State of California
AIR RESOURCES BOARD

WORKSHOP REPORT:

Technical Status and Revisions to Malfunction and Diagnostic System Requirements for 2010 and Subsequent Model Year Heavy-Duty Engines (HD OBD)

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I. INTRODUCTION

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 increases 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 identifying 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 comprehensive OBD regulations in 1989, requiring all 1996 and newer model year passenger cars, light-duty trucks, and medium-duty vehicles and engines to be equipped with OBD systems (referred to as OBD II). In 2004, ARB adopted the Engine Manufacturer Diagnostic system (EMD) regulation (section 1971, title 13, California Code of Regulations (CCR)), which requires manufacturers of heavy-duty engines and vehicles (i.e., vehicles with a gross vehicle weight rating greater than 14,000 pounds) to implement diagnostic systems on all 2007 and subsequent model year on-road heavy-duty Otto-cycle (gasoline) and diesel engines. However, the EMD regulation is much less comprehensive than the OBD II regulation, requiring the monitoring of only a few major emission control technologies and containing no standardized requirements. Essentially, the EMD regulation was developed to require heavy-duty engine manufacturers to achieve a minimum level of diagnostic capability while focusing most of their resources on meeting the new 2007 exhaust emission standards. In 2005, ARB adopted section 1971.1, title 13, CCR, which established comprehensive OBD requirements for 2010 and subsequent model year heavy-duty engines and vehicles, and a heavy-duty OBD-specific enforcement regulation, section 1971.5, was subsequently adopted in 2009.

Since amendments were last adopted for the heavy-duty OBD regulations in 2009, ARB staff has been meeting with manufacturers to review progress in meeting the regulatory requirements. A number of issues have been identified where staff and industry differ significantly as to the necessity of or the stringency of a monitoring requirement. While staff agrees some modifications are warranted in some cases, staff also disagrees with some of manufacturers' requested changes. The following section details the main issues and proposed changes as well as ARB staff's conclusions and attendant rationale. Staff is also proposing other minor amendments to the regulation, some of which are detailed below in the report. For a comprehensive look at all the proposed amendments to section 1971.1, refer to the draft regulation document included in Attachment A, with proposed additions to the regulation denoted by <u>underline</u> and proposed deletions denoted by ~~strikeout~~. Staff is also planning to propose a few amendments where applicable to the OBD II regulation section 1968.2 (included in

Attachment B) for medium-duty diesel engines and vehicles. These proposed amendments may also prompt changes to the associated enforcement regulations (sections 1968.5 and 1971.5) to align with the new or modified requirements. Such changes will be made as part of this rulemaking but draft regulatory language won't be available until the proposed amendments to the heavy-duty OBD and OBD II regulations have been finalized.

II. TECHNICAL STATUS UPDATE AND PROPOSED AMENDMENTS

A. HEAVY-DUTY HYBRID VEHICLES

One issue of concern to heavy-duty engine, vehicle, and hybrid system manufacturers is OBD monitoring of heavy-duty hybrid components. The heavy-duty OBD regulation currently requires hybrid systems and components to be monitored for emission-related malfunctions and to ensure the addition of such systems to a certified engine does not adversely affect the ability of the engine to comply with OBD requirements. Because hybrid systems vary greatly in terms of system architecture and capability, manufacturers are required to submit a monitoring plan for ARB's review and approval for hybrid vehicles. Affected manufacturers have argued that, unlike the light-duty and medium-duty industry, the heavy-duty industry is a horizontally-integrated industry where the heavy-duty engine manufacturers only manufacture the engine and the hybrid system manufacturers are responsible only for the hybrid components and neither have total integrated system responsibility or capability. Further, they argue the use of hybrid technology on heavy-duty vehicles is still emerging, that they constitute a very small market share, and that they are only economically viable to due to sizable government funding subsidies and incentives to purchasers and would be even less viable given additional expenses to incorporate OBD systems.

The hybrid system manufacturers have also indicated that, despite the requirements being adopted in the heavy-duty OBD regulation well in advance of the 2013 model year, they have not yet developed compliant diagnostics for their own components let alone attempted to understand their impact on the engine diagnostics. This leads to the engine manufacturers representing that they cannot be responsible for designing their engine diagnostics to account for all of the various hybrid applications that might get mated to one of their engines in the future. This also leads to hybrid system manufacturers arguing that because they have no knowledge of how the engine diagnostics work on the various engines they work with, they cannot be responsible for ensuring compliant systems. Accordingly, the hybrid system manufacturers have asked to be exempted from OBD requirements at least for the same time frame that the Environmental Protection Agency (EPA) has recently granted exemption for (i.e., up to the 2017 model year). Additionally, the engine manufacturers have requested relief for any of their engines that get mated to a hybrid, specifically proposing that they no longer be held liable for ensuring the engine diagnostics comply and, where necessary, be allowed to desensitize or disable diagnostics that no longer work correctly when used in a hybrid application.

Fundamentally, an integrated approach needs to be used for engine and hybrid system manufacturers to have a reasonable chance at meeting all of ARB's requirements, including the OBD requirements and tailpipe standards. Modern engine and emission control systems are extremely complex and must balance many competing factors such as durability, performance, emissions, and fuel economy. Engine manufacturers expend significant resources to find a solution that simultaneously meets all of these requirements, so it should come as no surprise that major alterations to the system such as attaching a hybrid system that can turn the engine on and off and change the speeds and loads the engine is routinely operated at can substantially compromise the ability of the engine to continue to meet all of the requirements. Further, an integrated approach has the advantage of likely being able to maximize hybrid operation and efficiency, thereby making the system more economically viable for the long term. As such, staff is proposing only one extra year of relief (the 2013 model year) before hybrid systems are required to be properly integrated and compliant with the OBD regulation.

In general terms, there are three areas where hybrid systems need to comply with the OBD requirements. Firstly, there are diagnostics of the added hybrid components/systems themselves. Such diagnostics are required to identify malfunctions that lead to emission increases or affect other diagnostics. These hybrid component/system diagnostics primarily fall under a section of the regulation that details monitoring requirements for comprehensive components, which ensures all electronic input and output components/systems that can affect emissions are fully monitored. While hybrid manufacturers readily acknowledge that they already have a fair amount of diagnostics for their components to facilitate service, these diagnostics do not fully cover all of the components and failure modes required by OBD. Therefore, most hybrid systems would need added diagnostics (i.e., added software routines and calibrations in the on-board computers) to cover the additional failure modes and components. It is expected that the hybrid system manufacturer and suppliers that already implement some diagnostics for service would also be the ones to implement such additional diagnostics since they know how these components work. Achieving this is primarily a matter of dedicating sufficient engineering resources to develop, implement, and calibrate the additional diagnostics.

Secondly, there are the engine diagnostics themselves. While they start out as compliant because the engine manufacturer has developed and calibrated them to the requirements, the addition of a hybrid system can adversely impact some of these diagnostics. As a very simple example, an engine manufacturer may have designed a required diagnostic of an emission control component to run only at idle. However, when mated to a hybrid system that turns the engine off at every idle, that monitor would no longer be able to run and, consequently, would no longer be able to detect failures of that emission control component. A more complicated example involves engine diagnostics that are calibrated to a tailpipe emission threshold such as exhaust gas recirculation (EGR) diagnostics that must detect malfunctions before tailpipe emissions exceed two times the tailpipe standards. Engine manufacturers do iterative testing on an engine dynamometer to determine the level of malfunction that equates to that tailpipe level and design a diagnostic using EGR parameters to detect such a level.

However, when mated with a hybrid, the engine could be utilized in different speeds and loads where it is even more dependent on proper EGR operation and thus, have even higher corresponding tailpipe emissions when a fault is detected. Engine manufacturers clearly cannot predict every possible hybrid system control strategy or feature and thus cannot by themselves design a compliant OBD system. Similarly, hybrid system manufacturers cannot by themselves be expected to know how every engine diagnostic works and make sure they design their system accordingly. This leads to the only viable solution of having an integrated system whereby some entity takes responsibility to ensure the system as a whole works. Such an approach is not unlike what engine manufacturers already do, with engine manufacturers coordinating with the suppliers that source the emission control components on their engines to ensure that the end result actually works. Hybrid system manufacturers currently do the same with their systems comprised of components from various suppliers. Coordination between the hybrid system manufacturer and the engine manufacturer (and even other entities like the transmission or vehicle manufacturers) already happens to various degrees to ensure some reasonable level of drivability and performance and to work out details such as warranty responsibility. Staff's proposal would require further coordination between the various manufacturers, especially the hybrid system manufacturer and engine manufacturer, and would ensure that somebody takes ultimate responsibility to ensure the system, in total, works. In some cases, there are manufacturers that are more vertically integrated (e.g., manufacture the engine and the vehicle and perhaps even the hybrid system), with a few of those manufacturers already well on their way to an integrated design. In other cases, staff expects hybrid system, engine, and even vehicle manufacturers to develop more formal relationships or partner together to achieve an integrated solution, though for some, staff expects the existing relationships to change very little other than more involvement between the entities and one of them taking overall responsibility for system compliance.

Thirdly, a more minor but still important element of OBD is structure and standardization of the diagnostics. The OBD requirements lay out detailed rules for everything from types of statistical protocols that can be used for diagnostics to when and how fault information must be stored and communicated to the driver and repair technicians. While the engine diagnostics should already meet these requirements, the hybrid system diagnostics likely do not, so changes would need to be made to the software in the on-board computers to be able to conform to the OBD requirements. For some of the requirements, industry standards such as SAE recommended practices are referenced and used, but some hybrid system manufacturers have expressed concern that sufficient standardization has not yet been defined for all of the various hybrid components and systems. Staff however believes the hybrid manufacturers have overemphasized the need for some elements to be standardized. The SAE committees are used to engine manufacturers and others adding new components and needing additional standardized designations and are usually able to accommodate such requests in a timely manner, so they should be able to do so here as well. Where such standardization is not likely to occur fast enough is in the area of messages for control of such systems (e.g., between the engine and hybrid system computers) - however, such standardization is not required to comply with OBD or any other ARB requirements. Any integrated approach would, by definition, resolve such issues regardless of whether the solution used standardized or proprietary control messages.

For simplification, the relief granted for the 2013 model year will be detailed in a separate document than the regulation itself. It will most likely be a mail-out or other form of document that will be directly referenced in the regulation and an alternative to complying with the regulation itself in 2013. Staff believes it is necessary to do this because the hybrid vehicles are expected to convert a vehicle containing an engine that is certified to the heavy-duty OBD regulation and those particular engines are also expected to need relief from the heavy-duty OBD requirements. Without providing clear and direct relief to engines that are used in hybrid vehicles, engine manufacturers may be hesitant to allow their engines to be used in such applications at the risk of their engines becoming noncompliant. A draft document containing the types of relief expected to be granted for engines utilized in hybrid vehicles is intended to be available before the workshop so it can be discussed in further detail at that time. It should be noted, however, that this relief is explicitly for relief from the heavy-duty OBD regulation and not from any other applicable emission standard or regulation such as tailpipe standards.

As one last point of clarification, staff's proposal to only provide relief for the 2013 model year and require OBD compliance in 2014 does not necessarily mean that all the systems will go from zero to full compliance in one year. The heavy-duty OBD regulation already contains provisions for deficiencies - areas of the requirements where manufacturers make a good faith attempt to comply in full but fall short—and manufacturers can use the provisions to still get certified even though they do not meet every requirement. Approval of deficiencies is based on several factors identified in the regulation including the overall compliance of the system, good faith effort on the part of the manufacturer to comply, and the manufacturer's plan to come into compliance as soon as possible. Staff expects many of the hybrid systems in 2014 to fall short of some of the requirements, despite their best efforts to comply, yet they will still be eligible to be certified by using the deficiency provisions. Staff also expects that some hybrid system manufacturers will make a business decision to not attempt to comply and thus will no longer be able to offer hybrids for sale in California in 2014 and beyond. For those that do remain in the California market and are thus eligible for incentive funds, the integrated design approach required by OBD will likely lead to more capable hybrids with increased efficiencies that also are more likely to meet all of ARB's requirements.

B. ALTERNATE-FUELED ENGINES

The heavy-duty OBD regulation currently allows alternate-fueled engines to delay implementation of "full" OBD systems until the 2020 model year, with 2013 through 2019 model year alternate-fueled engines required to comply only with the less comprehensive EMD requirements combined with basic monitoring of all NOx aftertreatment components. This late start date of 2020 was first proposed by staff with the expectation that alternate-fueled heavy-duty engines would make up a small portion of the market share and, based on light-duty experience with alternate fuel conversions of gasoline vehicles, that the engines would primarily be OBD-compliant gasoline or diesel engines that are converted to an alternate-fueled engine and largely continue to have functional full OBD systems. Recent information, however, has indicated that some of these assumptions by staff were incorrect or no longer are expected to hold true. Several manufacturers have indicated that alternate-fueled engine sales are not insignificant, with at least one engine manufacturer announcing plans to offer significantly more alternate-fueled engines in the near future. Recent discussions with other regulating agencies indicate they are considering near or mid-term measures to greatly increase the market share of alternate-fueled engines. Additionally, in discussions with manufacturers currently offering alternate-fueled engines, staff has found more diverse solutions than previously expected. These include alternate fuel conversions that remain compression-ignited (e.g., bi-fuel) and retain the diesel emission control solution, conversions that change from compression-ignition to spark-ignition and change over to more gasoline-like emission control solutions, conversions to non-stoichiometric spark-ignition that retain diesel-like emission control solutions, etc. Such conversions can have a much larger impact on the OBD system than simpler conversions staff were familiar with, resulting in additional unmonitored major emission control components along with the normal impacts of altering correlation to emission thresholds and monitoring frequency. Therefore, staff is proposing to move up the required start date for full OBD monitoring from the 2020 model year to the 2016 model year.

Further, while the heavy-duty OBD regulation currently does not have a specific definition for alternate-fueled engines, the definition of “gasoline engines” includes alternate-fueled engines based on staff’s presumption from light-duty experience that all alternate-fueled engines would be spark-ignited and have emission controls most like gasoline engines. As noted above, this presumption was wrong and there has been confusion about what exactly constitutes an alternate-fueled engine versus a gasoline or diesel engine. Specifically, issues have come up with engines that can use more than one type of fuel, such as bi-fueled engines (which can operate on two different types of fuels at the same time) and dual-fueled engines (which can operate on two different types of fuel but only one at a time). In some instances, engines such as bi-fueled engines are appropriately classified as alternate-fueled engines when both fuels are used for the engine to operate. In other cases, such engines can also operate exclusively on diesel or gasoline if the alternate fuel is not used or not available and such engines would not be appropriately considered alternate fueled during those conditions. Engines such as dual-fueled engines that can operate on one fuel alone (e.g., diesel, gasoline, compressed natural gas) similarly should not be classified as alternate-fueled engines while operating on gasoline or diesel. Accordingly, staff is proposing the addition of a definition that would more explicitly identify what configurations are considered alternate-fueled (and thus exempt from OBD monitoring until the 2016 model year). This clarification would provide manufacturers with direction as to what possible future configurations would be classified as and prevent gaming by manufacturers looking to inappropriately classify something as an alternate-fueled engine to avoid OBD requirements.

Lastly, regarding heavy-duty alternate-fueled engines, staff is proposing another clarification with respect to evaporative system monitoring. As currently written, engines are exempt from evaporative system monitoring if they are not required to be equipped with evaporative emission systems. Technically, ARB regulations do not mandate vehicles be equipped with evaporative emission systems but, instead, establish evaporative emission standards and identify which vehicles are subject to the standards. Accordingly, the proposed change would exempt engines from evaporative monitoring if they are not subject to the evaporative emission standards. As examples, compressed natural gas engines are not subject to evaporative emission standards but liquid propane gas (LPG) engines are subject to the standards. The change would make it clear that evaporative system monitoring is required for LPG engines, irrespective of whether the manufacturer claims it has or has not equipped the engine with an evaporative emission system. Alternate-fueled engines that are subject to evaporative emission standards and thus required to do evaporative system monitoring would be required to submit a plan for Executive Officer approval on what monitoring they would do and its equivalence to the type of evaporative system monitoring required for gasoline applications.

C. DEFINITIONS

The heavy-duty OBD regulation currently allows manufacturers to erase a confirmed fault code or a previously MIL-on fault code if the identified malfunction has not been again detected in at least 40 engine warm-up cycles and the MIL is presently not illuminated for that malfunction. The regulation currently defines “warm-up cycle” as “sufficient vehicle operation such that the coolant temperature has risen by at least 40 degrees Fahrenheit from engine starting and reaches a minimum temperature of at least 160 degrees Fahrenheit (140 degrees Fahrenheit for applications with diesel engines).” There have been concerns about certain vehicles such as vehicles with highly efficient engines that may not be able to meet these temperature criteria under normal driving and ambient conditions. Staff understands that some allowances should be made for such vehicles that are unable to warm-up the engine coolant temperature to the defined temperatures even if it has been sufficiently driven. Thus, staff is proposing to allow manufacturers the option to define a “warm-up cycle” as a driving cycle in which the criteria to erase a permanent fault code for continuous monitors are met. 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 confirmed or previously-MIL on fault codes.

Staff is proposing changes to the permanent fault code erasure requirements and the in-use monitor performance requirements that would apply to heavy-duty hybrid vehicles, the details of which are described below. Given the context of the proposed changes, new definitions would be needed to complement the proposed requirements. Thus, staff is also proposing three new definitions for “hybrid vehicle,” “fueled engine operation,” and “propulsion system active” to supplement the proposed changes. More details about the proposed definitions can be found below.

D. MIL ILLUMINATION AND FAULT CODE STORAGE PROTOCOL

The heavy-duty OBD regulation currently requires vehicles using the ISO 15765-4 protocol to store and erase freeze frame conditions in conjunction with the storage and erasure of either the pending fault code or the confirmed fault code. This, however, has unintentionally allowed manufacturers to erase freeze frame conditions for pending fault codes that mature to confirmed fault codes and leave repair technicians without helpful information to diagnose detected faults. To prevent such issues, staff is proposing that starting with the 2016 model year, manufacturers are required to store freeze frame conditions in conjunction with storage of pending fault codes. If the pending fault code is erased in the next driving cycle because no fault is detected, the manufacturers would be required to also erase the freeze frame conditions. Otherwise, if the pending fault code matures to a confirmed fault code, the manufacturer would be required to either retain the current freeze frame conditions or update the freeze frame conditions with those related to storage of the confirmed fault code. For monitors that do not store pending fault codes (e.g., one-trip monitors or monitors that use alternate statistical MIL illumination strategies), staff is proposing that manufacturers store and erase freeze frame conditions in conjunction with storage and erasure of a confirmed fault code.

Additionally, staff is proposing changes to address issues concerning permanent fault code erasure on heavy-duty hybrid vehicles for monitors that are designed to run continuously, including monitors that must wait until similar conditions are satisfied (e.g., gasoline misfire and fuel system monitors). Currently, the regulation requires that the permanent fault code for these monitors be erased only after the vehicle has been operated such that, among other conditions, criteria similar to those for a general denominator (section 1971.1(d)(4.3.2)(B)) have been satisfied on a single driving cycle (with the exception that the general denominator conditions require ambient temperature above 20 degrees Fahrenheit or below 8000 feet in elevation). This ensures 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 the permanent fault code. Among these conditions is the criterion that the “cumulative time since engine start” be greater than or equal to 600 seconds. This language may not be clear for vehicles such as hybrid vehicles, where the engine may not start running at the beginning of a drive cycle like it would on a conventional vehicle. Thus, for hybrid vehicles, staff is proposing to clarify that manufacturers should use 600 cumulative seconds of “propulsion system active” time in lieu of the 600 cumulative seconds after engine start, with “propulsion system active” defined as when the vehicle is operated, regardless of whether it is powered by the battery or the engine or both. Staff believes this new definition would ensure equivalent vehicle operation time between conventional vehicles and hybrid vehicles.

Staff is also proposing minor amendments to the erasure protocol for confirmed or previously MIL-on fault codes in the heavy-duty OBD regulation. The regulation language currently states that the OBD system “may” erase the fault code if the fault isn’t again detected “in at least” 40 warm-up cycles” and the MIL is not presently illuminated for that fault. To ensure consistency among manufacturers, staff is proposing to modify the language to state that the OBD system "shall" erase the fault code if the fault isn't again detected "in" 40 warm-up cycles and the MIL is not presently illuminated for that fault – this amendment would apply starting with the 2016 model year. This change will also ensure that repair technicians focus on recently detected faults and are not led astray chasing down faults that have long since disappeared.

E. STANDARDIZED METHOD TO MEASURE REAL WORLD MONITORING PERFORMANCE

The heavy-duty 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. The regulation also requires all vehicles to keep track of a "general denominator", which is a measure of how often the vehicle is operated. The regulation requires manufacturer to increment this denominator only if certain criteria are satisfied on a single driving cycle. This method allows very short trips or trips during extreme conditions such as very cold temperatures or very high altitude to be filtered out and excluded from the count. This is appropriate because these are also conditions where most OBD monitors are neither expected nor required to operate.

The heavy-duty OBD regulation currently requires all vehicles to increment the general denominator if, among other conditions, the cumulative time since engine start is greater than or equal to 600 seconds. For the same reasons noted above, hybrid vehicles need an alternate definition to recognize trips where the engine does not start right away. Thus, similar to the changes proposed above for the permanent fault code erasure protocol, for hybrid vehicles, staff is proposing to clarify that manufacturers must use 600 cumulative seconds of "propulsion system active" time in lieu of the 600 cumulative seconds after engine start when incrementing the general denominator. Additionally, staff is also proposing to require 10 seconds of "fueled engine operation" to be met in order to increment the general denominator to discern between trips with and without engine operation. This condition would ensure that only trips where the engine has at least turned on once during the driving cycle are counted when looking at how often engine-related emission control component monitors are running. These proposed changes would apply to all 2016 and subsequent model year hybrid vehicles.

Staff is also proposing amendments to the in-use monitor performance requirements for PM filter monitors. The heavy-duty OBD regulation currently requires the PM filter active/intrusive injection monitor (section 1971.1(e)(8.2.6)) to increment the denominator when , in addition to the general denominator criteria, a regeneration even tis commanded for a time greater than or equal to 10 second. Intrusive injection, however, is not necessarily tied to when regeneration begins. Staff believes the denominator incrementing criteria for such a monitor should instead be similar to monitors of other components/systems that are commanded to activate in-use where monitoring frequency is tracked relative to how often that particular component or system is used. Thus, staff is proposing to require manufacturers to increment the denominator for this monitor when, in addition to the general denominator criteria, the intrusive injection is commanded to function for a cumulative time greater than or equal to 10 seconds.

Further, staff is also proposing amendments to the in-use monitor performance requirements for PM sensor and PM sensor heater monitors. The heavy-duty OBD regulation currently requires the PM sensor monitoring capability monitor (section 1971.1(e)(9.2.2)(D)) and the PM sensor heater monitor (section 1971.1(e)(9.2.4)(A)) to use the general denominator as the monitor denominators. PM sensors, like PM filters, may be regenerated infrequently in-use, which may make frequent monitoring difficult. Further, as opposed to oxygen sensor and NOx sensor heaters, PM sensor heaters may be used infrequently in-use. Manufacturers are concerned that using the general denominator may result in the denominator incrementing more often than is appropriate for the sensor technology and how it is used. Thus, staff is proposing to allow manufacturers to propose alternate criteria (for ARB review and approval) to increment the denominator for PM sensor monitoring capability monitors until further experience is gained and more appropriate criteria can be defined in the regulation. For PM sensor heater monitors, staff is proposing to require manufacturers to increment the denominator when, in addition to the general denominator criteria, the heater has been commanded to function for a cumulative time greater than or equal to ten seconds.

Staff is also proposing changes to the ignition cycle counter requirements for heavy-duty hybrid vehicles. Currently, manufacturers are required to track and report an ignition cycle counter, which is required to be incremented every time the vehicle is started (i.e., “engine start” is met). This is basically a counter of the number of driving cycles experienced by the vehicle. Staff is proposing to modify the incrementing criteria for hybrid vehicles – specifically, staff is proposing to clarify that manufacturers increment the ignition cycle counter when the “propulsion system active” definition is met (e.g., each time the vehicle is operated, without respect to whether the engine is started or used).

Further, staff is proposing changes to the tracking and reporting requirements in the heavy-duty OBD regulation. Firstly, staff is modifying the diesel components/systems required to report in-use monitoring performance data (section 1971.1(d)(5.1.1) to align with the requirements in SAE J1979 and J1939. Secondly, staff is proposing changes to the in-use performance tracking and reporting requirements for diesel NOx and PM sensor monitors. The regulation currently does not require manufacturers to track and report the diesel NOx/PM sensor “monitoring capability” monitors (section 1971.1(e)(9.2.2)(D)) – it only requires manufacturers to track and report diesel NOx/PM sensor performance monitors that are emission threshold-based (section 1971.1(e)(9.2.2)(A)). However, recent discussions between staff and manufacturers have indicated that many of these sensors do not have such emission-threshold based monitors, and thus would only be subject to monitoring for faults that cause the sensor to no longer be sufficient for use as an OBD system monitoring device. Considering how important NOx and PM sensors are for monitoring of major aftertreatment emission control devices, it should be ensured that these monitors are running frequently in-use. Thus, staff is proposing to require manufacturers to additionally track and report the diesel NOx/PM sensor “monitoring capability” monitors.

Lastly, staff is considering amendments to the in-use monitor performance requirements that define a minimum acceptable in-use ratio and monitor-specific criteria for determining the ratio in the heavy-duty OBD regulation. When the current 0.100 minimum ratio was first adopted, staff did not have enough in-use driving data for heavy-duty vehicles to be able to determine more applicable final ratios. The ratios (and the denominator criteria for certain monitors) also took into account the likely monitoring technologies expected in the phase-in timeframes. Since then, staff believes there is enough data and information to propose some amendments including changes to the PM filter performance denominator criteria and minimum ratio given the likely future technologies and the importance of a properly-operating PM filter. Staff expects to discuss this in more detail at the workshop.

F. DIESEL MISFIRE MONITORING

Diesel manufacturers are currently required to monitor for misfire only during engine idle conditions and only for faults that cause one or more cylinders to be continuously misfiring. This requirement was first proposed based on diesel manufacturers’ assertion that misfire only occurred due to poor compression and would result in a cylinder misfiring under all operating conditions. The current heavy-duty OBD requirements also specify that, for 2013 and subsequent model year diesel engines equipped with sensors that can detect combustion or combustion quality, diesel manufacturers are required to monitor for misfire continuously under all positive torque engine speeds and load conditions. The premise for this was that engines so equipped would likely be more precisely controlling the combustion process based on information from these sensors such that misfires could likely exist only in limited operating regions.

However, the complexity of today’s control strategies on all diesel engines and the addition of new technologies in recent years, like aggressive use of EGR or target air-fuel ratios or fresh air concentrations in certain operating conditions, has resulted in additional factors that can cause misfire in very specific operating conditions instead of continuously under all conditions. Thus, even for diesel engines that do not have direct combustion quality sensors, staff is concerned that real world malfunctions will cause intermittent or off-idle misfires that would increase emissions but go undetected with today’s monitors. As stated in the 2005 Staff Report when the heavy-duty OBD regulation was first adopted, staff intended to investigate the possibility of such misfires and had indicated that a more comprehensive requirement may be proposed at a future Board review based on their findings. Staff has found that in the field that for such engines, misfire can occur during specific speed and load regions that would not be detected by an idle-only misfire monitor. Thus, staff is proposing to require all 2016 and subsequent diesel engines to continuously monitor for misfire and to detect misfire before the NMHC, CO, or NOx emissions exceed 2.0 times the application standards or the PM emissions exceed the applicable standard plus 0.02 g/bhp-hr.

G. DIESEL EXHAUST GAS RECIRCULATION (EGR) SYSTEM MONITORING

The heavy-duty OBD regulation currently requires manufacturers to monitor any EGR catalysts used in the EGR system on all 2013 and subsequent model year engines. Such catalysts, though not very common, are used to further clean up the exhaust gas before it is recirculated into the intake of the engine to reduce contamination or fouling that might otherwise affect durability of the EGR system. While failures of the EGR catalyst may not result in an immediate impact on emissions, such failures lead to more aggressive deterioration of other EGR system components such as fouling or plugging of the EGR cooler. Manufacturers, however, have argued that OBD has always focused on monitoring of components that directly influence emissions, not components that help to sustain the effectiveness or durability of the system. Further, they argued that there are issues with detecting and pinpointing EGR catalyst failures as opposed to relying on other monitors such as the EGR cooler diagnostic to eventually detect the subsequent failure of the cooler itself. Thus, staff is proposing to allow manufacturers to be exempt from monitoring the EGR catalyst if they can show that a fault of the catalyst will not cause a measurable emissions impact on the criteria pollutants (i.e., NMHC, CO, NOx, and PM) during any reasonable driving condition where the catalyst is most likely to affect criteria pollutants.

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

The heavy-duty OBD regulation currently requires 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 2.0 times the applicable standard for 2013 and subsequent 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.

Similar to what they argued during the 2009 heav-duty OBD biennial review, manufacturers have again expressed concern 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 again 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 to detect completely failed catalysts.

In the 2009 heavy-duty OBD staff report, staff detailed some possible monitoring approaches to meet the threshold monitoring requirements. Engine manufacturers have since argued the proposed approaches are not feasible. In the 2009 staff report, to counter manufacturers argument 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, staff had indicated that in talking with suppliers and individual manufacturers, catalysts do 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). Manufacturers now argue that though there may be some validity to this, there are significant limitations including the narrow temperature and time window around catalyst light-off that the exotherm monitor must run. Staff also mentioned in the 2008 staff report about monitoring the catalyst during a cold start, where the 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. Manufacturers again argued there are limitations with this approach as well, with many factors including the condition of the catalyst that can affect catalyst warm-up, and note that most manufacturers have found that the cold start component monitor for the catalyst can only detect a completely failed catalyst. Lastly, staff mentioned in the 2008 staff report that manufacturers can also reduce the engine-out NMHC emissions associated with a malfunctioning catalyst. Manufacturers have countered that lower engine-out NMHC emissions would mean higher engine-out NOx emissions, which would make it more difficult to meet the NOx-based monitoring requirements.

In more recent discussions with manufacturers and suppliers, staff has found that some manufacturers have indeed been successful in incrementally aging the NMHC catalyst much like what has been done for over 15 years with gasoline catalysts. Additionally, virtually all manufacturers have indeed moved towards higher engine-out NOx emission levels (and consequently, lower engine-out NMHC emission levels) to maximize efficiency and use of SCR systems as staff suggested was possible, thus requiring detection of a more degraded NMHC catalyst than before. Further, at least one manufacturer has already successfully demonstrated the ability to detect a degraded catalyst prior to emissions exceeding the current 2013 model year thresholds by monitoring the exotherm of the catalyst during regeneration events. Virtually all manufacturers have continued to make significant improvements to regeneration emissions both by increasing the time between regenerations and lowering the emissions during the actual regeneration events. This leads to reduced influences from the infrequent regeneration adjustment factors (IRAF), making it less of a factor in determining the threshold catalyst. Nonetheless, if a manufacturer were to choose a solution that still was very sensitive to NMHC catalyst degradation (due to high engine-out NMHC and/or high IRAFs), it is appropriate that such a solution be monitored at a reasonable emission level and not at something that is four times a standard that is already generous for diesel engines. Accordingly, staff is proposing no change in the current NMHC catalyst monitoring threshold.

Additionally, staff is proposing amendments to the heavy-duty OBD requirement for manufacturers to monitor the ability of the catalyst 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). Currently, the regulation requires 2013 and subsequent model year engines to meet this requirement. During the most recent OBD II regulatory review for light- and medium-duty vehicles, manufacturers have asked ARB to delay the start date to meet this requirement to the 2016 model year in part because their original plans to comply were based on using monitors for the NMHC conversion efficiency of the NMHC catalyst and/or NOx conversion efficiency of the SCR system and such approaches were not uniformly successful. This resulted in manufacturers having to investigate alternative monitoring strategies and consequently indicating they need more time to verify these strategies. While staff believes it is feasible to develop a monitor to meet this requirement and at least one manufacturer has already shown it will have this capability for the 2013 model year, staff acknowledges that more time is needed to develop a robust monitor to meet this requirement. Thus, to be consistent with what staff had recently proposed for the OBD II regulation, staff is proposing to delay monitoring of proper feedgas generation until the 2015 model year for heavy-duty engines.

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

The heavy-duty OBD regulation requires manufacturers to detect conversion efficiency faults of the NOx converting catalyst (typically a selective catalytic reduction (SCR) catalyst) before NOx emissions exceed the following thresholds: for the 2010 through 2012 model years, the applicable NOx standard plus 0.4 g/bhp-r, and for the 2013 and subsequent model years, the applicable NOx standard plus 0.2 g/bhp-hr.

Manufacturers have argued that the dynamics of the SCR system and its control, including the NOx sensors and the reductant delivery system, have made it difficult to meet the 2013 model year requirements. They contend that due to the high degree of conversion efficiency of the SCR catalyst, a system degraded to the level required to be detected by the OBD system is still a highly functioning SCR system and provides little separation from a properly performing one. They further contend that a good catalyst could resemble a bad catalyst since the instantaneous conversion efficiency can dramatically change given the operating conditions. Adding to the issue is the cross-sensitivity of the NOx sensors to ammonia (NH_3) and the less-than-desired accuracy of the sensors needed for robust monitoring.

Staff has met with virtually every manufacturer and several suppliers to assess current capability and what improvements are available in the near term. While several medium-duty manufacturers are on track to meet the existing 2013 standards, most heavy-duty manufacturers are not. Given the importance of achieving and preserving the NOx benefits of the 0.2 g/bhp-hr tailpipe standard, staff is committed to continuing to drive to the limits of technical feasibility to achieve the lowest threshold possible. Further, given industry trends towards increasing engine-out NOx emissions even higher for efficiency improvements or greenhouse gas reductions, staff is concerned that some may try to push too far in that direction such that tailpipe or OBD capability is sacrificed. Thus, staff is cautious about providing even interim relief that could be misinterpreted as showing that some ARB requirements are more important than others instead of keeping manufacturers on track to find a reasonable middle ground that meets all of our requirements, including OBD, tailpipe standards, and greenhouse gas standards (where applicable). In discussions with the manufacturers, it seems there are many elements of base SCR control and dynamics that are not well refined or understood. The problem appears to be exacerbated on larger catalysts that are more common on the biggest engine displacements, and many point to unknowns related to ammonia storage and release that produce both inconsistent in-use conversion efficiency and, consequently, quite varied catalyst monitoring results. Last-minute changes to the underlying base emission control strategy has also placed the OBD engineers within manufacturers at a disadvantage by forcing them to either develop and calibrate on less-than-finalized software or wait until very late in the process to begin the calibration process. Those manufacturers with more stable emission control solutions that were finalized early in the process tend to be further ahead in OBD capability as well.

When talking with manufacturers and suppliers, staff identified several items that continue to show promise for achieving the current 2013 model year threshold of the NOx tailpipe standard + 0.2 g/bhp-hr. NOx sensor accuracy is not expected to get appreciably better than the +/-10% and +/- 10 ppm accuracy of current sensors, but that doesn’t appear to be the limiting factor to achieving the final thresholds. Some manufacturers have shifted some focus to looking more at ammonia storage—both for purposes of better controlling emissions in the first place and also for another metric to correlate with the performance of the catalyst itself. One supplier has indicated that ammonia storage capability is affected earlier and more dramatically on deteriorated catalysts than NOx sensor-based measurements can detect, implying that monitoring strategies based on or incorporating some measure of ammonia storage would likely be more sensitive and able to detect malfunctioning catalysts sooner. Some manufacturers have even incorporated (or plan to incorporate) ammonia sensors to better quantify and understand the storage and release phenomena. Some of these strategies may even include intrusive monitors that saturate and/or deplete ammonia storage to better assess the current catalyst performance. Others have indicated they plan to look at partial volume monitoring approaches to monitor the conversion efficiency over a smaller portion of the total catalyst volume in an attempt to be able to work in an environment with higher NOx outlet concentrations. To the extent that the smaller engines (and thus catalysts) are closer to achieving (if not already achieving) the 2013 model year thresholds, such an approach continues to have promise. Additionally, some manufacturers believe that they just need to get a better handle on what they are currently observing as high variability in the monitor results through better base control strategies, including adaptive algorithms, further refinement of enable conditions to eliminate driving conditions that cause big fluctuations in catalyst efficiency, and even improved statistical filtering of the results.

Taking that all into consideration, staff is proposing a couple changes to the current requirement of a '+ 0.2' threshold across the board in the 2013 model year. Specifically, staff is proposing that for medium-duty vehicles, which are already further along than some of their heavy-duty counterparts (primarily because of the smaller catalyst size, more constrained vehicle packages and usage patterns, and perhaps earlier timing for finalized base calibrations), manufacturers would be required to meet a threshold of '+0.3' (i.e., the engine dynamometer standard + 0.3 g/bhp-hr) instead of the '+0.2' current threshold. For chassis dynamometer-certified applications, based on the current capability of several such products, a threshold of 2.0x the applicable standard would be used as a level that is consistent with section 1968.2(f)(17.1.5)(C), which requires the threshold be set as tight as technically feasible.

For heavy-duty applications, staff is proposing to modify the 2013 model year threshold to remain at the '+0.4' threshold that applied in 2012. However, starting with the 2014 model year, manufacturers would be required to phase in a tighter threshold of '+0.3'. Specifically, manufacturers would have to meet the '+0.3' threshold on 20% of their 2014 model year volume and 50% of their 2015 model year volume. For the 2016 model year, manufacturers would be required to meet the '+0.2' threshold with the exception that any products that were phased-in during 2014 or 2015 to the '+0.3' threshold would be able to remain at that threshold in 2016 and would not have to meet the '+0.2' threshold until the 2017 model year. This phase-in would force manufacturers to continue to push forward but allow them to focus their efforts on the easier products in the early years as well as give them time to continue to evolve base calibration beyond what was done for the 2013 model year. Further, the carry-over provision for the 2016 model year would provide them relief from having to recalibrate their entire product line to meet the tighter threshold in that one year. The phase-in would also provide much needed time to improve ammonia storage estimations and explore alternative monitoring methods or metrics.

J. 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 PM emissions exceed a specific threshold. For the 2010 through 2012 model year engines, the PM threshold was essentially 0.07 g/bhp-hr (for an engine certified to the nominal standard of 0.01 g/bhp-hr). For most 2013 through 2015 model year engines, the PM threshold drops to 0.05 g/bhp-hr (again for an engine certified to the nominal standard of 0.01 g/bhp-hr). For all 2016 and subsequent model years and for the 2013 through 2015 model years of the one engine family per manufacturer that was phased-in to HD OBD in the 2010 through 2012 model years, the threshold is 0.03 g/bhp-hr (for an engine certified to the nominal standard of 0.01 g/bhp-hr). For medium-duty vehicles and engines, the only difference is that the 0.03 g/bhp-hr standard applies across the board in 2013 and subsequent model years in lieu of a phase-in on some products in 2013 and the rest in 2016.

The heavy-duty OBD regulation originally required manufacturers to meet the PM threshold of 0.050 g/bhp-hr starting in the 2010 model year, but due to heavy-duty engine manufacturers' concerns about meeting the threshold, staff amended the starting date to the 2013 model year based on projections that PM sensors, which many believe will be the only viable way to meet the thresholds, would be available in time for the 2013 model year. Now manufacturers are still expressing concern that the threshold is too stringent and is not technically feasible for the 2013 model year time frame. They contend that PM sensors are not yet commercially ready across all of industry and thus, the emission threshold needs to be revised to what current monitoring technologies (primarily backpressure or delta pressure-based metrics) are capable of achieving. Accordingly, they proposed that heavy-duty engines continue to use the 2010 model year 0.07 g/bhp-hr PM threshold up to and including the 2015 model year, with 2016 and subsequent model year engines using the PM threshold of 0.05 g/bhp-hr.

Like noted earlier, staff met with virtually every manufacturer and several suppliers to assess their monitoring capabilities for 2013 and further improvements for the near term. And while at least one light-duty manufacturer is implementing a PM sensor in 2013 model year and a few heavy-duty manufacturers were on track to do that until very recently, staff generally agrees that PM sensors are not ready for full scale implementation in the 2013 model year. In some cases manufacturers have indicated 2014 model year is still viable for implementation on some of their products while others have indicated 2015 model year is more likely. Further, in most cases, the sensors continue to indicate that they are certainly capable of detecting faults at the final PM threshold level of 0.03 g/bhp-hr. Accordingly, some interim relief is appropriate given the delay in PM sensors becoming truly viable across industry. However, several manufacturers have continued to move forward on alternate monitoring techniques, including further refinement of delta pressure-based approaches and concepts such as a downstream secondary filter optimized for monitoring capability. In some cases, especially on medium-duty products, such techniques have already achieved the emission level of the 2016 threshold. However, some of these monitoring strategies still rely on relief provided in the regulation (and recently extended through the 2013 model year for medium-duty) to allow ARB to exclude certain failure modes such as a partially melted and partially cracked filter that results in the identical delta pressure characteristics of a good filter. Such relief is set to expire in 2014 for medium-duty because it provides an unknown risk for failures that cause high PM emissions to go undetected, but was seen as a necessary interim step to accommodate the best available monitoring techniques. Lastly, as most in industry continue to move towards higher engine-out NOx emission levels, this necessarily results in lower engine-out PM levels. As engine-out levels decrease, the amount of degradation of the PM filter the engine can handle before the emission threshold is reached is substantially increased. In some cases, engine-out levels are reaching 0.5 g/bhp-hr or lower, which in turn means a PM filter would need to drop from a 95% or higher trapping efficiency down to something less than 60% efficiency to reach the threshold of 0.3 g/bhp-hr.

Taking this into account, staff is proposing a variety of changes to the thresholds including a couple of phase–in options to provide some interim relief. With minor exceptions depending on the phase-in options selected, medium-duty and heavy-duty applications would all have the same end point for all 2016 and subsequent model year engines: PM threshold levels of 0.03 g/bhp-hr and no relief provision for exclusion of certain failure modes. PM sensors are certainly on track to be available across industry before that timeframe so that is a viable solution to meet the requirements.

Staff is proposing the following changes to the OBD II regulation for medium-duty vehicles. For the 2013 model year, staff is proposing that the PM threshold for medium-duty vehicles remain at 0.03 g/bhp-hr and with the recently added relief through 2013 model year of allowing the ARB to exclude specific failure modes. For 2014 and 2015 model year, medium-duty manufacturers would have two options. First, they could choose to implement monitoring to a PM threshold of 0.03 g/bhp-hr without the failure mode exemption relief on at least 20% of their 2014 model year medium-duty diesel volume and certify the rest of their 2014 model year volume to the 2013 threshold of 0.03 with the failure mode exemption. For the 2015 model year, the manufacturer would be allowed to meet the same requirements, allowing essentially full carry-over from 2014 to 2015. Alternatively, a manufacturer could chose to continue to meet the 2013 threshold with failure mode exemption relief in the 2014 model year. However, for the 2015 model year, the manufacturer choosing this second path would need to certify at least 50% of its 2015 model year medium-duty diesel volume to the threshold of 0.03 without the failure mode exemption. These two options provide manufacturers the flexibility to either implement earlier (2014 model year) on a smaller portion of their fleet or implement later (2015 model year) but on a larger fraction of their fleet.

Staff is proposing the following changes to the heavy-duty OBD regulation. For 2013 model year heavy-duty engines, staff is proposing the PM threshold of 0.05 g/bhp-hr apply to all engines and to retain the provision for ARB to exempt certain failure modes. For 2014 and 2015 model year heavy-duty engines, staff is proposing two options. First, manufacturers can choose to certify 20% of their 2014 model year heavy-duty diesel volume to a PM threshold of 0.05 without the failure mode exemption relief. For those using this option, the requirements for the 2015 model year would be the same, allowing essentially carry-over from 2014 to 2015. Additionally, manufacturers using this alternative would be allowed to carry-over the 0.05 threshold without the failure mode exemption into the 2016 model year on engines first certified to this option in the 2014 model year. This would provide an extra year at the higher threshold on those engines brought in early and allow the manufacturer to avoid having to recalibrate all of its products in 2016 to the lower 0.03 threshold. As an alternative, manufacturers could choose to certify the 2014 model year engines to the same requirements as the 2013 model year --- a PM threshold of 0.05 g/bhp-hr with failure mode exemption relief. Those choosing this second option, however, would be required to certify 50% of their 2015 model year diesel volume to a PM threshold of 0.03 g/bhp-hr without the failure mode exemption. Manufacturers choosing this second option would also still be required to meet the 0.03 threshold without failure mode exemption on all 2016 model year engines.

The heavy-duty OBD regulation also currently requires manufacturers to monitor the NMHC conversion capability of catalyzed PM filters starting with the 2013 model year. The catalyzed coating of a PM filter has secondary functions that have an emission impact. These functions can include promotion of passive regeneration at lower exhaust temperatures, conversion of HC and carbon monoxide created during an active regeneration, and generation of NO_2 feedgas for downstream SCR systems. Manufacturers, however, have argued that many of these functions are just side effects that directionally help, but are not necessary to comply with the emission standards. They further indicated that there are currently no suitable robust monitoring strategies available to discern the proper operation of these secondary functions. Thus, manufacturers have asked ARB to delay the start date to meet this requirement to the 2016 model year. Staff believes that such secondary functions are not trivial and warrant monitoring to ensure overall effectiveness of the emission control system. The success of the monitoring approaches may still 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) and thus require manufacturers to take OBD monitoring capability into consideration when designing and implementing the aftertreatment system and control strategy; however, staff recognizes that the OBD engineers have often been left out of the design process due to the rapid deployment of new technologies and increasingly stringent standards. Thus, consistent with what staff had recently proposed for the OBD II regulation, staff is proposing to delay the monitoring requirements of the catalyst function of catalyzed PM filters until the 2015 model year for heavy-duty engines to give manufacturers more time to refine their systems, optimize regeneration strategies, and better investigate the impacts of the catalyzed PM filter.

Further, staff is also proposing that for 2015 and subsequent model year engines that use catalyzed PM filters to generate feedgas constituency (e.g., NO_2) to assist SCR systems, manufacturers are required to monitor the capability of the system to generate this desired feedgas. Currently, the heavy-duty OBD regulation has specific language requiring manufacturers to monitor the NMHC catalyst for proper feedgas generation for the SCR system, since this seems to be the primary component used to generate such feedags. Staff has learned, however, through discussions with manufacturers that catalyzed PM filters were also used to generate such feedgas. Thus, staff's proposal would ensure that monitoring of all components that generate the desirable feedgas is covered.

K. DIESEL NOx SENSOR MONITORING

The heavy-duty OBD regulation currently requires manufacturers to detect faults of the NOx sensor before emissions exceed the following thresholds: for the 2010 through 2012 model years, the applicable NOx standard plus 0.4 g/bhp-r, and for the 2013 and subsequent model years, the applicable NOx standard plus 0.2 g/bhp-hr. Manufacturers have argued that they are unable to meet the 2013 model year thresholds given the current NOx sensor technology – specifically, considering the tolerances of the latest NOx sensors, they claimed there is too little separation between good sensors and bad sensors to ensure robust detection. Thus, they proposed that staff delay the 2013 model year thresholds until a later model year.

There is undoubtedly some interaction between NOx sensors located downstream of the NOx converting catalyst and the sensor itself, making it more difficult to discern sensor malfunctions from catalyst system malfunctions. Manufacturers, however, have come up with separate diagnostics to discern the likely root cause and be able to direct a repair technician to a troubleshooting procedure that focuses on the likely cause. For upstream sensors, the condition of the NOx converting catalyst system has little or no impact and other aftertreatment upstream of the sensor generally has minimal impact on the NOx levels the sensor sees. Accordingly, most manufacturers have monitoring strategies based on expected/modeled engine-out emission levels. Given the higher NOx concentrations seen by the upstream sensor, the limitations of sensor accuracy (+/- 10%) have a smaller impact on the ability to discerning a threshold sensor from a good sensor. Nonetheless, manufacturers are still refining these diagnostics including improving engine-out models and adaptation strategies to compensate for any sensor drift.

Accordingly, staff is proposing identical thresholds for NOx sensors as those being proposed for NOx converting catalyst monitoring (described in section I above). Specifically, staff is proposing that for 2013 model year medium-duty vehicles, manufacturers would be required to meet a threshold of '+0.3' (i.e., the engine dynamometer standard + 0.3 g/bhp-hr) instead of the '+0.2' current threshold. For heavy-duty applications, staff is proposing to modify the 2013 model year threshold to remain at the '+0.4' threshold that applied in 2012. However, starting with the 2014 model year, manufacturers would be required to phase in a tighter threshold of '+0.3'. Specifically, manufacturers would have to meet the '+0.3' threshold on 20% of their 2014 model year volume and 50% of their 2015 model year volume. For the 2016 model year, manufacturers would be required to meet the '+0.2' threshold with the exception that any products that were phased-in during 2014 or 2015 to the '+0.3' threshold would be able to remain at that threshold in 2016 and would not have to meet the '+0.2' threshold until the 2017 model year. As already stated in section I for NOx catalyst monitoring, this phase-in would force manufacturers to continue to push forward but allow them to focus their efforts on the easier products in the early years as well as give them time to continue to evolve base calibration beyond what was done for the 2013 model year. Further, the carry-over provision for the 2016 model year would provide them relief from having to recalibrate their entire product line to meet the tighter threshold in that one year.

L. GASOLINE MISFIRE MONITORING

The heavy-duty OBD regulation currently requires manufacturers to continuously monitor for misfire faults from no later than the end of the second crankshaft revolution after engine start and, for engines that employ shutoff strategies (e.g., hybrid vehicles that shut off the engine at idle), no later than the end of the second crankshaft revolution after each engine restart. The term “engine start” is currently being used in the regulation for many requirements with the intent that “engine start” signifies the start of vehicle operation, which may or may not involve the engine actually being started in a hybrid vehicle. To avoid confusion about when exactly misfire monitoring is required to resume after the engine is shutoff, staff is proposing to revise the language to require manufacturers to monitor for misfire faults from no later than the end of the second crankshaft revolution after “engine fueling begins for the initial start and after each time fueling resumes.”

M. GASOLINE SECONDARY AIR SYSTEM MONITORING

The heavy-duty OBD regulation currently requires manufacturers to monitor the secondary air system for malfunction prior to either a decrease or an increase from the manufacturer’s specified air flow that would cause emissions to exceed 1.5 times the standards. Further, if no fault could cause emissions to exceed 1.5 times the standards, the manufacturer is required to detect a fault when “no detectable amount of air flow is delivered during normal operation of the secondary air system”, but no functional monitoring is required for failures that cause an increase in air flow. Consistent with what is required for other component/system monitors, staff believes that complete coverage of faults is needed for secondary air systems as well. Thus, staff is proposing to modify the language to require manufacturers to detect a fault when no detectable amount of air flow is delivered only if no fault that causes a decrease in air flow could cause emissions to exceed the threshold. However, if no fault that causes an increase in air flow could cause emissions to exceed the threshold, the manufacturer would be required to detect a fault when the system has reached its control limits such that it cannot reduce air flow during normal operation of the secondary air system.

N. ENGINE COOLING SYSTEM MONITORING

The heavy-duty OBD regulation requires manufacturers to monitor cooling systems for malfunctions that affect emissions or other 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 thermostat 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. Currently the regulation requires this thermostat monitor to be enabled “on every driving cycle in which the ECT sensor indicates, at engine start, a temperature lower than the” threshold temperature, but also indicates that ARB will not approval “disablement of the monitor on engine starts where the ECT at engine start is more than 35 degrees Fahrenheit lower than the” threshold temperature. The language has caused confusion about when the thermostat monitor is allowed to be enabled on a given driving cycle. Thus, staff is proposing clarifications to the language to make clear when the thermostat monitor can be enabled. Essentially, the manufacturers is required to disable the thermostat monitor on driving cycles where the ECT at start is within 35 degrees Fahrenheit of the thermostat monitor malfunction threshold temperature to avoid false passes when cooling system faults are present but still manage to warm the system up by a few degrees. However, manufacturers may request Executive Officer approval to enable the monitor if the ECT at start is within a portion of this region (e.g., if the malfunction threshold temperature is 160 degrees Fahrenheit, the manufacturer may request approval to enable the monitor for a portion of the temperature region above 125 degrees but still below 160 degrees Fahrenheit) provided they submit data demonstrating that the monitor can indeed robustly detect thermostat malfunctions and is not at risk for false passing when starting at engine temperatures in those regions.

O. COMPREHENSIVE COMPONENT MONITORING

The heavy-duty OBD regulation currently requires diesel manufacturers to detect faults of the idle control system if, among other things, the fuel injection quantity is "within +/-50 percent of the fuel quantity necessary to achieve the target idle speed for a properly functioning engine and the given operating conditions." Manufacturers have expressed concern that not all the "given operating conditions" are known to manufacturers, making it hard to determine what the appropriate fuel quantity to achieve the target idle speed should be and, consequently, whether or not there actually is a fault. Staff is proposing to modify the language to require detection of idle control system faults of the fuel quantity in relation to achieving the target idle speed for "known", not "given," operating conditions.

The heavy-duty OBD regulation currently requires manufacturers 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 on 2013 and subsequent model year engines. Examples of these include individually coded injector flow characteristics and fuel pumps that use in-line resistors to correct differences in fuel pump volume output. Monitoring of the components would ensure that misassembled systems, erroneous programming, or incomplete repair procedures that result in incorrect adjustment being applied (and consequently, increases in emission levels) will be detected. Manufacturers, however, have questioned the need to monitor this feature and have expressed concern about meeting this requirement in the 2013 timeframe. They additionally stated that the fuel system monitoring requirements already require detection of emission-related malfunctions for pressure control, timing, and quantity. Light- and medium-duty manufacturers, who are also required to monitor this feature, have indicated they have been working hard on improvements to their fuel system adaptive strategies to fully compensate or learn out any errors that may occur due to mismatches in the injector and the programmed tolerance/adjustment. This would allow manufacturers to avoid adding new hardware, such as a communication chip in the injector that would automatically communicate its characteristics to the engine computer, and avoid other alternatives such as tighter tolerances on the injectors to meet this requirement. Staff believes that heavy-duty manufacturers could also take the same approach. Thus, consistent with what was proposed for light- and medium-duty diesel vehicles in the OBD II regulation, staff is proposing to delay the monitoring requirement of this feature until the 2015 model year for heavy-duty engines. Such a delay should give sufficient time for manufacturers to fully refine adaptive strategies such that they can compensate for any mismatches that occur or to determine that such strategies are ineffective and implement an alternative method such as those previously mentioned.

P. STANDARDZATION REQUIREMENTS

The staff is proposing amendments that would update the list of SAE and ISO documents that are incorporated by reference into the heavy-duty OBD regulation. As is common practice with technical standards, industry periodically updates the standards to add specification or clarity.

Staff is also proposing amendments to the diagnostic connector and protocol requirements in the heavy-duty OBD regulation. Firstly, staff is proposing specific language requiring diesel manufacturers using SAE J1939 to use the "Type 1" specification (i.e., the 250kbps baud rate connector specifications) of the connector and to use the 250kbps baud rate version of the protocol itself. When the heavy-duty OBD regulation was first adopted, SAE J1939 only had a 250 kbps baud rate version of the protocol and a single connector. As such, there was no need to identify a specific baud rate or connector version like had been done to call out the 500kbps baud rate version for the ISO 15765 protocol and Type "A" connector of SAE J1962 (because the protocol had two baud rate versions and the connector had two versions to handle different system voltages). However, since originally adopted, SAE J1939 had been updated to include an additional 500 kbps baud rate version of the protocol and a second version of the connector itself (i.e., the "Type 2" version) to handle the new baud rate. Thus, staff is proposing the amendments to clarify that only the original baud rate and connector versions that were adopted are allowed for purposes of meeting the standardized requirements in the heavy-duty OBD regulation.

Secondly, based on light-duty experience, staff is proposing to prohibit manufacturers from putting an additional identical diagnostic connector to the required standardized connector (i.e., the "Type 1" SAE J1939 connector or "Type A" SAE J1962 connector) in the same area as the standardized diagnostic connector is required to be located. This would help avoid confusion among technicians or inspectors attempting to identify the 'correct' diagnostic connector to retrieve OBD information from the vehicle. Manufacturers would still be allowed to equip their engines and vehicles with additional diagnostic connectors as needed but, if they choose additional connectors that are identical to the standardized one, they would not be allowed to install those connectors in the driver footwell area where the heavy-duty OBD connector is required to be.

Staff is also proposing amendments to the readiness status requirements in the heavy-duty OBD regulation. Manufacturers are required to incorporate readiness status indications of several major emission control systems and components into their OBD systems, which helps determine if the OBD monitors have performed their system evaluations. When the OBD system is interrogated by an off-board tool, the system would report a readiness status for each major emission-related component of either "complete" (if the monitor has run a sufficient number of times to detect a malfunction since the memory was last cleared), "incomplete" (if the monitor has not yet had the chance to run since the memory was last cleared), or "not applicable" (if the monitored component in question is not equipped or monitored on the vehicle). The main intent of the readiness status is to ensure an engine or vehicle is ready for an OBD-based inspection (i.e., that monitors have run prior to inspection). Technicians also can use the readiness status to verify OBD-related repairs. With the current language, however, there has been confusion about which monitors manufacturers are required to include when determining readiness status for each component/system. Further, manufacturers have expressed concern that certain diesel-related monitors may take too long to run and complete (e.g., monitors that require PM filter regenerations to occur), which would unnecessarily delay setting of the readiness status to "complete". While staff understands manufacturers' concerns, staff also believes it is important to include most monitors of the primary emission controls on the engine. Staff is proposing revisions that would clarify exactly which monitors are required to be included when determining readiness status to ensure consistency in implementation among all manufacturers. Staff is also proposing additional amendments to clear up other confusion related to implementing the readiness requirements, including specific language on how to deal with monitors that detect faults of more than one major emission-related component (e.g., an oxygen sensor monitor that is used to detect both oxygen sensor faults that are tied to the oxygen sensor readiness bit and air-fuel ratio cylinder imbalance faults that are tied to the fuel system readiness bit).

Staff is proposing an additional data stream parameter to be made available – specifically, starting with the 2016 model year, manufacturers of engines equipped with reductant quality sensors would be required to output such sensor data in a standardized format to a scan tool.

Staff is also proposing amendments related to the erasure of emission-related information. Currently, the heavy-duty OBD regulation allows permanent fault codes to be erased when the individual control module containing the permanent fault code is reprogrammed and the vehicle/engine readiness status for all monitors (in all emission-related modules) are set to "not complete". The regulation similarly requires all emission-related information (from all emission-related modules) to be erased in conjunction with the reprogramming of the vehicle identification number (VIN) or engine serial number (ESN). Manufacturers have argued that actions that affect only certain control modules (e.g., erasing a permanent fault code stored in just the engine control module) should not require resetting of readiness bits or erasing of emission-related information from "all" control modules and such 'coordinated clearing' can be difficult to achieve. The rationale for clearing all information was to reduce the opportunity for selective reprogramming events to be used to evade detection during inspections or avoid necessary repairs. However, staff agrees that some relief could be granted while still meeting the original intent. Specifically, the primary objective was to ensure that readiness status for the major monitors was reset to “not complete” to provide an obvious indication that some or all relevant information to an inspection had recently been altered or erased. Given that many modules do not support readiness bits or only support the comprehensive components readiness bit (which, by design, immediately reports “complete” even after a code clear event), staff is proposing that such reprogramming events must ensure a readiness reset only in modules that support readiness for major components (i.e., any readiness bits other than comprehensive components). While this does still require some form of ‘coordinated’ code clearing, it limits the number of involved modules. For example, if a vehicle has an engine ECU that supports readiness for major components and five auxiliary emission-related modules that don’t support readiness for any major components, and if one of the auxiliary modules has a permanent fault code stored and that module is reprogrammed and erases the permanent fault code, the OBD system would only need to ensure that the engine ECU resets all readiness bits and not that all five of the auxiliary modules also reset readiness.

Lastly, staff is proposing amendments to the software calibration verification number (CVN) requirements. The heavy-duty OBD regulation currently requires the CVN to be stored at all times, calculated and re-stored at least once per ignition cycle, and to be made immediately available at all times through the data link connector to a generic scan tool in accordance with the requirements in SAE J1979 or J1939. The only exceptions allowed in the regulation are for extreme circumstances where the stored value has been erased and not had an opportunity to be calculated and re-stored yet. Specifically, relief is granted from having the CVN immediately available to a scan tool if it is requested within 60 seconds of the ECU being reprogrammed or having non-volatile memory cleared, or within 30 seconds of a volatile memory clear or battery disconnect. The language has been rewritten to clarify these timeframes and the associated events that are allowed and to clarify that, at all other times, immediately available means the value is returned to the requesting scan tool within the normal message response timing and does not allow for any extended message response timings or negative response codes.

Q. CERTIFICATION DEMONSTRATION TESTING REQUIREMENTS

The heavy-duty OBD 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. The regulation currently contains language detailing the testing required for gasoline fuel system monitoring. Staff, however, mistakenly forgot to include specific language for the air-fuel ratio cylinder imbalance monitor, so staff is proposing language detailing the testing requirements for this monitor. Further, the regulation currently requires that “for purposes of fuel system testing, the fault(s) induced may result in uniform distribution of fuel and air among the cylinders” and that “non-uniform distribution of fuel and air used to induce a fault may not cause misfire.” While this language works for testing of the main fuel system feedback monitor, it doesn’t apply to testing of other fuel system monitors such as the air-fuel cylinder imbalance monitor, which, by definition is ‘non-uniform’ and in some cases does produce misfire. Therefore, staff is proposing amendments to limit this language to testing of the main fuel system feedback monitor.

Staff is also proposing amendments to the testing requirements for gasoline oxygen sensor emission threshold-based monitors to limit the number of tests required to be performed. Specifically, for conventional oxygen sensors, the manufacturer would be required to perform a test for two malfunction cases: (1) the single worst case response rate malfunction among all symmetric and asymmetric patterns, and (2) the worst case asymmetric response rate malfunction that results in delays during transitions from rich-to-lean or lean-to-rich sensor output. For wide range or universal sensors, the manufacturer also would be required to perform a test for two malfunctions cases: and (1) the single worst case response rate malfunction among all symmetric and asymmetric patterns, and (2) the symmetric response rate malfunction that results in delays during transitions from rich-to-lean and lean-to-rich sensor output. For the worst case malfunctions, staff would require manufacturers to submit data and/or analysis demonstrating that the malfunction will result in the worst case emissions compared to all the other response rate malfunctions.

Lastly, staff is proposing changes to the regulatory language to clarify demonstration testing for catalyst faults and other faults where default actions are taken subsequent to fault detection. Staff's proposed modifications provide more direction to manufacturers to handle various scenarios of default actions and incremental levels of fault detection to ensure diesel monitors are appropriately tested.

R. OTHER CHANGES

Staff is proposing other minor amendments to the heavy-duty OBD regulation. These include proposed additional items required to be submitted by the manufacturer as part of the heavy-duty OBD certification application and minor amendments to the production engine/vehicle evaluation testing procedures, as well as clarification changes throughout the regulation. As these amendments are mostly self-explanatory, they will not be discussed in detail in this report. All the proposed amendments are detailed in the attached regulatory language.

Concerning the OBD II regulation, staff is proposing amendments for medium-duty diesel vehicles certified to a chassis dynamometer tailpipe emission standard. The OBD II regulation currently requires manufacturers of these vehicles to request approval of the emission-based malfunction criteria in lieu of the engine dynamometer-based malfunction criteria (e.g., 2.0 times the applicable standards) required for each applicable diesel monitor in section 1968.2(f). At the time of the last amendments, the vast majority of medium-duty diesels were certified using the engine dynamometer standards and chassis dynamometer-based certifications were extremely rare. However, since then, chassis dynamometer certification has become quite common and staff has developed more experience as to the monitoring capability of these systems with respect to emission levels relative to the emission standards. Therefore, staff is proposing that for 2016 and subsequent model year medium-duty diesel vehicles certified to a chassis dynamometer tailpipe emission standard, manufacturers would be required to use the same engine dynamometer-based malfunction criteria currently required for passenger cars, light-duty trucks, and medium-duty passenger vehicles certified to a chassis dynamometer tailpipe emission standard. This would eliminate the requirement for manufacturers to individually propose chassis-based thresholds and seek Executive Officer approval and instead would provide clear thresholds that all manufacturers would be required to meet.