool can process and read so technicians can access the data for trouble-shooting malfunctions. In recent years, feedback from technicians in the field has identified the need for additional parameters to be made available by the OBD system to assist them in effective repair. Thus, the proposed amendments define some additional parameters (data stream and freeze frame values) that manufacturers would be required to report. These additional parameters would include values related to PM filter regeneration (e.g., average distances between regeneration events), EGR temperature, reductant level, and NOx adsorber regeneration and deSOx status. While the proposed data parameters would generally be used by technicians to assist them in repairs, some of the data could also used to facilitate inspection programs and compliance or enforcement testing by ARB staff. It is also expected that continued improvement and development in the in-use emission testing procedures and equipment currently being established for heavy-duty engines may identify the need for additional standardized parameters and/or modifications to proposed parameters that can be incorporated during a future regulatory revision.

D. EMISSION-RELATED TEST RESULTS

The heavy-duty OBD regulation currently requires a large number of monitors to report the test results of the most recent monitoring event. Some manufacturers have questioned the necessity of requiring continuous monitors to store test results, since the test results technicians will read from a scan tool will not reflect the most recent monitoring event anyways. Staff has reviewed the monitors subject to reporting test results and has identified and proposed language to exclude test results for several monitors related to feedback control. However, the proposed amendments do not remove the requirement to report results for continuous monitors. While staff recognizes that there will be a lag between decisions being made and those that the technician is currently looking at, the results could still be a benefit when diagnosing intermittent malfunctions. Such malfunctions may be present long enough for technicians to see them or, more likely, current scan tools will be able to continuously update test results and log them so a technician could scroll through the data to look for anomalies. Some manufacturers also indicated that for many of the continuous monitors, such as fuel pressure, a technician might be better served by watching the instantaneous fuel pressure rather than periodically updated test results. However, manufacturers often use complicated algorithms to determine if a system is passing or failing (e.g., integrated pressure error above and beyond a variable level of expected deviation from the commanded pressure) that would not be discernible to a technician visually observing instantaneous fuel pressure. Outputting the results that are already being calculated internally in the computer should be a trivial task for software designers and could provide tangible benefits to repair technicians.

E. IDENTIFICATION AND VERIFICATION NUMBERS

The HD OBD regulation currently requires OBD systems to support parameters identifying the current software "version" or calibration (CAL ID) and an internal calculated result to verify the integrity of the software (calibration verification number (CVN)). These two parameters are intended to be used to help verify that valid software is installed in the on-board computer and that the software has not been corrupted or tampered. As various states around the nation have begun to collect these data on OBD II vehicles, further revisions were found to be necessary based on feedback from the field to facilitate the usage of these parameters in inspection programs. Thus, staff recently adopted changes to the CAL ID and CVN requirements in the OBD II regulation, and is currently proposing similar amendments to the requirements in the HD OBD regulation. First, staff is proposing to require all engines to respond with an equal number of CAL IDs and CVNs and in the same order such that off-board equipment could match up each CAL ID with its corresponding CVN. Further, manufacturers are required to either design the engines to respond with a single CAL ID and CVN combination for each on-board computer or to respond with them in a fixed order of importance (from most critical for proper emission control to least critical). These two changes will allow reasonable size databases to be established to gather and use the CAL ID and CVN data in inspection programs. Lastly, the regulation currently requires the CAL ID and CVN information to be reported in a “standardized electronic format”, but with no information on what the standardized format is. Staff recently developed such a standardized template and will be sending it out to industry in an ARB mail-out and is proposing to bring amendments to the Board at the hearing to specifically refer to this mail-out in the regulation. This will provide a uniform format to receive the data from all manufacturers and facilitate further testing to incorporate usage of the data. Lastly, regarding CVN and CAL ID, a clarification was made by removing the word ‘reprogrammable’ from the language. When originally adopted in the light-duty OBD II regulation, CVN was only required on reprogrammable computers. Subsequent revisions required CVN for all computers but the old language for reprogrammable was never removed and mistakenly included in the HD OBD regulation. To avoid further confusion, the term is being removed so that there is no conflict with the following sentence which requires CVN in every emission or diagnostic-critical computer.

Staff is also proposing two additional pieces of information be made available from the HD OBD system to a scan tool. Specifically, as was previously adopted for light- and medium-duty vehicles, staff is proposing that 2013 and subsequent OBD systems support a function that associates a name or function with each electronic control unit (ECU) that responds to a generic scan tool. This ECU name function provides technicians with additional valuable information by allowing a scan tool to not only report data or fault information but tell the technician which ECU is reporting the data (e.g., engine controller, transmission controller). For some faults, diagnosis and repair can be greatly expedited by isolating which ECU is reporting the fault information especially in cases where data from a single component is used by several ECUs. Secondly, the proposed amendments include a requirement for the HD OBD system to report engine serial number (ESN) starting in the 2013 model year. Discussions with manufacturers and ARB staff from enforcement, roadside testing, and other sections has indicated that ESN is commonly used by industry to identify specific engine characteristics or configurations and is used by field inspectors when performing roadside inspections. As this parameter appears to already be supported and available in all engines, adding a requirement that it be available to generic scan tools should be a trivial change and will allow easier automated collection of data and identification of the engine.

F. EMISSION-INCREASING AUXILIARY EMISSION CONTROL DEVICE (EI-AECD) TRACKING

An additional important item relative to the effectiveness of diesel emission controls in-use is the usage of auxiliary emission control devices (AECDs). Typically, AECDs consist of alternate control strategies or actions taken by the engine controller for purposes of engine, engine component, or emission control component protection or durability. In some cases, activation of an AECD has been justified by the manufacturer as needed to protect the engine and it can result in substantial emission increases while the AECD is activated. AECDs have been an essential part of the certification process and the subject of numerous mail-outs and guidance by U.S. EPA and ARB to help ensure consistent interpretation and equity in usage among all manufacturers. Approval usually involves lengthy review and considerable scrutiny by ARB staff to try and understand the complex algorithms and strategies used by various manufacturers and additionally relies on data supplied by manufacturers as to the expected occurrence/operation of these items in-use. However, such data are often based on the operation of one or two trucks for a few hours of operation and are not likely to be representative of the extreme variances in engine duty cycles and vehicle operator habits that the diesel engines are exposed to in the real world. Further, the complicated algorithms and calculations used by manufacturers to activate such strategies are not easily decipherable nor comparable from one manufacturer to another, making consistent policy decisions and equity among all manufacturers extremely difficult, if not impossible, to achieve.

To help alleviate this issue, the OBD II regulation was recently amended to require the on-board computer on light- and medium-duty diesel vehicles to keep track of cumulative time that a subset of these AECDs is active – the staff is now proposing similar requirements for the HD OBD regulation. Specifically, the proposed language would require tracking of AECDs that cause an emission increase (i.e., emission increasing AECDs or EI-AECDs) on 2013 and subsequent model year diesel engines. Further, the proposed language would only require tracking of EI-AECDs that are justified by the manufacturer as needed for engine protection. Additionally, the proposal would include a provision for some AECDs to be approved as not-to-exceed deficiencies and for any such AECDs to be automatically excluded from being considered an EI-AECD. In the rare instance (if any) that there is an EI-AECD that is justified as needed for engine protection but it actually is comprised of no sensed, calculated, or measured value and no corresponding commanded action by the on-board computer to act differently as a result, it would also be excluded from being tracked as an EI-AECD. Lastly, AECDs that are only invoked solely due to any of the following conditions would be excluded from being considered and EI-AECD: (1) operation of the vehicle above 8000 feet in elevation; (2) ambient temperature; (3) while the engine is warming up and cannot be reactivated once the engine has warmed up in the same driving cycle; (4) failure detection (storage of a fault code) by the OBD system; (5) execution of an OBD monitor; or (6) execution of an infrequent regeneration event.

For those strategies that meet all the requirements above to be considered an EI-AECD, the on-board computer would be required to log cumulative time each one is active and update the stored counter at the end of each driving cycle with the total cumulative time during the driving cycle. Further, each EI-AECD would be counted and reported separately (EI-AECD #1, etc.). ARB staff would be able to use this data to confirm or refute previous assumptions about expected frequency of occurrence in-use and use the data to support modifications to future model year applications and better ensure equity among all manufacturers. This data will also help ARB staff identify “frail” engine designs that are under-designed relative to their competitors and inappropriately relying on EI-AECD activation to protect the under-designed system.

Manufacturers have raised several concerns regarding this required tracking including technical concerns, confidentiality concerns, and the inappropriateness of including such a requirement in the OBD regulations. Regarding technical concerns, manufacturers have argued that determination of which AECDs are emission-increasing will require additional emission testing time. However, as was done with the same requirements in the OBD II regulation, staff has defined emission-increasing as reducing the emission control system effectiveness and thus, made the determination based on engineering analysis, not any emission test data. Industry has also argued that many EI-AECDs have varied levels of emission increase and they are not simple on/off switches, thereby complicating the counting process and making no distinction between items with a large emission impact and those with only a minor emission impact. To address this, staff split tracking of each EI-AECD that is not a simple on-off decision into two separate timers to separately track time spent with “mild” EI-AECD activation (defined as action taken up to 75 percent of the maximum action that particular EI-AECD can take) and “severe” EI-AECD activation (defined as action taken from 75 to 100 percent of the maximum action that particular EI-AECD can take). As an example, an EI-AECD that progressively derates and eventually shuts off EGR when the engine overheats would be tracked in the “mild” timer for time spent commanding EGR derating of 1 to 75 percent and tracked in the “severe” timer for time spent commanding EGR derating of 75 to 100 percent (fully closed). For EI-AECDs where it is harder to determine the 75 percent point (e.g., strategies that activate two different actions of varying levels), manufacturers would be required to present a plan for tracking the timers for ARB approval to ensure that the action that has the most impact on emissions is accurately accounted for.

Manufacturers have also expressed concern about the complexity of tracking two EI-AECDs that may be overlapping and both commanding action. After further discussion with individual manufacturers about how their strategies were structured, staff modified the proposal to require independent tracking of each unique EI-AECDs (defined as a combination of parameter used to trigger the action, state/value of the parameter that actually triggers the action, and commanded action) and not require the software to decipher which of the overlapping EI-AECDs was actually having the bigger impact and only accumulate time in that counter. Additional modifications are also being proposed to further clarify how different types of EI-AECDs are required to be tracked.

Regarding confidentiality, manufacturers have indicated that their algorithms and strategies that comprise their EI-AECDs are extremely confidential and they do not want their competitors to know the details. Manufacturers have indicated that they believe staff's proposal would provide competitors with more detail of their EI-AECDs and make reverse-engineering easier. Staff's proposal, however, does not provide any additional information to make it easier to reverse-engineer a competitor's strategies nor does it provide any detail about the strategies or algorithms used. The only data staff's proposal would make available is cumulative time an engine is operated with a specific numbered EI-AECD active (e.g., EI-AECD #6). Only the certifying manufacturer and ARB would know for any particular engine what strategy or algorithm a particular EI-AECD corresponded to. Further, since the cumulative time data is only updated at the end of a drive cycle, a competitor could only ascertain that, at some previous time in the operation of this engine, a particular EI-AECD was activated a cumulative amount of time. The data would not indicate at what specific time(s) during any previous drive cycles the EI-AECD was active, whether it was active for one long period or many short bursts of time, or the severity of the action (or even what action) was taken during the EI-AECD activation. As can be done today, a manufacturer would be better served emission testing the engine, identifying real time spikes in emissions, and analyzing the engine operating conditions where the spikes actually occurred to reverse engineer his competitor's products rather than looking at data that does not tell him when the actual activation may have occurred. Lastly, given that the only items of discussion here are EI-AECDs justified by the need to protect the engine, a manufacturer's desire for confidentiality can be motivated by only one concern—that it is currently activating an EI-AECD (and thus, protecting its engine) during conditions that its competitors are not (and thus, not equally protecting their engine) thereby giving the manufacturer a competitive advantage in engine durability. By definition, this means that the manufacturer is activating its EI-AECDs more often (in conditions where its competitors are not). But this is also some of the very same inequity that ARB staff struggle to eliminate in certification in cases where a manufacturer is overly conservative in concluding engine "protection" is necessary and/or staff use to distinguish a "frail" engine design relative to competitors' engines.

G. SERVICE INFORMATION REQUIREMENTS

The heavy-duty OBD regulation currently contains requirements for service information that heavy-duty manufacturers are required to make available to the repair industry, which were not included in the stand-alone service information regulation, Cal. Code Regs., title 13, section 1969, at the time the heavy-duty OBD regulation was adopted in 2005. Thus, the heavy-duty OBD regulation currently details requirements for heavy-duty manufacturers to provide basic information including OBD monitor descriptions, information necessary to execute each monitor (e.g., enable conditions), and information on how to interpret the test data accessed from the on-board computer. Additionally, it requires manufacturers to make available repair procedures for OBD faults that either only require the use of a generic scan tool or require the use of a non-generic scan tool as long as they make information available to the aftermarket scan tool industry to manufacture their own tools to perform the same functions. Furthermore, it includes language that clarifies that the stand-alone service information regulation, to the extent it is effective and operative, supersedes any redundant service information requirement in the heavy-duty OBD regulation. In 2006, section 1969 was updated to include OBD information manufacturers are required to make available for heavy-duty vehicles, including requirements to make available to independent service facilities service tools to access the OBD information. Thus, the heavy-duty industry has requested that the service information requirements in the heavy-duty OBD regulation be deleted.

However, the updated detailed requirements in section 1969 only apply to 2013 and subsequent model year heavy-duty engines, while enhanced OBD systems are required on some 2010 through 2012 model year heavy-duty engines under the heavy-duty OBD regulation. For model years prior to 2013, section 1969 only requires heavy-duty manufacturers to make available information and tools they already currently provide to dealers and independent facilities. Thus, since heavy-duty manufacturers currently do not provide information regarding manufacturing of scan tools to perform the same functions as the non-generic scan tools, staff interpreted the requirements in section 1969 as saying heavy-duty manufacturers are not obligated to provide this information for the 2010 through 2012 model year engines. Accordingly, section 1969 is not redundant to the service information requirements of the heavy-duty OBD regulation and does not automatically supersede it. Further, with such a position, manufacturers could provide access only for their authorized dealers to the heavy-duty OBD fault information and deny access to all independent repair facilities. Given the intent of the heavy-duty OBD system is to achieve early identification of the presence of a malfunction and prompt repair, it would be inappropriate to allow manufacturers to restrict access only to authorized dealer facilities. Therefore, ARB staff is not deleting the current service information requirements in the regulation as manufacturers suggested to prevent this problem for 2010 through 2012 model year heavy-duty engines with OBD systems. These requirements are important to prevent the heavy-duty OBD program from getting off to a bad start. If repairs of OBD-related malfunctions can only be done by dealers (and not independent service facilities) during these first few years of heavy-duty OBD implementation, the overall intent of the program will be undermined and it could jeopardize the future acceptance of the system by the repair industry.

Though staff is not deleting the service information requirements, it agrees that some clarification is needed in what exactly is required for the 2010 through 2012 model years. There have been different interpretations among engine manufacturers about the language in section 1969. As stated above, while a few (including ARB staff) believe the language only requires manufacturers to sell tools they “currently” make available to the aftermarket (which would not include tools that perform OBD-related diagnosis), some engine manufacturers believe that the language requires the manufacturers to sell their diagnostic tools that perform the OBD and emission-related diagnosis and repairs to the aftermarket industry during this timeframe. Since the original intent of ARB's keeping the service information language was so that the aftermarket repair industry has a means to repair engines with HD OBD detected faults, staff agrees that this intent would be satisfied if manufacturers are indeed required to sell their tools to non-dealer repair facilities during this timeframe (which most of industry already says they are required to do). Thus, staff modified the service information language in the HD OBD regulation to make sale of a manufacturer's service tool to non-dealers a clear option for compliance.

V. PROPOSED REVISIONS TO HEAVY-DUTY OBD DEMONSTRATION TESTING REQUIREMENTS

Manufacturers are required to design and calibrate the OBD system to detect some malfunctions before specific emission thresholds are exceeded at any time within the full useful life of the engine. Depending on the size of the heavy-duty vehicle, the useful life can be 110,000 miles, 185,000 miles, or 435,000 miles. The current regulation requires manufacturers to conduct emission demonstration testing prior to certification to ensure that the systems are indeed able to detect faults before the thresholds are exceeded. And, to ensure the emission thresholds are not exceeded for the full useful life, ideally, the manufacturers would age the whole system (i.e., the engine and all emission controls) to full useful life and then verify the calibration for each fault is correct. However, ARB recognizes that manufacturers have limited experience, resources, and time to age the engine, engine emission controls, and aftertreatment to full useful life prior to certification, especially for engines subject to a 435,000 mile useful life. Additionally, manufacturers have traditionally claimed that engines and engine components deteriorate very little based on past experience, and that this trend is expected to continue. ARB, therefore, compromised in 2005 by allowing manufacturers to simply 'break-in' the engine and engine components by aging for 125 hours while requiring aging of only the aftertreatment to full useful life for demonstration tests. Further, since aging to accumulate the full mileage is time consuming, ARB also allows manufacturers to develop and use accelerated aging processes to simulate full useful life aging. Manufacturers would ideally develop and validate these processes with actual aged parts and are required to have these processes approved by ARB after a thorough review.

Even with ARB's compromise on the aging requirements, the manufacturers assert that they will not be able to create full useful life aged aftertreatment components or develop an accelerated aging process for the aftertreatment in time for the 2010 model year. Manufacturers cite the lack of time and experience in developing such a process and validating it with real data and the lack of experience with the new aftertreatment components in the field. Therefore, the manufacturers instead proposed a phase-in schedule that would allow for less rigorous aging to lower mileage goals in the initial years of implementation. Specifically, for the 2010 through 2012 model years, an engine manufacturer would age the aftertreatment to the level used to satisfy ARB certification requirements for determining the deterioration factor, whatever that intermediate mileage level for each manufacturer may be. For the 2013 through 2015 model years, an engine manufacturer would age the aftertreatment up to 185,000 miles. And finally, for the 2016 and subsequent model years, an engine manufacturer would age the aftertreatment to the current requirement of full useful life. Additionally, the manufacturers proposed that the scope of the aftertreatment aging be limited to 'key components' only, specifically the diesel oxidation catalyst, diesel particulate filter, NOx aftertreatment catalyst, oxygen sensors, and NOx sensors. The manufacturers' proposal also retained the requirement that the engine only be 'broken-in' with 125 hours and aging only be required of the aftertreatment.

After discussing engine manufacturers' progress towards meeting the 2010 emission standards and OBD implementation, ARB recognized that manufacturers are further behind than anticipated. Thus, ARB agrees that interim relief is appropriate to allow manufacturers to build up the knowledge and field experience with these new components to understand the extent of deterioration during useful life. However, staff does not believe the schedule or scope of the manufacturers' proposal really provides the necessary incremental steps towards a long term solution. The changes proposed by staff below are intended to focus on a successful long term solution and require manufacturers to meet interim requirements that are logical steps in the process.

While this discussion is specific to the allowed aging during demonstration testing, it is important to remember that manufacturers are liable in-use for proper detection of faults before the OBD emission thresholds are exceeded at any time during the useful life. If manufacturers do not properly account for all the synergistic effects and total system deterioration that occurs during useful life, they risk non-compliance and recall, fines, or other remedial action. Thus, from ARB's perspective, even for OBD monitor calibration purposes (not just demonstration testing), manufacturers need to (and are required and expected to) account for full useful life deterioration and base their calibration efforts on that. As is commonly done within the light-duty vehicle community, manufacturers are expected to develop engineering shortcuts and procedures to account for this full useful life performance. However, to be successful, these procedures have to accurately represent in-use deterioration and overall system performance. The only way a manufacturer can be sure that its procedure accurately represents in-use performance is to validate the systems (engine, engine component, and aftertreatment) created by their engineering procedures against actual full useful life (e.g., high mileage) systems.

Based on discussions with manufacturers and suppliers as they are progressing towards finalizing 2010 model year system designs, ARB is especially concerned about engine (and component) deterioration and its synergetic effects with the aftertreatment. Despite manufacturers' previous assertions that diesel engines and components deteriorate very little, ARB has seen fairly dramatic changes in diesel engines with control strategies and new components (including new EGR systems, EGR coolers, fuel injection system changes, turbo component changes, etc.) that operate in much more varied control points (e.g. near partial homogeneous charge compression ignition type operation with heavy EGR, tight air-fuel ratio control in specific regions). In light of such complicated system architecture and control strategies, previous conventions and knowledge about diesel engine and component deterioration no longer seem applicable.

Until experience is gained with high mileage evaluations and real world experience, it would be inappropriate to assume past deterioration characteristics will continue on these new systems. With this perspective, an engine aged for 125 hours (which is currently required by the OBD regulation) would not likely be representative of one at full useful life, so calibration or demonstration testing with such an engine would not provide assurance of OBD compliance throughout useful life. Additionally, manufacturers appear to have insufficient experience and knowledge to be able to accurately account for or predict the cumulative aging effects of the total system by simply aging a few “key” components of the aftertreatment (as manufacturers have proposed). ARB believes the only long term solution to get compliance assurance is to require manufacturers to generate high mileage systems and/or to collect and use data from real world high mileage systems to develop and validate accelerated aging procedures for the <u>entire</u> system (i.e., the engine, engine components, and aftertreatment system).

Thus, while agreeing that interim relief with lower aging mileage goals is appropriate, ARB is proposing to revise the requirements with a phase-in schedule containing higher interim goals than those proposed by the manufacturers. Additionally, for the reasons stated above, ARB believes that total system aging (engine plus the aftertreatment system) must be considered and is revising the requirements to achieve that in the long term.

For the 2010 to 2012 model years, the proposed changes would continue to allow the use of an engine aged for 125 hours. However, in lieu of requiring the aftertreatment system to be aged and validated as representative of full useful life, the changes would allow manufacturers to only age the individual aftertreatment components (e.g., PM filter, oxidation catalyst) and exhaust gas sensors (e.g., NOx, lambda sensors) to the manufacturer’s best estimates of useful life without the rigors of validation that would normally be required for ARB to approve the system as representative of full useful life. In discussions with manufacturers and suppliers, it appears fairly straightforward for manufacturers, in consultation with their suppliers, to identify the key aging mechanism (e.g., time at or above specific temperatures), to calculate expected operation over useful life in those key conditions, and to develop an accelerated aging process to condense that aging into a reasonable timeframe. Where these approaches fall short is in validation to real world operation that the estimates of expected operation were correct and/or whether other component deterioration altered the outcome. However, the manufacturer’s responsibility to validate the accelerated aging process would be waived for these model years.

In exchange for the relaxed requirements, a manufacturer would be required to collect and report in-use data from 2010 or later model year engines operated in the real world. The data collected would be from engines and systems operated for approximately 18 months or longer and with mileages equal to the full useful life for engines subject to 110,000 or 185,000 mile useful life and at least 185,000 miles for engines subject to 435,000 mile useful life. Such data collection by manufacturers would require removing real world aged systems (engine and aftertreatment) from vehicles, installing the systems on engine dynamometers, running various emission tests to quantify the system deterioration, and reporting the data to ARB late in the 2011 calendar year. For 2013 to 2015 model year engines subject to 110,000 or 185,000 mile useful life, a manufacturer would be required to use the knowledge gained from the collected data to modify (if needed) and validate its accelerated aging processes for ARB's approval. For 2013 to 2015 model year engines subject to 435,000 mile useful life, a manufacturer would also be required to use the collected data to validate and/or modify the accelerated aging procedure used in 2010 to better equate to real world deterioration, however, the manufacturer would still be allowed to use its best estimates for full useful life aging as the collected data would only allow validation up to 185,000 miles and not to the full useful life of 435,000 miles.

For engines subject to 435,000 mile useful life, manufacturers would additionally be required to collect data from 2010 or newer model year real world aged systems with mileage equal to 435,000 miles and report the data to ARB in the 2014 calendar year. Identical to the data collected at 185,000 miles, the manufacturer would be required to obtain high mileage systems, perform various emission tests to quantify and understand the deterioration, and incorporate that knowledge to refine and validate its accelerated aging procedures to be representative of full useful life and used for certification of 2016 and subsequent model year systems.

The following table summarizes the proposed requirements.

Table I: Phase-in aging data requirement schedule
for engine and aftertreatment

Year	Aging data required at certification for accelerated aging	
	Engine	Aftertreatment
2010-2012 model year	125 hours aging	Accelerated aged to best estimates of full useful life on aftertreatment components
Report in-use data in 2011	~18 months (for light and medium HDDE, full useful life, for heavy HDDE,185,000+ miles) real world aging data on 2010 model year engines	
2013-2015 model year	For light and medium HDDE: accelerated aging to full useful life validated with real world aging data For heavy HDDE: Best estimates for accelerated aging to full useful life incorporating 185,000 real world aging data	
Report in-use data in 2014	435,000 mile full useful life real world aging data on 2010 or later model year engines	
2016 model year and after	Accelerated aging to full useful life validated with real world aging data	

Manufacturers had requested that ARB adopt the same proposed procedures that U.S. EPA is currently developing for determining deterioration factors (DFs) in lieu of staff's proposal. Specifically, U.S. EPA's plan would require manufacturers to do partial aging of the engines (i.e., not require aging to full-useful life) and extrapolation of the emission data to determine the projected emission levels at full useful life. While partial aging may be appropriate for determining the likely emission levels of non-malfunctioning engines at useful life, it is not appropriate for projecting emission levels of engines with emission-related malfunctions. As previously stated, manufacturers are liable in-use for proper detection of faults before the OBD emission thresholds are exceeded at any time during the full useful life. To accurately determine how high emissions will be when a malfunction occurs, the performance level of the engine and aftertreatment system aged to full useful life must be taken into consideration. For example, to accurately calibrate an EGR system monitor to the emission threshold, the manufacturer must know how much of the increased engine-out NOx emissions caused by a malfunctioning EGR system is going to be cleaned up by the downstream SCR system at full useful life. This determination cannot be "extrapolated" by implanting a fault at low mileage and measuring the reaction of a low mileage SCR system. Accordingly, staff has rejected the manufacturers' suggestion to mimic EPA's DF determination process and continue down the path of requiring manufacturers to develop validated rapid aging procedures to simulate full useful life aging.

In addition to the aging requirements, staff is also proposing modifications to the malfunction simulation methods. Currently, the regulation allows manufacturers to electronically simulate malfunctions (e.g., use of an external simulator) but does not allow them to make modifications to the electronic control unit (on-board computer) except for a few limited monitors. In general, staff has severely limited the use of internal computer modifications because it results in special software (non-production intent) to run the demonstration tests and increases the risk that the system will perform differently with the special software than it would with the actual production intent software. However, given the wide variety of technologies and strategies being implemented by diesel manufacturers, staff believes there may be additional cases that arise where it is not technically feasible or very expensive, difficult, and resource-intensive to implant faults through hardware or an external simulator. Accordingly, the proposal includes a provision for manufacturers to request and receive ARB approval to use internal computer modifications for additional monitors upon demonstration or analysis that it is infeasible or disproportionally difficult and resource intensive to implant the fault externally. Further, the proposal clarifies that, in cases where a manufacturer elects to electronically simulate a fault through an external simulator or internal computer modifications, the manufacturer must demonstrate that the failure characteristics produced by the simulation are equivalent to an induced hardware failure. This ensures that manufacturers are calibrating and designing the monitor to detect failures that are related to actual hardware malfunctions and not purely theoretical or idealized simulations of a fault.

Staff is also proposing modifications concerning the actual testing process. The current requirements were primarily copied from the test procedure for light-duty vehicles, however, recent discussions with manufacturers have revealed some fundamental differences in how heavy-duty emission tests are run. Unlike light-duty, the heavy-duty test procedure does not include a ‘preconditioning’ cycle the day before the emission test. To be consistent with the current heavy-duty test procedures and to eliminate unnecessary extra testing, the proposed amendments would eliminate the preconditioning cycle and require manufacturers to implant the fault and immediately perform the emission test. Further, because the previous test procedures anticipated the use of a preconditioning cycle, the procedure expected that the fault would be detected once during the preconditioning cycle and a second time during the first engine start of the emission test. In conjunction with eliminating the preconditioning, the language was modified to expect the fault to be first detected on the first engine start of the emission test and detected a second time during the second engine start of the emission test. The proposed language does still allow a manufacturer to request approval to use preconditioning cycles if technically justified to stabilize the emission control system. While manufacturers have not yet identified a need for this provision, it will be in place in case future emisison controls require such stabilization.

Lastly, staff is also proposing modifications to the data collected during demonstration testing. The current regulatory language requires specific fault information (i.e., time after start when the MIL illuminated, fault code(s), freeze frame information, test results) to be collected. Staff is proposing that manufacturers also be required to collect other OBD electronic information as well, including readiness status, current data stream values, CAL ID, CVN, VIN, in-use performance ratios, and engine run time tracking data. Furthermore, staff is also proposing that manufacturers be required to collect all the test data immediately prior to or after each engine shut-down, such as at the end of the preconditioning cycle (if used), cold start FTP cycle, and warm start FTP cycle. By analyzing this data when reviewing the demonstration test results, staff will be able to better understand the scenario of events and ensure that the standardized data is outputting expected values during the test sequence. Historically, in testing done at ARB's facility, review of such data has identified many other small issues and having this data at the time of certification would allow identified issues to be corrected sooner.

VI. PROPOSED REVISIONS TO HEAVY-DUTY OBD CERTIFICATION REQUIREMENTS

### A.	CERTIFICATION APPLICATION

Based on the staff's review of manufacturers' OBD II applications in the past years, minor changes are being proposed to the HD OBD certification submittal requirements to expedite the OBD review and approval process. Specifically, the proposed amendments would require some information, including a checklist, the summary table, and misfire monitor disablement data, to be submitted in a standardized format that will be detailed in a future ARB mail-out to facilitate consistent and quick review by staff (the specific mail-out number will be made available at the Board Hearing and as part of the subsequent 15-day changes to the regulations). Staff is also proposing to require manufacturers to submit data supporting their infrequent regeneration adjustment factors and information regarding EI-AECDs. Lastly, the staff is also proposing to require manufacturers to include a cover letter with each OBD application identifying the deficiencies and concerns (if any exist) that apply to the equivalent engine family or OBD group in the previous model year and the changes and/or resolution of each concern or deficiency for the current model year. This would allow the ARB staff to spend less time determining if past problems have been corrected.

### B.	IN-USE COMPLIANCE TESTING

As a condition for certification, manufacturers would be required to perform in-use compliance testing on their own engines. The actual procedures are detailed in the proposed enforcement regulation (§1971.5) and would require manufacturers to procure actual in-use engines, at roughly 75 percent of full useful life mileage, and perform a series of engine dynamometer emission tests to confirm the OBD system will detect faults at the emission levels specified in the HD OBD regulation (§1971.1). ARB has previously adopted similar requirements for manufacturers to do their own in-use compliance testing. This includes the "CAP 2000" program adopted for light-duty vehicles that sets forth in-use compliance requirements and procedures in the test procedures incorporated by Cal. Code Regs., title 13, section 1961 and requires manufacturers to procure in-use vehicles, at various mileages, and perform emission tests to verify compliance with the tailpipe standards established in section 1961. It also includes the heavy-duty on-road manufacturer in-use compliance testing program in test procedures incorporated by Cal. Code Regs., title 13 sections 1956.1 and 1956.8 that requires manufacturers to procure in-use vehicles, equip them with emission measurement devices, and collect emission data to verify compliance with the not-to-exceed (NTE) tailpipe standards established in sections 1956.1 and 1956.8. Cal. Code Regs., title 13, section 2438 establishes a manufacturer in-use testing program for large spark-ignition engines with greater than 1.0 Liter displacement. Similar to what is proposed for HD OBD compliance, this program requires manufacturers to procure a number of in-use engines with a minimum mileage, perform emission tests to verify compliance with the established tailpipe standards, perform further testing if initial tested engines fail, and ultimately, generate sufficient data to determine if the engines do not comply and if remedial action is warranted. Another similar program exists for spark-ignition engines used in personal watercraft and outboard marine engines in Cal. Code Regs., title 13, section 2444.1 and requires manufacturers to procure in-use engines and perform emission testing to verify compliance with the established emission standards. Further, in the HD OBD (§1971.1(l)) and the OBD II (§1968.2(j)) regulations, manufacturers are also required to do other forms of production vehicle or engine evaluation testing to confirm various elements of their OBD systems comply with the certification standards and procedures established within the regulations themselves.

In all of the above examples, the requirements are indeed mandatory requirements that apply to the manufacturers of applicable vehicles and engines. EMA has argued that the heavy-duty in-use compliance program is not a valid confirmation of ARB's authority to adopt similar requirements for HD OBD compliance because manufacturers agreed to do such testing during discussions and settlements in 1998 that ended with consent decrees to resolve engines produced in the 1990's that allowed the engines to comply with emission limits under certification conditions but caused significantly higher NOx emissions during highway driving. However, not all engine manufacturers were part of the settlements and consent decrees yet all manufacturers are now required to do the in-use compliance testing. In any case, this and the other programs cited above are not optional requirements or voluntary agreements entered into by the manufacturers with ARB. It is both consistent with past and current practice of ARB to have manufacturers do some form of self-testing for verifying compliance with adopted standards.

VII. PROPOSED REVISIONS TO HEAVY-DUTY OBD STANDARDIZED METHOD TO MEASURE REAL WORLD MONITORING PERFORMANCE

Currently, the HD OBD regulation requires manufacturers to track monitor performance by counting the number of monitoring events and the number of driving events. The number of monitoring events is defined as the numerator and the number of driving events is defined as the denominator. The ratio of these two numbers is referred to as the monitoring frequency and provides an indication of how often the monitor is operating relative to vehicle operation. It is important to note that the denominator is a measure of vehicle activity, not a measure of "monitoring opportunities". The regulation requires manufacturers to design monitors that meet a minimum acceptable ratio, currently set at 0.1 for 2013 and subsequent model year engines.

The current requirement for incrementing the general denominator is:

1.) minimum engine run time of 10 minutes;
2.) minimum of 5 minutes, cumulatively, of vehicle operation at vehicle speeds greater than 25 miles-per-hour (mph) for gasoline engines or calculated load greater than 15 percent for diesel engines; and
3.) at least one continuous idle for a minimum of 30 seconds encountered; and the above three conditions met while:
4.) ambient temperature above 20 degrees Fahrenheit and
5.) altitude of </= 8000 feet.

Industry has expressed concerns that some monitors may not execute on the denominator drive cycle defined above and, therefore, some vehicles may exhibit poor in-use ratios. However, industry has erroneously reached the conclusion that the denominator represents a drive cycle during which all monitors must be executed. On the contrary, manufacturers are not required to design monitors to execute during the denominator drive cycle but are required to design robust monitors that perform frequently in-use. Monitors are designed to run when specific engine operating conditions are met—not when a specific drive cycle is met—and the occurrence of those conditions happens independent of whether a denominator drive cycle is met. For example, a case may exist where a monitor never executes on the denominator cycle but the minimum in-use frequency ratio may still be satisfied because the monitor executes frequently on other drive cycles. The purpose of the denominator is not to provide industry with a drive cycle by which to run all monitors but to provide ARB with a measure of vehicle activity.

Additionally, industry has requested changes in the definition of the denominator drive cycle. When the HD OBD regulation was adopted in 2005, diesel engine manufacturers indicated that they did not always have access to vehicle speed and thus, could not determine when a vehicle had spent five cumulative minutes above 25 mph. As an alternative, they proposed, and ARB accepted, five minutes above 15 percent engine load for diesel engines. At this time, however, diesel engine manufacturers have now indicated that 15 percent engine load is not a consistent indicator from engine to engine, since it could be satisfied at idle on some engines while it is satisfied with operation somewhere above 25 mph on other engines. Diesel engine manufacturers now propose greater than 50 percent calculated load for five cumulative minutes in lieu of greater than 15 percent for five cumulative minutes. Further, for those engines that do have access to vehicle speed, industry has requested permission to alternatively use the gasoline engine parameter of greater than 25 mph for five cumulative minutes on diesel engines in lieu of the greater than 15 percent load.

Regarding the denominator drive cycle, ARB's objective is to provide a common definition because manufacturers will be held to the same minimum in-use frequency ratio based on this definition and the use of different definitions would lead to inequity among manufacturers. Under the current regulation, while gasoline and diesel engines do not use the same definition, all diesels are required to use a consistent definition and all gasoline are required to use a consistent definition. This consistency among similar engines is imperative to ensure equivalent stringency in requirements among manufacturers and must be maintained. However, staff agrees that the 15 percent engine load criterion is inappropriate as a consistent measure of engine work or vehicle activity. To address industry's concern and maintain commonality, staff is proposing to change this definition to exclude the calculated load parameter and instead include five cumulative minutes of engine speed at or above 1150 rpm for diesel engines. Staff believes 1150 revolutions-per-minute (rpm) represents an engine speed above idle in virtually all engines and is a positive indicator that the engine is being used to do work (e.g., move the vehicle, operate a substantial power take-off unit). Many engines have peak torque that occurs at 1200 rpm and above and most manufacturers' engines are subject to the not-to-exceed emission standard at engine speeds above 1150 to 1200 rpm. And, whenever the engine is doing work, it is vital that the emission controls are working properly so basing an in-use monitoring frequency relative to how often the engine is being used to do work is appropriate. Further, all manufacturers have access to engine speed and could accurately determine when this criteria was satisfied. With the 2010 model year production fast approaching, however, staff believes some lead time is necessary and is allowing 2010 through 2012 model year diesel engines to use the 15 percent calculated load criterion. Additionally, to maintain consistency of the denominator definition and equality among manufacturers, staff does not agree with manufacturers' request to optionally use the vehicle speed criterion in lieu of the engine speed or load criterion.

In addition to the proposed changes to the general denominator definition above, staff is proposing a separate denominator for PM filter monitoring. Currently, the regulation allows manufacturers to submit proposed criteria for incrementing the PM filter monitor denominator for ARB approval. Since the adoption of the requirement, staff has gained enough knowledge from discussions with engine manufacturers to propose specific criteria for the PM filter monitor, which engine manufacturers have indicated will most likely be tied to PM filter regeneration events. Thus, in addition to meeting the general denominator on at least one driving cycle, staff is proposing that the PM filter denominator be incremented after 750 minutes of cumulative engine run time. The basis for 750 minutes is calculated starting from a 300-500 mile interval that industry has indicated is typical of distance between PM filter regenerations and assuming an average vehicle speed of 40 mph (500 miles / 40 mph = 12.5 hours = 750 minutes).

The proposed revised definition for the general rate-based denominator for diesel engines is:

1.) minimum engine run time of 10 minutes;

2.) minimum of 5 minutes, cumulatively, of engine operation with engine speed at or above 1150 rpm; and
3.) at least one continuous idle for a minimum of 30 seconds encountered; and the above three conditions met while:
4.) ambient temperature above 20 degrees Fahrenheit and
5.) altitude of </= 8000 feet.

The proposed definition for the PM filter rate-based denominator is:

1.) minimum of 750 minutes of cumulative engine run time since the last time the PM filter denominator was incremented and
2.) meeting the above requirements for the general denominator on at least one driving cycle.

For the PM filter denominator, the proposed language also provides clarification regarding tracking the order of events when determining the criteria have been met. Specifically, the language identifies methods to first identify on a particular key start if a general denominator has been satisfied and subsequently to then determine if the cumulative engine run time has been satisfied. The language also provides direction to manufacturers on when the cumulative engine run time counter must be restarted.

Staff is also proposing to modify the definition of “idle” operation (which is also referred to in the permanent fault code erasure requirements and the standardization tracking requirements of the regulation). “Idle” operation is currently defined as conditions where vehicle speed is less than or equal to one mph, among other criteria. As indicated above, some manufacturers have indicated that their engines do not utilize vehicle speed information and thus, cannot sense vehicle speed. They further indicated that engine speed is an acceptable surrogate to use to determine idle operation. Thus, ARB is proposing to define idle operation as conditions where, among other criteria, either the vehicle speed is less than or equal to one mph or engine speed is less than or equal to 200 rpm above the normal warmed-up idle speed.

VIII. PROPOSED REVISIONS TO OBD II REGULATION

At the request of medium-duty diesel manufacturers in order to maintain consistency between the HD OBD and OBD II diesel requirements, staff is proposing to carry over almost all of the proposed diesel-related changes mentioned above for the HD OBD regulation to the OBD II regulation, applying them to light- and medium-duty diesel vehicles. The only difference between what would be proposed for light-duty diesel vehicles versus medium-duty diesel vehicles is that any of the proposed changes related to modification of the specific malfunction emission threshold values would only apply to the medium-duty diesel vehicles. The specific proposed changes to the OBD II regulation can be found in Attachment B.

Additionally, staff is proposing one change to the gasoline monitoring requirements in the OBD II regulation concerning the phase-in schedule for primary oxygen sensor response rate monitoring data submission. Currently, manufacturers are required to submit data and/or engineering analysis to demonstrate that their oxygen sensor monitors are able to detect all asymmetric and symmetric response rate malfunctions with a phase-in starting with the 2010 model year. However, recent discussions with manufacturers indicate that more time is needed to meet this requirement. Thus, staff is delaying the start of the phase-in from the 2010 model year to the 2011 model year, with all vehicles required to meet this requirement for the 2013 and subsequent model years.

IX. PROPOSED HEAVY-DUTY OBD ENFORCEMENT REGULATION

A. OVERVIEW

The staff is proposing that the Board adopt a comprehensive in-use enforcement protocol that applies specifically to the HD OBD requirements (Cal Code Regs., title 13, §1971.1), pursuant to the Board's general and specific authority to adopt procedures that ensure compliance.[2] The proposed HD OBD enforcement provisions would help ensure the effectiveness of the HD OBD regulation and the underlying more stringent emission standards that have been adopted for 2010 and subsequent model year heavy duty engines. Among other things, the staff is proposing procedures for the in-use testing of HD OBD systems installed on heavy-duty engines. The proposal would further provide the Executive Officer with authority to order engine manufacturers to take remedial action when in-use testing indicates that an HD OBD system within an identified engine class does not meet the certification requirements of Cal. Code Regs., title 13, section 1971.1.

The staff believes that specific HD OBD enforcement provisions are necessary to better address and identify the special circumstances involved in in-use testing and remedying identified nonconformities with HD OBD systems. Past experience in light- and medium-duty revealed that the general enforcement procedures (Cal. Code Regs., title 13, §2111-2135), which were specifically adopted to enforce noncompliance with tailpipe and evaporative emission standards, do not allow for effective enforcement of OBD requirements and standards. The general enforcement procedures do not neatly apply to OBD regulations for two main reasons. First, the OBD regulations include both emission standards and other non-emission-related requirements, such as test procedures and standardization requirements. Second, OBD systems are comprehensive and exceedingly complex; and, consequently, in-use enforcement of OBD systems involves a myriad of issues that do not arise in the enforcement of tailpipe and evaporative emission standards. Over time, it became apparent that the simplified general enforcement approach used for tailpipe noncompliance did not adequately address the unique issues involved in the in-use operation of OBD systems.

In 2002, the Board adopted stand-alone specific enforcement procedures for the OBD II requirements (codified at Cal. Code Regs., title 13, §1968.5). Since adoption of the

[2] Health and Safety Code, sections 39600, 39601, 43013(b), 43018, 43102, 43104, and 43105.

enforcement regulation, ARB has applied its detailed protocols in addressing OBD II noncompliance. In general, the procedures provide for straight-forward evaluation and remediation (where necessary) of complex, OBD II-specific in-use issues. The detailed protocols have also provided clear direction to manufacturers as to the procurement, testing, sampling, and evaluation criteria that ARB staff uses to determine compliance with the OBD II requirements and has eliminated many uncertainties for manufacturers related to the procedures that ARB will follow in carrying out enforcement and the criteria ARB will use in determining compliance and appropriate corrective action. Further discussion about the need for an OBD specific enforcement procedure can be found in the staff report for the 2002 OBD II Board hearing available at ARB's website (http://www.arb.ca.gov/msprog/obdprog/pastregs.htm) and incorporated by reference.

During the 2005 HD OBD rulemaking process, staff indicated its intent to return to the Board with a proposal to adopt similar independent enforcement provisions for HD OBD. To that end, staff is now proposing adoption of section 1971.5, which would establish enforcement procedures and requirements for heavy-duty engines with HD OBD systems. It is ARB staff's goal that the regulation becomes effective prior to implementation of HD OBD system requirements, which commence with the 2010 model year.

The proposed HD enforcement procedures are similar in comprehensiveness to those currently required for light-duty and medium-duty vehicles under the OBD II regulation. Both regulations include performance testing of emission-related monitors, downloading of data of in-use performance monitoring ratios, and evaluation of other OBD requirements (e.g., diagnostic connector location, communication protocol standards, MIL illumination protocol, etc.). But there are distinct differences, primarily because heavy-duty engines are certified on engine dynamometers and the testing of emission-related monitors on HD OBD systems will require the removal of engines from in-use vehicles for testing. Accordingly, the proposed regulation provides that, in addition to ARB-initiated enforcement testing, engine manufacturers will be responsible for compliance self-testing of OBD systems to ensure that the systems in-use actually meet certification requirements.

One of the reasons manufacturer self-testing is necessary is because of the uniqueness of engine dynamometer testing. Unlike chassis dynamometer testing of the complete vehicle as is done in light-duty and can easily be replicated by ARB, manufacturers, and independent laboratories, engine dynamometer set-up and testing differs for each engine and involves the use of custom parts, modifications, and configurations. Because the engine is removed from the vehicle, various inputs and outputs to the engine control computer must be generated to simulate operation in a vehicle. Further, many engine components especially heat exchangers like the radiator, charge air cooler, and EGR cooler that rely on outside airflow (that would occur through the front of the engine compartment while driving on the road) must be removed and simulated because there is no comparable source of outside airflow in the test cell. Such simulations vary from manufacturer to manufacturer and engine model to engine model because they must duplicate the performance applicable to those components for that particular engine in a specific vehicle type. Some manufacturers have also indicated that certain software functions or features within the engine control unit must be disabled during engine dynamometer testing to prevent abnormal operation due to specific engine dynamics that occur during testing and disablement of such features requires manufacturer-specific tools and hardware to implement. Without intimate knowledge of all the individual component specifications and input and output signals, not to mention custom hardware and software to replace the removed components, or tremendous reliance on the voluntary cooperation and resources of the engine manufacturer, successful engine dynamometer testing is very difficult to perform. Engine manufacturers, who routinely perform engine dynamometer testing of their own engines, including testing for research, development, and tailpipe certification, have, by definition, the knowledge and equipment necessary to perform engine dynamometer testing.

B. THE NEED FOR HD OBD-SPECIFIC ENFORCEMENT PROCEDURES

The staff believes that specific HD OBD enforcement provisions are necessary to better address and identify the special circumstances involved in in-use testing and remedying identified nonconformities with HD OBD systems. As stated, experience with OBD II has revealed that the existing general enforcement procedures, which were specifically adopted to enforce noncompliance with tailpipe and evaporative emission standards, do not allow for effective enforcement of OBD requirements and standards. For example, the adoption of OBD II-specific enforcement provisions helped clarify that a manufacturer cannot escape liability for failing to comply with the OBD II standards and requirements by demonstrating that vehicles with the nonconforming OBD II system, on average, comply with certification standards for tailpipe and evaporative emissions. The OBD II emission standards and requirements serve very different purposes from the tailpipe and evaporative emission standards, and compliance with the latter two standards should not excuse noncompliance with the former.

As with OBD II, to allow a heavy-duty engine manufacturer to overcome the need to remedy a nonconforming HD OBD system by showing that the failure would not result in the engine class, on average, to fail to conform to the tailpipe emission standards would undermine the purpose and intent of the
HD OBD requirements. In adopting the HD OBD regulation, the Board specifically determined that functional OBD systems were necessary and should be equipped on all heavy-duty engines in the future. In so determining, the Board found that functional OBD systems are a vital complement to the success of the ARB's heavy-duty engine emission reduction programs. The HD OBD system is intended to insure that 2010 and subsequent model year engines meet the adopted tailpipe emission standards in-use. The HD OBD systems are there to ensure that forecasted emission reductions will be achieved, and the proposed enforcement provisions are necessary to ensure that the adopted HD OBD requirements are fully effective in-use.

C. AUTHORITY TO ADOPT ENFORCEMENT PROCEDURES

Depending upon the nature of the nonconformity of the HD OBD system and the circumstances surrounding the nonconformity, recall may be an appropriate remedy. Health and Safety Code section 43105 authorizes the Executive Officer to order recalls, if a manufacturer has violated emission standards or test procedures and has failed to take corrective action. The HD OBD regulation, Cal. Code Regs., section 1971.1, establishes both emission standards and test procedures for certification to those standards. The ARB expressly adopted the HD OBD regulation pursuant to authority granted by the Legislature to adopt and implement emission standards and test procedures under the Health and Safety Code.[3] In 2000, in adopting Senate Bill 1146, the Legislature expressly recognized ARB's authority to adopt OBD regulations, finding that OBD requirements are emission standards, stating:

> Recent emission standards adopted and implemented by the State Air Resources board for motor vehicles manufactured after 1993 have resulted in the development by vehicle manufacturers of "on board diagnostic computers" that interface with the many component parts of a vehicle's emission control system. (Stats. 2000, Ch. 1077, Sec. 1; emphasis added.)

Similarly, in granting California a waiver of federal preemption for the OBD II regulation, pursuant to section 209(b) of the federal Clean Air Act, the U.S. Environmental Protection Agency (U.S. EPA) expressly found that the requirements of the California OBD II regulation were emission standards, stating.

> OBD requirements appear to be closer in their application and effect to standards than to enforcement procedures: they establish specific levels of emissions that beyond which the MIL must be illuminated and fault codes be stored; they create direct requirements on the manner in which manufacturers build their vehicles; the OBD II requirements set forth how a vehicle must operate at time of certification and in use, and not how the state would ensure that the vehicle is operating properly as is typical of an accompanying enforcement procedure.

Beyond being emission standards, the HD OBD regulation sets forth specific test procedures that manufacturers must follow to assure certification and compliance to the established standards. Accordingly, Health and Safety Code section 43105 expressly authorizes the ARB to adopt regulations regarding corrective actions, including recall, that the Board may take for violations of the OBD II emission standards and the test procedures established to certify vehicles to those standards.

In addition to the express authority of Health and Safety Code section 43105 to adopt enforcement procedures, the Board has unmistakable implied authority to adopt such regulations. The general powers granted to the Board in Health and Safety Code section 39600 provide that the Board shall do such acts as may be necessary for the proper execution of the powers and duties granted to it. The OBD II requirements were

[3] See Health and Safety Code §§ 43013, 43018, 43101, 43104, and 43105.

adopted pursuant to general authority granted under sections 43013, 43018, and 43101 among others. Specifically, sections 43013(a) and 43101 authorize the Board to adopt and implement motor vehicle emission standards. And section 43018 directs the Board to take whatever actions are necessary, cost-effective, and technologically feasible in order to achieve specific emission reductions, including the adoption of standards and regulations that will result in, among other things, reductions in motor vehicle in-use emissions through improvements in emission system durability and performance.

Although the Legislature did not expressly authorize the adoption and implementation of OBD II requirements, the Legislature recently gave its imprimatur to the regulation.[4] Having implicitly authorized the Board to adopt the OBD II regulations in furtherance of the Board's mission, it cannot reasonably be argued that the Legislature has not also entrusted the Board with authority to properly enforce the adopted standards and test procedures to ensure compliance.[5]

Such authority would extend to the requirements discussed below that require manufacturers to self-test HD OBD emission threshold monitors so long as those requirements do not impose a significant economic burden on manufacturers and are cost-effective. As stated manufacturers are in the best position, with specialized knowledge of how they tested engines for certification on the dynamometer and convenient access to the engine parts that enable accurate testing, to perform such self-testing. As explained below in the economic cost section, the enforcement self-testing provisions would not impose an excessive economic burden on manufacturers, and effective and accurate dynamometer testing that ensure that OBD systems work correctly and that forecasted emission reductions are achieved is unquestionably cost-effective.

D. SUMMARY OF THE HD OBD COMPLIANCE/ENFORCEMENT REGULATION

1. General

The main differences between the OBD II enforcement procedures and those proposed here for HD OBD involve non-compliance related to monitors exceeding the OBD emission malfunction thresholds (e.g., verifying that the fault is detected before emissions exceed 2.0 times the applicable tailpipe standard). The differences include the criteria that would need to be met for ARB to assume non-compliance and require further enforcement testing, and the specific testing procedures that would need to be carried out. For light-duty enforcement under the OBD II regulation, the enforcement protocol relied heavily on well established vehicle procurement, screening, and testing procedures used for tailpipe emission compliance testing. No such detailed protocol exists for heavy-duty OBD testing. To a large extent, the proposed procurement and selection process parallels the recently established procedures that EPA, ARB, and

[4] See section 43105.5(a)(4), Stats. 2000, Ch. 1077, Sec. 4; see also Sec. 1.

[5] See *California Drive-In Restaurant Ass'n* v. *Clark* (1943) 22 Cal.2d 287, 302 [140 P.2d 657], "the authority of an administrative board or officer, . . . to adopt reasonable rules and regulations, which are deemed necessary to the due and efficient exercise of the powers expressly granted, cannot be questioned."

manufacturers agreed to for the manufacturer self-testing for tailpipe emission compliance using portable emission measurement systems.

The proposed regulation provides that ARB may conduct enforcement testing for emission threshold noncompliance by procuring engines from in-use vehicles and testing them on an engine dynamometer in accordance with the procurement, selection, and testing criteria noted above. ARB, however, has very limited experience with such testing and no existing facilities capable of conducting such testing of heavy-duty engines. To address this issue, the proposed regulation would also require manufacturers to perform self-testing for compliance on a limited number of engines each year.

For each engine tested by the manufacturer, if the faults are detected prior to the prescribed emission levels being exceeded, the testing is completed. However, if initial testing indicates that the system fails to detect one or more faults before emissions exceed the emission thresholds of Cal. Code Regs., section 1971.1, the manufacturer would be required to procure, select, and test four more engines from the same engine family for that specific monitor. And, if two or more of the additional four engines fail, an additional five more engines are to be procured for testing of the failing monitor. At most, a manufacturer would have to test 10 engines from the same engine family. For both testing done by ARB and by the manufacturer, the monitor would be judged noncompliant if five or more of the 10 tested engines failed to detect the fault before the appropriate emission threshold is exceeded.

Manufacturers have argued that it is inappropriate to require them to do their own compliance testing and that ARB has no authority to require them to do testing beyond certification. As previously indicated, staff disagrees as ARB clearly has authority to adopt test procedures, including in-use compliance testing, as part of the certification process to ensure that its regulations are met and there is no restriction that such procedures are limited to items that are conducted prior to certification. Further, ARB clearly has authority to adopt enforcement regulations and procedures to be used on engines and vehicles after certification and there is no restriction that these procedures be carried out exclusively by ARB.

Staff did consider alternatives to the manufacturer self-testing element and to the engine dynamometer testing. Staff looked into various methods to contract out for and perform engine dynamometer testing. However, as noted above, engine dynamometer testing requires very detailed knowledge about the engine and often requires custom equipment or parts created by the manufacturer themselves to successfully conduct a test (e.g., water to air coolers to simulate on-vehicle air-to-air coolers, simulations of vehicle or transmission outputs to enable the engine to operate over the required speed and load regions). Engine manufacturers are uniquely qualified to test their own engines at a substantial economic savings relative to anyone else. Staff investigated methods to develop a ‘screening’ test of some sort using portable emission measurement systems (PEMS) which would allow testing while the engine is still in the vehicle. If such a method could identify whether an engine would likely pass or fail, then only engines that are more likely to fail could be sent on to engine dynamometer based testing for the ultimate compliance decision. Unfortunately, several complications were encountered that, at this time, render such a screening test infeasible. Staff has discussed this with industry and has indicated it is still open to suggestions that evolve in the future. And, because the first engines won't need to be tested until 2013 calendar year, there is significant time between now and then for more ideas to surface and be considered during a future biennial review. Should such an idea surface and need to be used before a future biennial review can incorporate it, language is included in section 1971.5 to allow the Executive Officer to accept alternative testing procedures upon the manufacturer demonstrating they will provide an equivalently robust determination as to the compliance of the OBD system on the engine.

2. ARB Conducted Testing

The structure of the proposed regulation is similar in many respects to the OBD II enforcement regulation, especially as it applies to the testing of OBD systems that would occur while the engine is installed in the vehicle. Under the proposed regulation, the ARB staff could elect to periodically evaluate engines from any certified engine class. It would be directly responsible for enforcement testing of all HD OBD requirements other than the testing of emission-related monitors, which require engine dynamometer testing. For example, ARB staff would conduct enforcement for testing of in-use performance monitoring ratios and other non-emission-threshold related requirements. For such non-emission related testing, the protocols that the ARB would use would closely follow the OBD II protocols for procuring, testing, and determining compliance of OBD systems. Additionally, ARB could elect to conduct testing on emission-threshold monitors that require engine dynamometer testing at an independent laboratory or at an ARB facility, but such testing is expected to be limited due to the difficulties in conducting such testing and lack of an ARB testing facility.

The proposed procedures set forth detailed provisions on how ARB will conduct testing, including, among other things, how the staff would initially determine the scope of engines (the engine class) to be tested, the number of engines to be tested (i.e., the size of the test sample group), and the type of testing to be conducted. As indicated, ARB enforcement testing would be grouped into three different categories depending on the nature of the OBD II noncompliance issue to be tested. Specifically, the protocol proposes that separate guidelines and procedures be followed for in-use performance ratio testing, "other" HD OBD testing, and testing of emission-related threshold monitors.

For OBD ratio testing, ARB staff would collect data from a test sample group of 30 engines that have been properly procured and selected. In determining compliance with other requirements that do not require emission testing, the staff would determine, on a case by case basis, the number of engines needed to ensure that the results of such testing may be reasonably inferred to the engine class. The determination would be based upon the nature of the nonconformance and the scope of the engine class. The test sample group could be as few as two test engines. For OBD emission testing, the ARB staff would follow the provisions of Cal. Code Regs., title 13, section 2137 regarding test sample size. In accordance with section 2137, the staff would test 10 engines that have been properly procured and selected.

The ratio testing procedures would be used when the in-use monitor performance is tested for compliance with the minimum acceptable in-use monitor performance requirements (i.e., does the monitor run often enough?). In cases where the monitor being tested has a ratio that is required to be tracked and reported to a scan tool in standardized manner, the actual ratio testing of procured vehicles would be a rather expeditious and straightforward process. The "testing" of the 30-plus engines would be as simple as electronically downloading the stored data from the engines with a diagnostic tool (e.g., an OBD scan tool).

For testing of monitors that are required to meet the ratio but are not required to track the data in the on-board computer or report it in a standardized manner, the process would be lengthier and slightly more involved. In these cases, rather than downloading information stored in the on-board computer, each test engine would be equipped with instrumentation that would record and collect engine activity data and diagnostic activity. Each test vehicle would then be returned to the vehicle operator for accumulation of data. After collection of sufficient data (the same amount of data as required for the ratios that are tracked and reported), the data would be analyzed to determine the ratio for the tested monitor for each engine. This method is directly analogous to that used for the ratios that are required to be tracked and reported in the on-board computer by effectively tracking and reporting the ratio in an "off-board" computer (i.e., the instrumentation attached to the engine).

Testing of HD OBD requirements other than rate-based monitoring or emission testing would be determined on a case-by-case basis because of the myriad of different requirements included in this residual category and the many nuances of the complex systems that they regulate that may affect some aspects of the system performance. Given this complexity, it is impossible to predict every possible permutation or noncompliance that might occur in the future. As such, it is impossible to prescribe exact test procedures that will adequately address every possible noncompliance scenario. For example, a problem could be as simple as a system not complying with the MIL display requirements (e.g., using an incorrect symbol or wording instead of the required engine symbol on the dashboard light). The noncompliance would likely be confirmed by using a visual examination of the procured vehicles. On the other hand, the problem could be complex such as the inability of the HD OBD system to properly detect malfunctioning thermostats that cause the engine to warm up too slowly. Such a malfunction could cause a vehicle to have increased emissions and/or cause the disablement of other diagnostics. In contrast to the first example, testing could not be conducted to confirm noncompliance by performing a visual inspection but would require implanting of a faulty thermostat and operation of the vehicle in various ambient and driving conditions to ensure the manufacturers' disclosed monitoring conditions have been satisfied, all while recording results and data with an off-board tool. Accordingly, for the "other" HD OBD testing category, the proposed regulation defines general guidelines to be followed by the staff when conducting testing in this area. The Executive Officer would have discretion to determine, on a case-by-case basis, the most appropriate procedures for selection and testing of vehicles based on the nature of the noncompliance and the projected number of affected engines. The Executive Officer would be required to provide notice of the selection and testing procedures to the manufacturer of the engines subject to such testing (see discussion below).

The HD OBD emission testing procedures would be used when the measurement of tailpipe emission levels relative to the tailpipe emission standards is essential to determining system compliance. Emission testing for HD OBD compliance is comprised of two distinct parts: (1) emission testing in accordance with the test procedures used by the Executive Officer for in-use testing of compliance with tailpipe emission standards in accordance with Cal. Code Regs., title 13, sections 2138 and 2139; and (2) on-road and/or dynamometer testing with the engine being operated in a manner that reasonably ensures that all of the monitoring conditions disclosed in the manufacturer's certification application for the tested monitor are encountered. The latter testing will be conducted to determine the MIL illumination point and the former testing will be conducted to determine the tailpipe emission level at the MIL illumination point. Together, these two parts of testing are necessary to determine if the MIL illuminates prior to exceeding the tailpipe emission levels as required in the HD OBD regulation. As stated, HD OBD emission-threshold monitoring requires engine dynamometer testing. For all such testing, the staff must implant a malfunction into the engine and then determine if the HD OBD system properly detects the malfunction at the required tailpipe emission levels.

Like the OBD II regulation, the proposed HD OBD regulation sets forth the decision criteria that the Executive Officer would use to determine if a system is noncompliant for each type of testing. For example, for HD OBD minimum in-use monitoring frequency testing, the system would be noncompliant if the average in-use performance of the sample engines is below a critical ratio that indicates the average ratio for the entire engine class is below the required minimum in-use monitor performance ratio of 0.100 set forth in Cal. Code Regs., title 13, section 1971.1(d)(3). For 2016 and subsequent model year engines, engines would be considered noncompliant with the in-use performance ratio requirement if either 66 percent or more of the 30-engine test sample had a ratio of less than 0.100 or the average of the ratios in the test sample was less than a critical ratio of 0.088. This critical ratio was calculated using the same method discussed in Appendix V of the 2002 OBD II Staff Report referenced above to provide statistical confidence that the results derived from the 30-engine sample represent the actual in-use performance of the affected engines.

And, for the “other” testing category, the system would be determined to be noncompliant if 30 percent or more of the sample engines fail to meet the same requirement that falls within the residual-testing category. This criterion is consistent with the criterion set forth in the existing tailpipe emission enforcement procedures, which provides that a test group or sub-group of vehicles shall be considered nonconforming when a specific emission-related failure occurred in three or more test vehicles from a sample that includes a minimum of 10 in-use vehicles. The staff believes that use of the definitive 30 percent criterion is preferable to the use of the term "substantial number of a class or category of vehicles that …experience a failure of the same emission-related component…", that is used in the definition of nonconformity in the existing enforcement procedures.[6] The specific percentage will provide clear notice to all parties of what is expected for compliance with the regulations.

For HD OBD emission testing, the regulation specifies that the system would be determined to be noncompliant if 50 percent or more of the tested sample engines are unable to properly detect a malfunction and illuminate the MIL before tailpipe emissions exceed the malfunction criteria thresholds set forth in Cal. Code Regs., title 13, section 1971.1(e) and (f). Further details of the emission testing are provided in section IX. D.4. below

If any of the above testing indicates that the HD OBD system is suspected of being noncompliant, the Executive Officer would be required to provide the manufacturer with a notice of the test results. The proposed regulation would require that such notice include all relevant supporting information that the Executive Officer relied upon in making his or her determination of nonconformance of the HD OBD system.

Manufacturers would have the opportunity to respond to the preliminary notice and present test results and other data that they believe rebut the preliminary findings of noncompliance. Upon consideration of the information submitted by the manufacturer, the Executive Officer may decide to perform additional in-use testing if necessary. The Executive Officer would consider all information submitted by the manufacturer in ultimately determining whether an HD OBD system is nonconforming.

Lastly, the Executive Officer would be required to issue a notice of final determination to the manufacturer as to whether the HD OBD system is nonconforming. If the Executive Officer finds the HD OBD system to be nonconforming, the regulation would require the notice to set forth the factual bases for the determination. After receiving the notice of noncompliance from the Executive Officer, a manufacturer would have 45 days to elect to conduct an influenced recall and repair of the affected vehicles. If the manufacturer were to take no action, the Executive Officer could order the manufacturer to take appropriate remedial action scaled to the level of noncompliance. The proposed regulation sets forth a detailed set of factors that the Executive Officer would consider in determining the appropriate remedy. Three distinct categories of remedial action are identified in the regulation and are discussed in section 4 below.

3. Manufacturer Self-Conducted Compliance Testing

Cal. Code Regs., title 13, section 1971.1, would require as a condition for certification that manufacturers conduct compliance testing of in-use engines to ensure that production engines in-use continue to meet the HD OBD requirements. The requirements for compliance testing are set forth as part of Cal. Code Regs., title 13,

[6] Cal. Code Regs., title 13, section 2112(h)

section 1971.5, and are discussed immediately below. ARB may use the results of such testing to determine if enforcement remedial action is necessary. A summary of the compliance test procedures that manufacturers would be required to follow is provided below.

Specifically, manufacturers would be required to perform enforcement testing on one to three engine families per year, depending on the size of the manufacturer. For each engine family, manufacturers would be required to procure a single representative in-use engine with approximately 75 percent of full useful life mileage and remove it from the vehicle for engine dynamometer testing. For each tested engine, the manufacturer would run the same sequence of tests ARB would run—testing each threshold component one after the other and determining the emission level at which the fault is detected. Given the mileage for procurement, such testing would occur approximately three years after introduction of the engine into the marketplace so 2010 model year engines would first be tested in 2013 calendar year.

Under the proposed procedures, an engine manufacturer would be required to submit a listing to the Executive Officer of all of the engine families and engine ratings within each family that have been certified for each model year. The Executive Officer would then select the engine family(ies) and the specific engine rating within the engine family(ies) that the manufacturer shall use as a test engine for the test sample group to provide emission test compliance data. For the 2010 model year, a manufacturer would be required to provide emission test data of a test engine from the OBD parent rating. In 2013 and subsequent model years, the number of test engines that a manufacturer would be required to provide emission test data from would depend upon the number of engine families that it certified in any model year: if from one to five engine families were certified, the manufacturer would be required to provide data from one engine rating; six to ten certified engine families would require data from two engine ratings; and eleven or more certified engine families would require data from three engine ratings. The Executive Officer could waive the requirement for submittal of data of one or more of the test engines if data have been previously submitted for all of the engine ratings.

In selecting the test sample group, the engine manufacturer would be required to follow the same criteria that ARB would follow in conducting enforcement testing. Within three calendar years after the model year of the engine (e.g., by the end of calendar year 2013 for a 2010 model year engine), the engine manufacturer would be required to complete compliance testing of the emission threshold monitors of the test engine. Prior to conducting any testing, the engine manufacturer would be required to replace components monitored by the OBD system with components that are sufficiently deteriorated or simulated to cause malfunctions that exceed the malfunction criteria established in Cal. Code Regs., title 13, sections 1971.1(e) through (g) in a properly operating system. The engine manufacturer would not be required to use components deteriorated or simulated to represent failure modes that could not have been foreseen to occur by the manufacturer.

After the test engine(s) has been selected and procured, engine manufacturers would need to perform emission testing for all applicable components/systems according to the certification demonstration testing requirements of Cal. Code Regs., title 13, sections 1971.1(i)(3) and (i)(4), unless a manufacturer obtains approval from the Executive Officer to deviate from the procedures for the purpose of compliance testing. If the initial testing on the originally selected test engine indicates that the OBD system properly illuminates the MIL for all component/system monitors before emissions exceed the malfunction criteria defined in title 13, CCR sections 1971.1(e) through (g), no further testing is required.

However, if the results of the OBD emission tests indicate that the OBD system does not properly illuminate the MIL for one or more of the component/system monitor(s) before emissions exceed the malfunction criteria defined in Cal. Code Regs., title 13, sections 1971.1(e) through (g), the engine manufacturer would need to conduct further testing on an additional four engines from the same engine rating and engine family as the test engine. The engine manufacturer would only be required to test the component/system monitor(s) for which the OBD emission test results exceeded the malfunction criteria specified in the HD OBD requirements. If the results indicate that the OBD system properly illuminates the MIL for the tested component/system monitor(s) before emissions exceed the malfunction criteria, on three or more of the additional test engines, the no further testing is required. If, however, two or more of the engines failed the second round of testing, the manufacturer would be required to test five more engines. At the conclusion of testing, if five or more of the ten total tested engines failed, the Executive Officer would make a determination that the engine family is noncompliant.

Under the proposed compliance/enforcement testing procedures, manufacturers would be required to allow ARB personnel access to any facility where a manufacturer performs any work related to procurement, selection, or testing and any facility where documents relating to the above are located. Among other things, ARB staff would be allowed to inspect and monitor work performed at these facilities, including the right to verify correlation or calibration of test equipment, inspect and photograph any part or aspect of the tested engine(s) and any components added to the engine(s) in conjunction with testing. ARB personnel would also have the right to inspect and make copies of any such records, designs, or other documents related to a tested engine and its testing.

Within 30 days after completing testing of the initial engine, the manufacturer would be required to submit a report of the results of the testing as well as a detailed description of the conducted testing to the Executive Officer. If testing of additional engines is required, the manufacturer would have six months to complete the testing and would need to submit an additional report within 30 days of completing the additional testing.

After the engine manufacturer has conducted testing pursuant to sections (c)(3) and (c)(4) and the Executive Officer has received the test results pursuant to section (c)(6) as described above, the Executive Officer shall make a finding of nonconformance of the OBD system in the engine class using the same criteria that is used in ARB-conducted enforcement testing. The Executive Officer would provide the manufacturer of his or her compliance determination. In the case of a finding of noncompliance, the Executive would follow the procedures similar to that previously described for ARB-conducted notices.

4. Remedial Action

A. Introduction

After notification of noncompliance from the Executive Officer, a manufacturer would have 45 days to elect to conduct an influenced recall and repair of the affected engines. If the manufacturer takes no action, the Executive Officer could order the manufacturer to take appropriate remedial action scaled to the level of noncompliance. The regulation would set forth a detailed set of factors that the Executive Officer would consider in determining the appropriate remedy.

The proposed regulation would provide for the recall of effectively nonfunctional HD OBD systems because the existence of such a noncomplying system effectively defeats the purposes and objectives of the HD OBD program and potentially undermines the emission reduction benefits that have been projected from recently adopted tailpipe standards for heavy-duty engines. It has been the long-standing position of the ARB that it is necessary to repair or replace such nonconforming systems because they are not capable of detecting future malfunctions of the engine's emission control systems and that this would likely lead to future emission increases.[7] This position is consistent with the Senate Committee on Environment and Public Works when considering federal adoption of onboard diagnostic regulations.[8]

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[7] See e.g., Manufacturers Advisory Correspondence No. 87-06 (July 1, 1987), in which the ARB stated.

> A recall . . . would be appropriate based on . . . the underlying defect identified by the OBD system even where the vehicles could pass the FTP, assuming a substantial number of vehicles in the class or category being tested contained that defect.

[8] P.L. 101-549, Clean Air Act Amendments of 1989, S.Rep. 101-228, 101st Cong., lst Sess. 1989, 1990 U.S.C.C.A.N. 33855, 1989 WL 2326970 et seq. , in which the Committee reported:

> The amended section 202 of the [CAA] authorizes the Administrator to promulgate regulations for [emission control diagnostics (ECD)]. Existing section 207(c) of the [CAA] provides for recall of vehicles which do not conform to the regulations adopted under section 202, thus providing clear authority for the Administrator to recall classes or categories of vehicles determined to have malfunctioning ECD systems during their full useful life. This authority will enable EPA to ensure that the emission components and the ECD system operate properly. A vehicle will be recalled or repaired if, during the useful life of the vehicle, the ECD system itself is broken or malfunctions such that it would no longer be able to serve its intended function of alerting the vehicle operator to the need for emission related maintenance and properly storing such information for subsequent retrieval by inspection or maintenance personnel. The ECD system is intended to alert the operator to the need for maintenance which may head off further emission deterioration or damage to the emission control system. Therefore, the Administrator may order a recall and a

It is beyond dispute that as heavy-duty engines age and accumulate high mileage, their emission control systems deteriorate, increasingly malfunction, and cause emissions to increase. No one knows or can accurately predict how well emission control systems of different manufacturers will work 10, 20, or more years from now. This is especially true when heavy-duty engines are being required to meet increasingly stringent emission standards, requiring new and complex technologies to be utilized.

B. Mandatory Recall

The staff is proposing that the most seriously design-flawed nonconforming HD OBD systems discovered as part of manufacturer compliance testing or ARB enforcement testing be subject to mandatory recall. See Table 1 below. Under Cal. Code Regs., section 1971.5(d)(3) of the proposed regulation, the Executive Officer would be required to order the recall of HD OBD systems that have at least one major monitor that performs so egregiously that it cannot effectively detect malfunctions or cannot be validly tested in a roadside inspection or fleet self-inspection. The ARB adopted the HD OBD requirements to address this problem and, specifically, to provide assurance that when malfunctions in emission control systems do occur, they will be expeditiously discovered and repaired. To properly perform these objectives, the HD OBD system itself must be functional and capable of detecting malfunctions when they occur. To minimize potential emission increases in future years, it is imperative that the identified, effectively nonfunctional OBD systems be recalled and repaired at the time noncompliance of the systems is discovered. Monitors that perform at levels significantly below the established criteria thresholds in-use run the risk of undermining the potential benefits of the HD OBD program. The ARB staff has concluded that systems that operate below these levels are essentially nonfunctional and need to be repaired or replaced.

By specifying minimum performance levels, below which a system would be considered nonfunctional and in need of recall, the Executive Officer would be providing manufacturers with clear notice and direction as to what the ARB considers to be a totally unacceptable system. With such knowledge, manufacturers can better plan and design their product lines and perform necessary internal testing to assure proper performance of the HD OBD systems that they manufacture and distribute. The minimum performance levels that would be established by the regulation for recall are fair and reasonable. The levels have been set so as to provide a liberal margin of error that distinguishes between a monitor that fails to meet the threshold levels required for proper detection of malfunctions and a monitor that performs so poorly that it cannot be considered functional. The proposed criteria for mandatory recall are summarized in Table 1 below.

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repair of the ECD system in cases wherever there is systematic misdiagnosis, even if the vehicle is passing emission standards, either by not alerting the operator to the need for necessary repair or by flagging a repair which is not necessary.

Table 1: HD OBD Enforcement Regulation Mandatory Recall Criteria

		2010-2012		2013-2015			2016-2018		2019
		parent [*1]	child [*2]	previous 2010-2012 phase-in engine family	parent	child	previous child from 2013-2015	all others	all engines
Tailpipe Level	< OBD threshold	pass	n/a	pass	pass	n/a	pass	pass	pass
	> OBD threshold and < 2x OBD threshold	pass	n/a	pass	pass	n/a	pass	fail (except PM filter monitor)	fail
	> 2x and < 3x OBD threshold	fail	n/a	fail	fail	n/a	fail	fail, mandatory recall (except PM filter monitor)	fail, mandatory recall
	> 3x OBD threshold	fail	n/a	fail, mandatory recall	fail, mandatory recall	n/a	fail, mandatory recall	fail, mandatory recall	fail, mandatory recall
	Applicable standard (FTP or SET)	Manufacturer determined at cert	n/a	Manufacturer determined at cert	Manufacturer determined at cert	n/a	Whichever is actual worst case	Whichever is actual worst case	Whichever is actual worst case
	Recall Liability	no mandatory	n/a	mandatory at >3x OBD threshold	mandatory at >3x OBD threshold	n/a	mandatory at >3x OBD threshold	mandatory at >2x OBD threshold (3x for PM filter monitor)	mandatory at >2x OBD threshold
Ratios	> 0.100 ratio in reg	n/a	n/a	pass	pass	pass	pass	pass	pass
	>0.05 and < 0.100	n/a	n/a	pass	pass	pass	fail	fail	fail
	>0.033 and < 0.05	n/a	n/a	fail	fail	fail	fail	fail	fail
	< 0.033	n/a	n/a	fail	fail	fail	fail, mandatory recall	fail, mandatory recall	fail, mandatory recall
	Recall Liability	n/a	n/a	no mandatory	no mandatory	no mandatory	mandatory <0.033	mandatory <0.033	mandatory <0.033

Note: "2x OBD threshold" does not mean 2x standard. E.g., if OBD threshold is 2.5x std, 2x OBD threshold is 2x (2.5x std) = 5.0x std

[*1] "Parent" in this table refers to a specific engine rating within an engine family that is required to be fully compliant with HD OBD

[*2] "Child" in this table refers to the other engine ratings within an engine family that are allowed to "carry over" calibrations from the parent engine and are not required to be fully compliant with HD OBD

C. Discretionary Remedial Action

The proposed regulation also provides the Executive Officer with discretionary authority to order remedial action when he or she finds a HD OBD system to be nonconforming for reasons other than those requiring mandatory recall. The Executive Officer would have discretion to order a graduating scale of remedies. In determining appropriate remedial action, the Executive Officer would consider all relevant circumstances surrounding the existence and discovery of the nonconformity, including the factors specifically set forth in section 1971.5(d)(4)(B). For example, in cases where the nonconformity is limited, the HD OBD system is largely functional, and the manufacturer has voluntarily identified the nonconformity, the Executive Officer would have authority to order a lesser form of remedial action, comparable to a deficiency. In the most serious cases, where the Executive Officer determines that the HD OBD system, when considered in its totality, is unacceptably ineffective, he or she would have discretion to order the recall of the nonconforming systems.

D. Monetary Penalties

Pursuant to authority granted under the Health and Safety Code,[9] the Executive Officer would be able to seek monetary penalties against a manufacturer for a nonconforming HD OBD system on a case by case basis. In determining whether to seek penalties, the Executive Officer would consider all relevant circumstances, including, but not limited to, the factors set forth in Cal. Code Regs., title 13, section 1971.5(d)(5).

E. Notice to Manufacturer of Remedial Order and Availability of Public Hearing

The proposed regulation requires the Executive Officer to notify the manufacturer of the ordered remedial action and/or his or her intent to seek monetary penalties in an administrative or civil court. The notice would be required to include a description of each class of vehicles or engines covered by remedial action and the factual basis for the determination. The notice would further provide a date at least 45 days from the date of receipt of such notice for the manufacturer to submit a plan outlining how it proposes to comply with the remedial order or to request a public hearing to consider the merits of the ordered remedial action.

F. Requirements for Implementing Remedial Action

The proposed regulation sets forth requirements and procedures to be followed by the manufacturer in implementing either a voluntary, influenced, or ordered remedial action. Among other things, the regulation would establish specific provisions requiring manufacturers to establish remedial action plans, provide notice to owners of heavy-duty vehicles and engines affected by the remedial action, and maintain and make available specific information regarding the remedial action. The proposed requirements and procedures are identical to the requirements of the OBD II enforcement regulation and similar, but not identical, to those required for tailpipe

[9] See Health and Safety Code, sections 43016, 43154, 43211-43212.

enforcement remedial actions in Cal. Code Regs., title 13, sections 2113 – 2121 and sections 2123 – 2132.[10] As with the existing enforcement provisions, the proposed requirements for implementing remedial action provide clear directions to a manufacturer subject to a remedial action on its obligations and responsibilities in carrying out a remedial action campaign. This should ensure effective and expeditious implementation of proposed remedial action plans and compliance with the HD OBD requirements. The proposed requirements should also ensure that all manufacturers follow consistent reporting requirements that allow for full and effective monitoring of the remedial action campaign by the ARB.

Having determined the need for specific enforcement procedures, it makes sense that the requirements and procedures for implementing HD OBD-related remedial actions should be included within the self-contained HD OBD enforcement procedures. This follows closely with the procedures for remedial action that manufacturers must follow under the OBD II enforcement procedures. Having a single regulation with all HD OBD enforcement provisions should prove helpful and convenient to both affected manufacturers and ARB staff. The result should be a clearer, more readily understandable document.

G. Penalties for Failing to Comply with the Requirements of Section 1971.5(e)

The staff is proposing a provision that would make it clear that a manufacturer could be subject to penalties, in addition to any penalties that could be assessed for HD OBD nonconformance, for failing to comply with the proposed requirements for implementing remedial action. Such failures would be considered a violation of the Health and Safety Code and would subject the manufacturer to penalties prescribed under Health and Safety Code section 43016. The ability to assess monetary penalties should encourage compliance with the requirements for implementing recall actions and result in thorough and timely implementation of both voluntary and ordered remedial action campaigns.

[10] The proposal includes a requirement that manufacturers subject to an HD OBD recall be required to report on the progress of the remedial action campaign by submitting reports for eight consecutive quarters. See section 1971.5(e)(6)(B). Although the eight consecutive quarter requirement differs from the reporting requirements of Cal. Code Regs., title 13, sections 2119(a) and 2133(c), the proposal is in fact consistent with ARB practice. See "Voluntary and Influenced Recall Recordkeeping and Reporting," MAC #96-08, July 26, 1996. Similarly, the proposed reporting requirements require manufacturers subject to vehicle recall to provide the ARB with a list of data elements and designated positions in the submitted reports that indicate all vehicles or engines subject to the recall that have not as yet been corrected. Although not expressly set forth in the existing recall reporting requirements, the information required under the proposed provision has a long-standing ARB requirement and is consistent with OBD II enforcement. See "Revision to Mail-Out 91-13 (Implementation of Air Resources Board's (ARB) and Department of Motor Vehicles' Registration Renewal/Recall Tie-In Program), Mail-Out 91-19, April 10, 1991.

E. INTERIM IN-USE RELIEF

With this proposed adoption, staff is also proposing to delete section 1971.1(m) of the HD OBD regulation, which detailed intermediate in-use compliance standards, as these criteria would be incorporated into the proposed stand-alone HD OBD enforcement regulation. These criteria provide interim relief by phasing in enforcement liability for manufacturers over the first years of HD OBD implementation. These criteria included higher interim in-use compliance standards for HD OBD monitors that are calibrated to specific emission thresholds as well as relaxed criteria for the minimum in-use frequency. This interim relief provides manufacturers with extra margin to fine-tune their calibration techniques and to gain experience with in-use operation, without imposing an excessive level of risk for mistakes.

Under the existing regulation, an OBD monitor in 2010 through 2015 model year engines will be considered compliant (and not subject to enforcement action) unless emissions exceed twice the OBD threshold without detection of a fault. Additionally, the number of engines subject to liability in these years is limited. For example, for 2010 through 2012 model years, manufacturers will only be liable for the highest sales volume engine rating (e.g., a specific rated power variant) within the one engine family that is required to have an OBD system. Other engine ratings within that engine family are not subject to liability even though they may fail to detect a fault at the specified emission threshold. For 2013 through 2015 model years, all engine ratings within this original OBD engine family are potentially liable if they fail to meet the emission thresholds. Further, a limited number of engine ratings in other engine families are subject to liability for in-use noncompliance in the 2013 model year. Emission threshold liability for all in-use engines does not become effective until the 2016 model year.

F. RESPONSIBLE PARTY

Under the proposed enforcement procedures, the engine manufacturer that is the certifying party would be the responsible party for all in-use compliance and enforcement actions. In this role, the engine manufacturer would be ARB’s sole point of contact for any noncompliance identified during in-use or enforcement testing. In cases where remedial action will be required (e.g., recall), the certifying party would be responsible for coordinating any actions to remediate the noncompliance (e.g., coordination with truck builders to contact vehicle owners or to provide service networks to conduct the recall work). To protect themselves, it is expected that engine manufacturers would require engine purchasers to sign indemnity clauses or other agreements to abide by the build specifications applicable to the engine and to bear ultimate financial responsibility for noncompliance caused by the engine purchaser.

X. ANALYSIS OF ENVIRONMENTAL IMPACTS AND ENVIRONMENTAL JUSTICE ISSUES

As stated, the proposed HD OBD and OBD II requirements and enforcement procedures help ensure that forecasted emission reduction benefits from adopted light-, medium-, and heavy-duty engine emission standards programs are achieved. Given the substantial shortfall in emission reductions still needed to attain the National and State Ambient Air Quality Standards and the difficulty in identifying further sources of cost-effective emission reductions, it is vital that the emission reductions projected for the light-, medium-, and heavy-duty vehicle programs be achieved. The OBD regulations are necessary to accomplish this goal, achieving these emission benefits in two distinct ways. First, to avoid customer dissatisfaction that may be caused by frequent illumination of the MIL because of emission-related malfunctions, it is anticipated that the manufacturers will produce increasingly durable, more robust emission-related components. Second, by alerting vehicle operators of emission-related malfunctions and providing precise information to the service industry for identifying and repairing detected malfunctions, emission systems will be quickly repaired. The benefits of the regulations become increasingly important as certification levels become more and more stringent and as a single malfunction has an increasingly greater impact relative to certification levels.

Regarding the HD OBD regulation, the proposed amendments are not expected to significantly alter previously calculated emission benefits or findings. Though the proposed amendments for diesel engines would delay the starting implementation date of a few emission threshold monitoring requirements and would allow higher interim malfunction emission thresholds for some monitors, the staff believes these short term interim delays and higher thresholds are necessary considering the diesel emission control technologies involved are new and evolving and have never previously existed on diesel engines.

For reference, during the 2005 HD OBD regulatory process, lifetime cumulative emission reductions attributable to the HD OBD program, on a per engine basis, were calculated to be 81 pounds of ROG, 5,735 pounds of NOx, and 24 pounds of PM. Details of the methodology can be found in the 2005 HD OBD staff report. However, staff has recalculated the benefits using the latest emission inventory models. The estimated emission benefits from HD OBD are significantly different from the 2005 estimates due primarily to a recent update of the base emission inventory model (EMFAC). EMFAC was updated with new data for heavy-duty vehicle miles traveled and emission rates. In addition, an error was found in the 2005 estimates that resulted in an overestimation of the NOx and ROG benefits. As a result, the lifetime cumulative emission reductions for HD OBD, on a per engine basis calculated with the most recent version of EMFAC, are 165 pounds of ROG, 2000 pounds of NOx, and 14 pounds of PM.

With this rulemaking, the primary amendments apply to the HD OBD regulation. As stated earlier, changes are also being made to the light- and medium-duty OBD II regulation to harmonize the medium-duty diesel requirements with the heavy-duty diesel requirements. The changes to the OBD II regulation, for both gasoline and diesel, are minor and are not expected to significantly alter previously calculated emission benefits or findings.

For reference, during the 2002 OBD II regulatory update, staff calculated a combined benefit for OBD II and LEV II of 57 tons per day of ROG + NOx in the South Coast Air Basin alone. Details of the methodology can be found in the 2002 OBD II staff report. Given the substantial shortfall in emission reductions still needed to attain the National and State Ambient Air Quality Standards and the difficulty in identifying further sources of cost-effective emission reductions, it is vital that the emission reductions projected for the LEV II program be achieved. The proposed OBD II regulatory revisions apply almost exclusively to LEV II vehicles and better ensure these vehicles will continue to operate at the expected emission levels, a necessary step towards achieving this goal.

Having identified that the proposed amendments to the regulations will not result in any adverse environmental impacts but rather will help ensure that measurable emission benefits are achieved both statewide and in the South Coast Air Basin, the amendments should not adversely impact any community in the State, especially low-income or minority communities.

XI. COST IMPACT OF THE PROPOSED REQUIREMENTS

A. COST OF THE PROPOSED REQUIREMENTS

For HD OBD, like the modifications to the OBD II program, the revisions to the regulation (§1971.1) consist primarily of interim relief and clarification of existing requirements. As such, the previously calculated cost estimate is still applicable. However, ARB staff has performed a comprehensive cost analysis of the proposed HD OBD enforcement program to add to the previous estimate. The goal of this analysis is to estimate the "learned-out" costs of the program to a heavy-duty engine purchaser for a "typical" engine. The analysis estimates the incremental costs of implementing the HD OBD enforcement regulation for a "hypothetical" larger-than-average engine manufacturer. The hypothetical engine manufacturer is projected to include eight engine families and five ratings per engine family. In contrast, the "average" engine manufacturer according to U.S. EPA's data of 2004 heavy-duty engines includes 6.5 engine families and five ratings per engine family. To determine the average sales number of the hypothetical manufacturer, the staff took the national sales numbers for the top nine engine manufacturers and determined a composite average value of 72,440. This number was rounded to 72,000 in the analysis.

The various types of costs that are addressed in this analysis are variable costs, support costs, investment recovery costs, capital recovery costs, and truck/coach builder costs. Results of the analysis from the 2005 staff report indicate the learned-out costs per engine to comply with the proposed HD OBD regulation (§1971.1) would be $132.39 for diesel engines and $35.04 for gasoline engines. As note above, since the proposed modifications to the regulation consist mainly of threshold modifications for diesel engines to provide compliance relief, the previous cost estimates should still apply. In the very limited cases where a new monitor is required (e.g., cylinder air-fuel imbalance), lead time is provided to allow manufacturers to implement necessary changes in conjunction with scheduled vehicle upgrades. None of the new monitoring requirements should require any additional hardware for monitoring. It is projected that only software modifications will be required to comply with the any of the new requirements.

B. COSTS OF THE HD OBD ENFORCEMENT PROGRAM

As described in section IX, staff is proposing the adoption of Cal. Code Regs., title 13, section 1971.5 which would establish enforcement procedures and requirements for heavy-duty OBD systems. Costs were estimated utilizing the same methodology and assumptions as described above for the HD OBD regulation (i.e., costs were based on a hypothetical larger-than average engine manufacturer). Additionally, costs were only estimated for diesel engines since the costs for testing diesel engines are significantly higher than gasoline engines due to the cost of the engine and the associated aftertreatment components. Results of the analysis indicate the learned-out incremental retail costs to incorporate the proposed HD OBD enforcement regulation would be $1.97 per engine. Therefore, the estimated combined costs of the HD OBD regulation and the proposed HD OBD enforcement regulation are $134.36 per heavy-duty diesel engine and $37.01 per gasoline engine. Details of the cost analysis methodology are described in the heavy-duty OBD staff report of July 2005. The primary costs associated with the enforcement regulation are for the provisions that require 'self-testing' by the manufacturer at a rate of one to three engines per year, depending on the size of the manufacturer (two per year has been assumed for this cost analysis). The primary assumptions used include a cost of $23,150 per engine in procurement related expenses and just over $80,000 per engine in testing costs. Staff talked with manufacturers, EPA, and independent laboratories that perform such procurement and testing in developing these estimates. Tables 1 and 2 below summarize the results of the cost analysis when spread out across all engines produced by a manufacturer.

Table 1: Incremental Consumer Cost of HDDE

		1971.1 Costs (in dollars)	1971.5 Costs (in dollars)	Total HD OBD Costs (in dollars)
Variable costs	Component	$37.18	$0.00	$37.18
	Assembly	$0.68	$0.00	$0.68
	Warranty	$1.64	$0.00	$1.64
	Shipping	$1.20	$0.00	$1.20
Support costs	Research	$22.49	$0.00	$22.49
	Engineering Support	$0.14	$0.08	$0.22
	Legal	$0.35	$0.00	$0.35
	Administrative	$2.08	$0.16	$2.24
Investment recovery costs	Mach. & equipment	$0.00	$0.00	$0.00
	Assembly plant changes	$0.00	$0.00	$0.00
	Development/Testing	$57.34	$1.59	$58.93
Capital recovery (a)		$7.39	$0.11	$7.50
Truck/Coach Builder costs	Cost of capital recovery (b)	$1.91	$0.03	$1.94
Total cost		$132.39	$1.97	$134.36

(a) Cost of capital recovery was calculated at 6% of the total incremental costs.
(b) Cost of capital recovery was calculated at 6%. Engines are assumed to remain in inventory for 3 months.

Table 2: Incremental Consumer Cost of HDGE

		1971.1 Costs (in dollars)	1971.5 Costs (in dollars)	Total HD OBD Costs (in dollars)
Variable costs	Component	$30.00	$0.00	$30.00
	Assembly	$0.20	$0.00	$0.20
	Warranty	$0.07	$0.00	$0.07
	Shipping	$0.60	$0.00	$0.60
Support costs	Research	$0.75	$0.00	$0.75
	Engineering Support	$0.00	$0.08	$0.08
	Legal	$0.00	$0.00	$0.00
	Administrative	$0.00	$0.16	$0.16
Investment recovery costs	Mach. & equipment	$0.00	$0.00	$0.00
	Assembly plant changes	$0.00	$0.00	$0.00
	Development/Testing	$0.96	$1.59	$2.55
Capital recovery (a)		$1.95	$0.11	$2.06
Truck/Coach Builder costs	Cost of capital recovery (b)	$0.51	$0.03	$0.54
Total cost		$35.04	$1.97	$37.01

(a) Cost of capital recovery was calculated at 6% of the total incremental costs.
(b) Cost of capital recovery was calculated at 6%. Engines are assumed to remain in inventory for 3 months.

C. COST EFFECTIVENESS OF THE PROPOSED REQUIREMENTS

Based on the emission benefit analysis and the additional cost numbers identified above, the cost effectiveness of the OBD regulation was re-calculated. For the cost estimation, it was assumed that half of the cost was for PM emission benefit and the other half was for ROG+NOx benefit. Accordingly, the per engine cost to implement OBD ($134) was added to the per engine repair cost ($496) (from the cost analysis in the 2005 HD OBD Staff Report) for a total cost of $630 per engine. Splitting that in half, $315 was attributed to PM benefit for a cost-effectiveness of $22.50 per pound of PM. The other half of the cost was attributed to ROG+NOx benefit for a cost-effectiveness of $0.15 per pound of ROG+NOx. Both values compare favorably with the cost-effectiveness of other, recently adopted regulations.

As noted above, the proposed light-duty and medium-duty OBD II regulation revisions are not expected to add any significant cost to gasoline or diesel vehicles nor change any previously calculated emission benefits. Accordingly, the cost-effectiveness numbers calculated from the 2002 regulation update are still applicable. For reference, in 2002 staff calculated two separate cost-analyses for OBD II systems. The first covered the useful life period of the vehicle (typically the first 120,000 miles) and combined with the LEV II program, was $2.18 per pound of ROG + NOx reduced. The second analysis was for the second phase of the vehicle's life, from 120,000 to 230,000 miles, when increased reliance on OBD II is necessary to maintain low in-use vehicle emissions. That cost effectiveness was calculated to be $4.57 per pound of ROG + NOx reduced. The methodologies for both analyses were detailed in the 2002 OBD II staff report, which is incorporated by reference herein (a copy of which may be found at http://www.arb.ca.gov/regact/obd02/obd02.htm).

XII. ECONOMIC IMPACT ANALYSIS

Overall, the proposed amendments to the HD OBD and OBD II regulation are expected to have a negligible impact on the profitability of heavy-duty engine manufacturers and automobile manufacturers. It is anticipated that the proposed amendments would result in negligible costs to heavy-duty vehicle manufacturers. For light- and medium-duty vehicles, the manufacturers are large and mostly located outside of California with the exception of the New United Motor Manufacturing, Inc. (NUMMI), which is a joint venture between Toyota Motor Corporation and General Motors Corporation. The proposed changes involve minimal development and verification of software above what is already incorporated into HD OBD and OBD II systems. Staff believes, therefore, that the proposed requirements would cause no noticeable adverse impact in California employment, business status, and competitiveness.

A. LEGAL REQUIREMENTS

Section 11346.3 of the Government Code requires State agencies to assess the potential for adverse economic impacts on California business enterprises and individuals when proposing to adopt or amend any administrative regulation. Section 43101 of the Health and Safety Code similarly requires that the Board consider the impact of adopted standards on the California economy. This assessment shall include a consideration of the impact of the proposed regulation on California jobs, business expansion, elimination, or creation, and the ability of California business to compete.

B. AFFECTED BUSINESSES AND POTENTIAL IMPACTS

Any business involved in manufacturing, purchasing, or servicing passenger cars, light-duty trucks, medium-duty vehicles, and heavy-duty engines and vehicles could be affected by the proposed amendments. Also affected are businesses that supply parts for these vehicles.

There are 21 heavy-duty engine manufacturers, none of which is located in California. Of these businesses, two of the engine manufacturing companies are assumed to be “small businesses” (i.e., selling less than 150 engines per year based on California certification data). There are approximately 8 major heavy-duty vehicle manufacturers, but staff has been unable to obtain an estimation of the total number of vehicle manufacturers that manufacture and sell heavy-duty vehicles in California. Thus, staff is unable to determine how many of these companies are located in California and how many are considered “small businesses.” However, the cost related to vehicle manufacturers is determined to be negligible based on the minor effects these regulatory provisions might have on their operations.

California accounts for only a small share of total nationwide light- and medium-duty motor vehicle and parts manufacturing. There are 34 companies worldwide that manufacture California-certified light- and medium-duty vehicles and heavy-duty gasoline engines. As stated, only one motor vehicle manufacturing plant is located in California, the NUMMI facility.

C. POTENTIAL IMPACTS ON VEHICLE OPERATORS

For heavy-duty engines and vehicles, the proposed amendments would provide OBD information and encourage manufacturers to build more durable engines, which would result in the need for fewer repairs and savings for vehicle owners. However, OBD is expected to detect malfunctions that may otherwise have gone undetected (and thus, unrepaired) by the vehicle owner. A single additional repair was estimated to occur on approximately two-thirds of the trucks over a 21 year lifetime as a result of OBD at an average cost of $741 per repair. This is a conservative cost estimate, since OBD will potentially result in savings by catching problems early before they adversely affect other components and systems in the engine. The proposed amendments are anticipated to have a negligible impact on new vehicle prices, since the calculated increase in retail price of an engine to meet OBD is less than one percent of the retail cost of the engine and less than 0.2 percent of the retail cost of a heavy-duty vehicle.

For light- and medium-duty vehicles, the proposed amendments would provide improved OBD II information and encourage manufacturers to build more durable vehicles, which should result in the need for fewer vehicle repairs and savings for consumers. The proposed changes involve minimal development and verification of software above what is already incorporated into OBD II systems. Additionally, because manufacturers would be provided sufficient lead time to incorporate the minimal proposed changes, incorporation and verification of the revised OBD II software would be accomplished during the regular design process at virtually no additional cost. Any additional engineering resources needed to comply with the proposed program would be small, and when spread over several years of vehicle production, these costs would be negligible. Thus, the proposed amendments are anticipated to have a negligible impact on manufacturer costs and new vehicle prices.

D. POTENTIAL IMPACTS ON BUSINESS COMPETITIVENESS

The proposed amendments are not expected to adversely impact the ability of California businesses to compete with businesses in other states as the proposed standards are anticipated to have only a negligible impact on retail prices of new engines and vehicles. Additionally, U.S. EPA adopted federal OBD II and heavy-duty OBD requirements that are harmonized with those of ARB. Therefore, any increase in costs will also be experienced by non-California businesses due to federal requirements. Thus, any price increases of light-, medium-, and heavy-duty vehicles are not expected to dampen the demand for these vehicles in California relative to other states, since price increases would be the same nationwide.

E. POTENTIAL IMPACTS ON EMPLOYMENT

The proposed amendments are not expected to cause a noticeable change in California employment because California accounts for only a small share of motor vehicle, heavy-duty engine, and parts manufacturing employment, and the minimal additional work done by heavy-duty vehicle manufacturers can be done with existing staff.

However, some jobs may be created at heavy-duty engine manufacturing companies. Currently, heavy-duty engine manufacturers lack significant experience in designing and implementing OBD systems on heavy-duty engines. This may result in additional jobs for programmers and engineers.

F. POTENTIAL IMPACT ON BUSINESS CREATION, ELIMINATION, OR EXPANSION

The proposed amendments are not expected to affect business creation, elimination or expansion.

REFERENCES

Below is a list of documents and other information that the ARB staff relied upon in developing the Staff Report.

1) Staff Report: Initial Statement of Reasons (ISOR): Technical Status and Revisions to Malfunction and Diagnostic System Requirements for 2004 and Subsequent Model Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles and Engines (OBD II), March 8, 2002.

2) Staff Report: Initial Statement of Reasons (ISOR): "Malfunction and Diagnostic System Requirements for 2010 and Subsequent Model Year Heavy-Duty Engines (HD OBD)," June 3, 2005.

3) Staff Report: Initial Statement of Reasons (ISOR): "Technical Status and Revisions to Malfunction and Diagnostic System Requirements for Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles and Engines (OBD II) and the Emission Warranty Regulation," August 11, 2006

Below is a list of documents newly incorporated by reference in the HD OBD and OBD II regulations.

1) EMFAC2007

2) EMFAC 2007 Technical Memo "EMFAC Modeling Change Technical Memo," September 13, 2006

3) International Standards Organization (ISO) 15765-4:2005 "Road Vehicles – Diagnostics on Controller Area Network (CAN) – Part 4: Requirements for emission-related systems," January 2005.

4) Society of Automotive Engineers (SAE) J1930 "Electrical/Electronic Systems Diagnostic Terms, Definitions, Abbreviations, and Acronyms – Equivalent to ISO/TR 15031-2," October 2008.

5) SAE J1978 "OBD II Scan Tool – Equivalent to ISO/DIS 15031-4:December 14, 2001," April 2002.

6) SAE J1979 "E/E Diagnostic Test Modes," May 2007.

7) SAE J2012 "Diagnostic Trouble Code Definitions," December 2007.

8) SAE J2403 "Medium/Heavy-Duty E/E Systems Diagnosis Nomenclature," August 2007.

9) SAE J1939 consisting of:

J1939 Recommended Practice for a Serial Control and Communications Vehicle Network, March 2009;
J1939/1 Recommended Practice for Control and Communications Network for On-Highway Equipment, September 2000;
J1939/11 Physical Layer, 250K bits/s, Twisted Shielded Pair, September 2006;
J1939/13 Off-Board Diagnostic Connector, March 2004;
J1939/15 Reduced Physical Layer, 250K bits/sec, UN-Shielded Twisted Pair (UTP), August 2008;
J1939/21 Data Link Layer, December 2006;
J1939/31 Network Layer, April 2004;
J1939/71 Vehicle Application Layer (Through February 2008), January 2009;
J1939/73 Application Layer—Diagnostics, September 2006;
J1939/81 Network Management, May 2003; and
J1939/84 OBD Communications Compliance Test Cases For Heavy Duty Components and Vehicles, December 2008.

10) SAE J1699-3 – "OBD II Compliance Test Cases", May 2006.

11) SAE J2534-1 – "Recommended Practice for Pass-Thru Vehicle Programming", December 2004.

APPENDIX I

The following tables were used to support the cost estimates in Section XI. “Cost Impact of the Proposed Requirements” of the Staff Report.

Manufacturer Self Testing Cost of Heavy-duty OBD Enforcement (Engineering Support)

Staff	Number of Staff (person yrs.)	Staff Cost (a) (in dollars)	Testing and Equipment Costs (d) (in dollars)	Cost/vehicle(c) (dollars/veh.)
Test Cell Technician	0.13	$13,000	$262,662	$0.64
			Total	$0.64

Legal and Administrative costs

	No. of Staff required	Number of years	Staff cost (in dollars)	Cost/vehicle (c) (dollars/vehicle)
Administrative	0.15	3	67,500	0.16
			Total	0.16

(a) Development cost includes personnel, overhead and other miscellaneous costs at a total rate of $150k/yr for an engineer and $100k/yr for a technician.
(b) Testing Costs includes Labor Costs for Technicians needed to staff the Tests
(c) Staff cost has been distributed over 72,000 engines per year for a total of 3 years.
(d) Equipment costs have been distributed over 72,000 engines per year for a total of 3 years

Incremental Consumer Cost of HDV OBD Enforcement Testing

		HDV (in dollars)
Variable costs	Component	$0.00
	Assembly	$0.00
	Warranty	$0.00
	Shipping	$0.00
Support costs	Research	$0.00
	Engineering Support	$0.06
	Legal	$0.00
	Administrative	$0.16
Investment recovery costs	Mach. & equipment	$0.00
	Assembly plant changes	$0.00
	Development/Testing	$1.22
Capital recovery (a)		$0.09
Truck/Coach Builder costs	Cost of capital recovery (b)	$0.02
Total cost		$1.55

(a) Cost of capital recovery was calculated at 6% of the total incremental costs.
(b) Cost of capital recovery was calculated at 6%. Engines are assumed to remain in inventory for 3 months.

Long term Costs

reg	description	# of engine families	**phase 1 test number**	**phase 1 test percentage**	**phase 2 test number**	**phase 2 test percentage**	**phase 3 test number**	**phase 3 test percentage**	sets of test hardware per engine family
1971.5 (c)	manufacturer self testing	8	2	1	4	0.1	5	0.05	1

cost per test hardware	# of faults to be tested	Engine dyno test cell hours	Engine removal from Truck	New engine install into truck	Engine Install	FTP/SET test Phase 1	FTP/SET test Phases 2 &3	Engine uninstall	Procurement Cost per engine including aftertreatment
$21,488	16.3	130.4	1500	1500	2460	80196	9840	2460	$23,150

Technician Manhours to run test - Phase 1	Technician Manhours to run test - Phase 2 and 3	cost per tech pY	Hourly cost per tech	Equipment/ test costs	PY costs	Total
130.4	5	$100,000	$ 50	$ 262,662	$ 13,043	$275,705

Parts Cost

Task Description	2016 Emissions/OBD Component List	New Part Cost	Limit Part Cost
Fuel System			
fuel system injection quantity low/high	Injector	$200	$1,000
fuel system pressure low/high	Rail Pressure Sensor	$200	$1,000
fuel system injection timing advance/retard	Injector	$200	$1,000
Misfire Monitor		$0	$0
Air Handling			
VGT Underboost/overboost/slow response	VGT Actuator	$500	$2,500
CAC Undercooling	Charge Air Cooler	$25	$125
EGR			
EGR low/high flow	EGR Valve Actuator	$500	$2,500
EGR Undercooling	EGR Cooler	$25	$125
Oxidation Catalyst			
NMHC cat conversion efficiency	oxidation catalyst	$1,000	$5,000
SCR Catalyst			
SCR NOx cat conversion efficiency	SCR Catalyst	$2,000	$10,000
SCR reductant injection performance	Urea Injector	$300	$1,500
PM Filter			
PM filter leak/missing substrate	PM Filter	$5,000	$6,000
PM filter regeneration frequent	PM Filter	$5,000	$6,000
PM filter regeneration incomplete	PM Filter	$5,000	$0
NMHC conversion of catalyst	oxidation catalyst	$1,000	$5,000
Active injection (in exhaust) (in-cylinder no cost)	computer mod to post inj	$0	$0
NOx Sensors			
NOx sensor performance	NOx sensor	$75	$375
NOx sensor offset	NOx sensor	$75	$375
NOx sensor monitoring capability	NOx sensor	$75	$375
Sensor Heaters			
Sensor heater performance	computer mods to induce fault	$0	$0
ECT Sensor/Thermostat			
t-stat monitor warm-up performance		$20	$100
Total			$42,975