ChRON

Air Resources Board

Linda S. Adams
Secretary for Environmental Protection

Robert F. Sawyer, Ph.D., Chair
1001 I Street • P.O. Box 2815
Sacramento, California 95812 • www.arb.ca.gov

Arnold Schwarzenegger
Governor

September 22, 2006

Honorable Stephen L. Johnson, Administrator
U.S. EPA Headquarters
Ariel Rios Building
1200 Pennsylvania Avenue, N.W.
Mail Code: 1101A
Washington, D.C. 20460

Re: Adoption of "Malfunction and Diagnostic System Requirements for 2010 and Subsequent Model-Year Heavy-Duty Engines"; Request for Waiver of Preemption Under Clean Air Act Section 209(b)

Dear Administrator Johnson:

At a public hearing on July 21, 2005, the California Air Resources Board (ARB), by Resolution 05-38 (appended to the enclosed Waiver Request Support Document), approved the adoption of a regulation establishing "Malfunction and Diagnostic System Requirements for 2010 and Subsequent Model-Year Heavy-Duty Engines" (HD OBD). I am writing to request that you grant California a waiver of preemption for the HD OBD regulation pursuant to Clean Air Act section 209(b).

An analysis setting forth California's basis for making the authorization request is enclosed for your review. The analysis sets forth a summary of the regulation, a review of the criteria governing the evaluation by U.S. Environmental Protection Agency of a California waiver request, and the legal grounds for why California's request must be granted. The analysis in turn includes appendices, which are included in the enclosed CD-ROM for your convenience.

If you need additional technical information on this item or have legal questions, please contact Michael L. Terris of ARB's Office of Legal Affairs, at (916) 445-9815.

Sincerely,

Catherine Witherspoon
Executive Officer

Enclosures (2)

cc: Mr. David J. Dickinson, Attorney/Advisor
U.S. Environmental Protection Agency
Ariel Rios Building
1200 Pennsylvania Avenue, N.W.
Mail Code 6405J
Washington, D.C. 20460

Mr. Steve Albu, Chief (w/o enclosures)
Engineering Studies Branch
Mobile Source Control Division

Mr. Mike McCarthy, Manager
Advanced Engineering Section
Mobile Source Control Division

W. Thomas Jennings, (w/o CD-ROM)
Chief Counsel
Office of Legal Affairs

Mr. Michael L. Terris
Senior Staff Counsel
Office of Legal Affairs

WAIVER REQUEST SUPPORT DOCUMENT

REQUEST FOR WAIVER PURSUANT TO CLEAN AIR ACT SECTION 209(b) TO ADOPT AND ENFORCE CALIFORNIA'S MALFUNCTION AND DIAGNOSTIC SYSTEM REQUIREMENTS FOR 2010 AND SUBSEQUENT MODEL-YEAR HEAVY-DUTY ENGINES

September 22, 2006

I. INTRODUCTION AND BACKGROUND

Pursuant to section 209(b) of the Clean Air Act (CAA), the California Air Resources Board (ARB or Board) requests that the Administrator of the U.S. Environmental Protection Agency (U.S. EPA) grant California a waiver from the preemption set forth in CAA section 209(a), which prohibits states from adopting and enforcing emission standards relating to the control of emissions from new motor vehicles or new motor vehicle engines. The requested waiver would cover the California regulation on Malfunction and Diagnostic System Requirements for 2010 and Subsequent Model-Year Heavy-Duty Engines (HD OBD), which the Board approved at a public hearing on July 21, 2005, by Resolution 05-38 (enclosed herewith). At the direction of the Board, after making modifications to the regulation available on September 9, 2005 for supplemental public comment, ARB's Executive Officer formally adopted the HD OBD requirements by issuing Executive Order R-05-010 on December 28, 2005. The requirements are codified at title 13, California Code of Regulations (CCR) section 1971.1.[1] The California Office of Administrative Law approved the regulation on February 15, 2006, and it became operative on March 17, 2006, after being certified by the California Secretary of State.

On-board diagnostics (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, resulting in fewer emissions from the vehicle. Additionally, the OBD system stores important information that identifies faulty components or systems and the nature of the failure, enabling service technicians to make quick diagnoses and proper repairs. Quick and accurate detection of malfunctions helps minimize repair costs to vehicle owners.

ARB initially adopted the first generation OBD regulation in 1985, which applied to all new passenger cars, light-duty trucks, and medium-duty vehicles. It subsequently adopted second-generation requirements (OBD II) in 1989 that require motor vehicle manufacturers to incorporate OBD II systems on new motor vehicles in these vehicle categories commencing with the 1994 model year. Essentially all new passenger cars, light-duty trucks, and medium-duty vehicles were required to have such systems installed by the 1996 model year.[2]

---

[1] Unless otherwise noted, all section references are to title 13, CCR.

[2] U.S. EPA granted California a waiver for the OBD II monitoring requirements and accompanying enforcement provisions as amended through 1994. (*California State Motor Vehicle Pollution Control Standards; Waiver of Federal Preemption; Decision,* 61 Fed.Reg. 53371, October 11, 1996).

Only recently did ARB adopt diagnostic requirements for heavy-duty vehicles (vehicles with a gross vehicle weight rating (GVWR) greater than 14,000 pounds). Specifically, in 2004, ARB adopted Engine Manufacturer Diagnostic system (EMD) requirements (title 13, CCR section 1971) for all 2007 and subsequent model year on-road heavy-duty Otto-cycle (gasoline) and diesel engines. On January 4, 2006, U.S. EPA published a notice of issuance of a waiver for this regulation.[3]

The EMD regulation is much less comprehensive in scope and stringency than the OBD II regulation, requiring the monitoring of only a few major emission control technologies and containing no standardized requirements. ARB's primary purpose in adopting the EMD regulation was to require heavy-duty engine manufacturers to achieve a minimum level of diagnostic capability while still allowing them to focus most of their resources on meeting the new 2007 exhaust emission standards. At the Board hearing at which the ARB adopted the EMD requirements, the staff indicated that it intended to return to the Board in 2005 to propose that it adopt an HD OBD regulation that would require comprehensive diagnostic monitoring and standardization procedures for future heavy-duty engines.

Thereafter, in July 2005, ARB staff proposed and the Board approved new HD OBD requirements that would be phased-in beginning with the 2010 model year. The ultimately adopted regulation requires manufacturers to install a fully compliant HD OBD system on a single engine family for model years 2010 through 2012 before requiring manufacturers to incorporate fully compliant HD OBD systems on all 2013 and later model year engines. The phase-in is primarily designed to allow manufacturers to gain experience on a smaller number of engines prior to wide scale implementation, promoting more effective use of their personnel and testing resources.

Among other things, the regulation requires that for vehicles subject to the 2010 model-year phase-in manufacturers do the following:

- Implement OBD systems that monitor for engine misfire as well as emission-related malfunctions in various systems, including, but not limited to, fuel, catalyst, turbocharging, exhaust gas recirculation (EGR), particulate matter (PM) filter, cooling, and variable valve timing and control (VVT).
- Calibrate major emission control monitors so that malfunctions are detected before emission levels exceed thresholds correlated to certification emission standards.
- Design the OBD system to monitor other emission-related components and systems for proper performance and functionality.
- Conduct post-assembly testing on a sample of production engines and vehicles to ensure that the OBD systems, as built, are able to properly detect malfunctions, store the appropriate fault codes, and illuminate the MIL.

[3] *California State Motor Vehicle Pollution Control Standards; Waivers of Federal Preemption; Notice of Decision*, 71 Fed.Reg. 335 (January 4, 2006).

- Use a standardized methodology for determining the frequency of OBD monitor operation for most monitors during in-use driving and a minimum operating frequency that manufacturers are required to meet.

II. SUMMARY OF THE HD OBD SUBSTANTIVE REQUIREMENTS[4]

As stated, the purpose of the HD OBD system is to detect malfunctions of the emission control system while the vehicle is being operated. To best achieve this, the regulation requires that OBD monitors be designed to run during conditions routinely encountered by drivers of heavy-duty vehicles. While manufacturers may limit the conditions under which certain monitors must run to ensure reliable monitoring of the component or system, these conditions cannot be so restrictive that monitoring rarely occurs during real-world driving. Given the wide variety of operating patterns used within the heavy-duty industry (e.g., from refuse trucks and transit buses to line-haul applications), it is especially imperative that heavy-duty manufacturers design monitors to run under as broad a range of driving conditions as possible.

A. General Requirements

The regulation requires several major monitors and most circuit monitors to run continuously throughout the driving cycle.[5] However, for the majority of monitors, it requires each monitor to run at least once per driving cycle during which the applicable monitoring conditions are met.[6] For several of these monitors that are not required to operate continuously, the HD OBD system must track and report monitor operational performance.[7] Starting with the 2013 model year, engines required to be equipped with fully compliant HD OBD systems must be able to demonstrate that specified monitors operate at least 10 percent of the time that the vehicle is operated.[8]

In the event of a malfunction, the regulation requires the HD OBD system to store a fault code that identifies the nature of the malfunction and illuminate an OBD-specific malfunction indicator light (MIL) that will alert the driver of the presence of the fault. For most OBD monitoring strategies, manufacturers must have the MIL illuminated after the same malfunction has occurred on two separate driving cycles. The first time a malfunction is detected, the system must set a "pending" fault code identifying the suspected failing component or system. If the same malfunction is again detected the next time monitoring occurs, the MIL must illuminate and store a "confirmed" or "active" fault code. Alternatively, if the same malfunction is not detected when next monitored, the pending fault code may be erased. To minimize the possibility of the MIL cycling on and off, once the MIL is illuminated, the regulation requires that the MIL cannot be

---

[4] A detailed discussion of the adopted HD OBD requirements is set forth in the Staff Report: Initial Statement of Reasons, a copy of which is enclosed herewith.
[5] See e.g., requirements for fuel system monitoring, section 1971.1(e)(1.3); EGR monitoring, (e)(3.3); and turbocharger boost monitoring, (e)(4.3).
[6] Section 1971.1(d)(3.1.2).
[7] Section 1971.1(d)(3.2).
[8] Section 1971.1(d)(4).

extinguished unless the monitor related to the malfunction runs three consecutive times without detecting the malfunction.

The requirements for MIL illumination described above are generally referred to as the "two-in-a-row" strategy. While ARB expects that most monitors will be designed as "two-in-a-row" driving cycle monitors, the regulation allows manufacturers to seek ARB approval to use alternate "statistical algorithm" monitoring strategies that generally analyze diagnostic information collected over more than two driving cycles. For ARB approval of an alternate statistical MIL illumination and fault code storage protocol, the manufacturer must submit information demonstrating that the alternate protocol is able to evaluate the system performance and detect malfunctions in an effective and timely manner equivalent to the standard "two-in-a-row" protocol.

B. Proposed Monitoring System Requirements For Diesel/Compression-Ignition Engines

1. Fuel System[9]

The HD OBD regulation requires the OBD system to verify that the fuel system overall is meeting the applicable emission standards[10] and that individual aspects or capabilities of the system are properly functioning. The fuel system is an important component in controlling diesel engine emissions. The fuel system is primarily comprised of a fuel pump, fuel pressure control device, and fuel injectors. Additionally, the fuel system generally has sophisticated control strategies that utilize one or more feedback sensors to ensure the proper amount of fuel is being delivered to the cylinders. While gasoline engines have, in recent years, undergone relatively minor hardware changes (but substantial fine-tuning in the control strategy and feedback inputs), diesel engines have recently undergone substantial changes to the fuel system hardware and now incorporate more refined control strategies and feedback inputs.

Manufacturers of diesel engines have recently begun to use high-pressure fuel systems with "common-rail" technology and improved injector designs. The improved performance of these systems relies on proper control of one or more of the following: fuel pressure, injection timing, pilot/main/post injection timing, fuel quantity, and flow rates. Malfunctions affecting these controls can cause substantial increases in NOx or PM emissions. The regulation, accordingly, requires manufacturers to monitor control of these parameters for malfunctions.

a. Fuel System Pressure Control Monitoring

The regulation requires that the HD OBD system continuously verify that the fuel system maintains desired fuel pressure. It requires that a malfunction be detected before fuel system pressure causes emissions to exceed 2.0 times the non-methane hydrocarbon

---

[9] Section 1971.1(e)(1).

[10] "Applicable standards" is defined in section 1971.1(c) as the specific exhaust emission standards or family emission limits, including the FTP and SET standards, to which the engine is certified.

(NMHC), carbon monoxide (CO), or oxides of nitrogen (NOx) standards or when particulate matter (PM) emissions exceed the standard by more than 0.02 grams per brake horsepower hour (g/bhp-hr). If no failure can result in emissions exceeding the above thresholds, then the OBD system must detect a fault when the fuel system pressure has reached its control limits and the commanded pressure cannot be achieved.

b. Fuel Injection Quantity Monitoring

Similarly, the regulation requires that the HD OBD system verify that the fuel system accurately delivers the proper quantity of fuel required for each injection. The OBD system must indicate a fault when the fuel system cannot accurately deliver the desired fuel quantity such that emissions exceed 2.0 times the NMHC, CO, or NOx standards or the PM standard plus 0.02 g/bhp-hr. If no failure can result in emissions exceeding the above thresholds, then the OBD system must detect a fault when the fuel injection system has reached its control limits and can no longer increase or decrease the commanded injection quantity to achieve the desired fuel injection quantity.

c. Fuel Injection Timing Monitoring

The HD OBD system must verify that fuel injection timing is correct; that is, that fuel is injected at the precise time that it is commanded to happen. Small changes in fuel injection timing (advance or retard) can have significant impacts on emissions. The regulation requires the HD OBD system to verify that fuel injection occurs within a manufacturer-specified tolerance of the commanded fuel timing point and to indicate a malfunction prior to emissions exceeding 2.0 times the NMHC, CO, or NOx standards or the PM standard plus 0.02 g/bhp-hr. If no failure can result in emissions exceeding the thresholds, then the OBD system must detect a fault when the fuel injection system has reached its control limits and the commanded fuel injection timing cannot be achieved.

d. Feedback Control Monitoring

The regulation requires that the HD OBD system indicate a malfunction if the fuel system fails to begin feedback control within a manufacturer specified time interval, if a malfunction can cause open loop or default operation, or if feedback control has used up all of the adjustment allowed by the manufacturer. Malfunctions that cause delays in the start of feedback control or cause open loop operation can be detected under the regulation with either a fuel-system specific monitor or by individually monitoring the parameters or components that the engine uses to establish fuel system feedback control.

2. Misfire Monitoring[11]

Misfire, the lack of combustion in one or more cylinders, causes increased engine-out hydrocarbon emissions. To minimize these emissions, the regulation requires the HD OBD system to monitor for engine misfire that occurs continuously in one or more cylinders during idle conditions. Additionally, to the extent possible, the OBD system must identify, through the storage of the appropriate fault codes, which cylinder is misfiring or indicate if multiple cylinder misfiring is occurring. The OBD system must monitor for misfire at least once per drive cycle whenever manufacturer defined idling conditions have been met. Manufacturers may define and use off-idle monitoring conditions, with Executive Officer approval, so long as the resulting misfire detection capability is equally robust and timely in detecting malfunctions.

In addition to the above requirements that apply starting in 2010, the regulation requires HD OBD systems in 2013 and subsequent model year engines to continuously monitor for engine misfire if the engines are equipped with combustion or combustion quality sensors. In such cases, the OBD system must be capable of detecting a misfire prior to emissions exceeding 2.0 times the HC, CO, or NOx standards or the PM standard plus 0.02 g/bhp-hr.

3. Exhaust Gas Recirculation (EGR) Monitoring[12]

EGR systems are currently being used to complement advanced fuel injection and turbocharger systems to meet stringent NOx emission standards. Most heavy-duty diesel engines certified for the 2002 model year are equipped with EGR. While, in theory, the EGR system simply routes some exhaust gas back to the intake, it can be complex and involve many components to ensure accurate control of EGR flow and maintain acceptable PM and NOx emissions while minimizing effects on fuel economy. To determine necessary EGR flow rates and to control EGR flow, EGR systems normally use the following components: an EGR valve, valve position sensors, boost pressure sensors, intake (fresh air) temperature and airflow sensors, EGR temperature sensors, exhaust backpressure sensors, and tubing or piping to connect the various components of the system. Additionally, some systems use a variable geometry turbocharger to provide the backpressure necessary to drive the EGR flow. Therefore, EGR is not a stand alone emission control device. Rather, it is carefully integrated with the air handling system (supercharging and intake cooling) to control NOx while not adversely affecting PM emissions and fuel economy.

In proposing the EGR system requirements, ARB staff predicted that manufacturers will need to design EGR systems that accurately and continuously control EGR flow under both transient and steady state load conditions to meet the tailpipe emission certification standards for 2007 and subsequent model year heavy-duty vehicles. EGR systems will also have to be designed to accurately control flow rates under a range of ambient conditions represented by the Not-to-Exceed (NTE) test to maintain emissions while

---

[11] Section 1971.1(e)(2).
[12] Section 1971.1(e)(3).

maximizing in-use fuel economy. They will also need to address "NOx/PM trade-off" issues. Specifically, as it applies to EGR system design, excessive EGR flow causes increased PM emissions and insufficient EGR flow causes increased NOx emissions. When manufacturers design engines and emission control systems, they have to balance this trade-off to achieve both the NOx and PM emission standards.

Given the need to accurately control EGR flow to maintain acceptable emission levels, the staff is proposing monitoring requirements for flow rate and response rate malfunctions. Additionally, on vehicles equipped with EGR coolers, the HD OBD system must monitor the cooler for malfunctions that cause insufficient cooling.

a. EGR Flow Rate Monitoring

The regulation requires the HD OBD system to monitor for unacceptably low and high flow rates. The OBD system must indicate an EGR system malfunction before a decrease or increase in flow rate from that specified by the manufacturer causes vehicle emissions to exceed 2.0 times the HC, CO, or NOx standards or the PM standard plus 0.02 g/bhp-hr. In situations where no failure or deterioration of the EGR system can cause a decrease or increase in flow that results in vehicle emissions exceeding any of the above thresholds, the HD OBD system must indicate a malfunction when the EGR system has reached its control limits and cannot respectively increase or decrease EGR flow to achieve the commanded flow rate. The regulation specifies that the EGR system must continuously monitored for these low and high flow malfunctions. To the extent possible, as part of the monitoring strategy for detecting excessively high flow rates, the monitor must detect leaking EGR valves that cause emissions to exceed the above thresholds. In cases where a high flow rate monitoring strategy cannot detect such leaking EGR valves, the manufacturer may need to incorporate a separate monitoring strategy into the OBD system.

b. EGR Response Rate Monitoring

ARB anticipates that manufacturers will likely use transient EGR control to meet the 2007 emission standards. If so, EGR rates will vary with transient engine operating conditions to maintain an appropriate balance between NOx and PM emissions. Therefore, the regulation requires the HD OBD system to have a response rate diagnostic to verify that the EGR system can adequately respond to operating condition changes. This monitor would detect the inability of the EGR system to modulate EGR flow rates under transient engine conditions that cause emissions to exceed 2.0 times the HC, CO, or NOx standards, or the PM standard plus 0.02 g/bhp-hr. The manufacturer must monitor response rate during both increasing and decreasing EGR flow rate conditions. Considering the NOx/PM trade-off discussed above, slow response while trying to increase EGR rates may result in increased NOx emissions. Similarly, slow response while trying to decrease EGR rates may yield increased PM emissions. Manufacturers must account for these trends when determining their malfunction thresholds. Further, it is necessary to monitor response rate under both increasing and decreasing conditions because some malfunctions may affect response under only one of the conditions.

c. Feedback Control Monitoring

Regarding feedback-controlled EGR systems, the regulation requires that the HD OBD system indicate a malfunction if the EGR system fails to begin feedback control within a manufacturer specified time interval. The OBD system must also indicate a malfunction if failure or deterioration of components used as part of the feedback control strategy causes the system to go into open loop (i.e., stops feedback control) or into default operation of the EGR system. Lastly, the HD OBD system must indicate a malfunction if feedback control has used up all of the adjustment allowed by the manufacturer.

d. EGR Cooling System Monitoring

Insufficient EGR cooling can result in higher NOx emissions and can lead to default operation when EGR is commanded off. Accordingly, the regulation requires HD OBD systems to monitor EGR cooling system performance. Specifically, the OBD system must indicate a malfunction when the reduction in cooling of the exhaust gas causes emissions to exceed 2.0 times the HC, CO, or NOx standards or the PM standard plus 0.02 g/bhp-hr. For vehicles in which no failure or deterioration of the EGR system cooler can result in a vehicle's emissions exceeding applicable malfunction thresholds, the OBD system must indicate a malfunction when the system cannot detect at least some EGR cooling. If a manufacturer demonstrates that emissions will not be affected under any reasonable driving condition due to a complete lack of EGR cooling, the OBD system does not have to monitor the EGR cooler.

4. Boost Pressure Control System Monitoring[13]

Diesel engines use turbochargers to enhance performance by increasing the mass of intake air that enters the engine cylinders. Among other things, turbocharging helps increase horsepower, improve overall vehicle fuel economy, and decrease exhaust smoke density.[14] Most modern diesel engines take advantage of these benefits and are equipped with turbocharging systems. While turbochargers increase the efficiency of the diesel engine, exhaust emissions are also improved.

The most widely used turbochargers utilize exhaust gas to spin a turbine at speeds from 10,000 rpm to over 150,000 rpm. A boost pressure sensor is typically located in the intake manifold to provide a feedback signal of the current level of turbo boost. Proper boost control is essential to optimize emission levels. Even short periods of over- or under-boost can result in undesired air-fuel ratio excursions and corresponding emission increases. Additionally, the boost control system directly affects exhaust and intake manifold pressures. EGR is also very dependent on these two pressures and generally uses the differential between them to force exhaust gas into the intake

[13] Section 1971.1(e)(4).
[14] Ecopoint Inc., 2000. "Turbochargers for Diesel Engines", DieselNet Technology Guide.

manifold. If the boost control system is not operating correctly, the exhaust or intake pressures may be affected, preventing the EGR system from functioning as designed.

Manufacturers commonly use charge air coolers to maximize the benefits of turbocharging. The turbocharger compresses intake air, causing the temperature of the air to increase. This increasing temperature causes the air to expand, lowering its density, which is directionally opposite of what turbocharging is attempting to accomplish. Engine manufacturers use charge air coolers to exchange heat between the compressed air and ambient air or coolant, which effectively cools the compressed air. A decrease in charge air cooling performance can affect emissions by causing higher intake air temperatures leading to increased NOx emissions.

One drawback of turbocharging is known as turbo lag. Turbo lag occurs when the driver attempts to accelerate quickly from a low engine speed. Since the turbocharger is a mechanical device, a delay typically occurs from the time the driver commands more boost to the time that exhaust flow physically speeds up the turbocharger. In addition to a negative effect on drivability and performance, improper fueling (e.g., over-fueling) during this lag can cause emission increases (typically PM). To decrease the effects of turbo lag, engine manufacturers design turbochargers that spool up quickly at low engine speeds and low exhaust flow rates. Designing a turbocharger that will accelerate quickly from a low engine speed but will not result in over-speed/over-boost conditions at higher engine speeds is difficult. At near maximum engine speed and exhaust flow rates, excessive boost pressures and heat may lead to engine or turbocharger damage. To prevent excessive turbine speeds and boost pressures, a waste gate is often used to allow part of the exhaust stream to bypass around the turbocharger. The waste gate valve is typically closed at lower engine speeds so that all exhaust is directed through the turbocharger, thus providing quick response from the turbocharger when the driver accelerates quickly from low engine speeds. The waste gate is then opened at higher engine speeds to prevent engine or turbo damage from an over-speed/over-boost condition.

An alternative to a turbocharger with a waste gate is an improved turbocharger design commonly referred to as a variable geometry turbocharger (VGT). To prevent over-boost conditions and to decrease turbo lag, VGTs are designed so that the geometry of the turbocharger changes with engine speed. While manufacturers use various physical mechanisms to achieve the variable geometry, the overall result is essentially the same. At low engine speeds, the exhaust gas into the turbo is restricted in a manner that maximizes the use of the available energy to spin the turbo. This allows the turbo to spool up quickly and provide good acceleration response. At higher engine speeds, the turbo geometry changes so that exhaust gas flow into the turbo is not as restricted. In this configuration, more exhaust can flow through the turbocharger without causing an over-boost condition.

To address malfunctions that can affect the ability of the turbocharger system to properly control boost pressures, the regulation requires the HD OBD system to do the following:

a. General Boost Control System Monitoring

The boost control systems must be continuously monitored for proper operation, having the ability to indicate a malfunction before an increase or decrease in boost pressure causes emissions to exceed 2.0 times the HC, CO, or NOx standards or the PM standard plus 0.02 g/bhp-hr. For engines in which no failure or deterioration of the boost pressure control system can cause a decrease or increase in boost that results in an engine's emissions exceeding the above thresholds, the OBD system must detect a malfunction when the system has reached its control limits and cannot either increase or decrease boost to achieve the commanded boost pressure.

b. VGT System Monitoring

Manufacturers must design the HD OBD system to monitor the VGT system for slow response – that is, the time required to reach the desired boost level, whether transitioning from high to low boost or from low to high. The OBD system must indicate a malfunction before an increase in the response time causes emissions to exceed 2.0 times the HC, CO, or NOx standards or the PM standard plus 0.02 g/bhp-hr. For engines in which no failure or deterioration of the VGT system response can result in emissions exceeding these threshold levels, the OBD system must be capable of detecting a malfunction of the VGT system when proper functional response of the system to computer commands cannot be verified by the OBD system.

c. Charge Air Cooler Monitoring

The HD OBD system must also monitor charge air coolers for proper cooling of the intake air and detect a malfunction before cooling drops from the manufacturer's prescribed levels and causes emissions to exceed 2.0 times the HC, CO, or NOx standards or the PM standard plus 0.02 g/bhp-hr. If inadequate cooling cannot cause emissions to exceed the applicable threshold malfunction levels, the OBD system must monitor the cooling system to verify that some detectable level of cooling is occurring.

d. Feedback Control Monitor

If the boost pressure system uses feedback control, the regulation requires that the HD OBD system indicate a malfunction if the boost pressure system fails to begin feedback control within a manufacturer specified time interval. The system must indicate a malfunction if failure or deterioration of components used as part of the feedback control strategy causes the system to go open loop or into default operation of the boost pressure system. The system must also be designed to indicate a malfunction if feedback control has used up all of the adjustment allowed by the manufacturer.

5. Diesel Oxidation (NMHC Conversion) Catalyst[15]

Current diesel oxidation catalysts are optimized to reduce PM emissions as well as HC and CO emissions. At sufficiently high temperatures, diesel oxidation catalysts can convert up to 90 percent of engine out HC and CO emissions and 30 percent of PM emissions. Oxidation catalysts are also used in conjunction with other aftertreatment emission controls such as NOx adsorber systems, selective catalytic reduction (SCR) systems, and PM filters to improve their performance.

a. Conversion Efficiency Monitoring

To ensure that conversion efficiency of the catalyst is adequate, the regulation requires the HD OBD system to indicate a malfunction when the conversion efficiency decreases to a point that emissions exceed 2.0 times the applicable NMHC or NMHC+NOx standard. If a malfunctioning catalyst cannot cause emissions to exceed an applicable emission threshold, the HD OBD system must functionally monitor the NMHC catalyst and indicate a malfunction when the monitor cannot detect any conversion of any one of the pollutants subject to conversion by the catalyst. The regulation requires that manufacturers monitor the catalyst once per driving cycle when the prescribed monitoring conditions are met.

b. Monitoring Aftertreatment Assistance

The regulation also requires that the HD OBD system monitor the oxidation catalyst for aftertreatment assistance functions. For example, for catalysts used in the exhaust system design to generate an exotherm to assist PM filter regeneration, the OBD system must indicate a malfunction when the catalyst is unable to generate sufficient exotherm to achieve regeneration of the PM filter. Similarly, for catalysts used to generate a feed gas constituency to assist SCR systems (e.g., by increasing nitrous oxide concentration upstream of an SCR system), the OBD system must indicate a malfunction when the catalyst is unable to generate the necessary feed gas constituents for proper SCR system operation. Lastly, for catalysts located downstream of a PM filter and used to convert NMHC emissions during PM filter regeneration, the OBD system must indicate a malfunction when the catalyst has no detectable amount of NMHC conversion capability.

c. Catalyst Aging

To determine the proper HD OBD malfunction criteria for the oxidation catalyst, manufacturers must progressively deteriorate or "age" the catalyst(s) to the point where emissions exceed threshold criteria for NMHC or NMHC + NOx. The method used to age the catalyst(s) must be representative of real world catalyst deterioration (e.g., thermal and/or poisoning degradation) under normal and malfunctioning operating conditions. For engines with aftertreatment systems that only utilize diesel oxidation catalysts, the catalyst(s) can be aged as a system to the emission threshold for

[15] Section 1971.1(e)(5).

determining the malfunction threshold. However, for engines with aftertreatment systems that utilize multiple catalyst technologies (e.g., an aftertreatment system that includes the combination of an oxidation catalyst, catalyzed NOx adsorber, catalyzed PM filter, or lean NOx catalyst), manufacturers must submit a monitoring plan to the Executive Officer that includes the manufacturer's proposed monitoring strategy, malfunction criteria, and monitoring conditions. The Executive Officer would review and approve the plan if she found it to be representative of real world catalyst deterioration under both normal and malfunctioning operating conditions, effective in verifying that each catalyst component is functioning as designed, and in pinpointing the likely area of malfunction if one exists.

6. NOx Conversion Monitoring[16]

The OBD regulation requires HD OBD systems to continuously monitor vehicles equipped with selective catalytic reduction (SCR) catalysts or active/intrusive reductant injection catalysts (e.g., lean NOx catalysts).

a. Conversion Efficiency

For model years 2010-2012, the HD OBD must continuously monitor each NOx catalyst, either individually or in combination with other NOx catalysts for conversion efficiency. The monitoring system must detect a malfunction when NOx conversion decreases to the point that NOx emissions exceed the standards of the appropriate emission test cycle (i.e., the Federal Test Procedure (FTP) or Supplemental Emission Test (SET)) by more than 0.3 g/bhp-hr. If no failure or deterioration of the catalysts' NOx conversion capabilities could result in NOx emissions exceeding the above thresholds, the HD OBD system must detect a malfunction when there is no detectable amount of catalyst NOX conversion capability.

For 2013 and subsequent model years, an HD OBD system must be able to detect when a catalyst's NOx conversion capability decreases and causes NOx emissions to exceed the applicable FTP or SET emission test standards by more than 0.2 g/bhp-hr. If no failure or deterioration of the catalysts' NOx conversion capabilities could result in NOx emissions exceeding the above thresholds, the HD OBD system must indicate a malfunction when the catalyst has no detectable amount of NOX conversion capability.

b. Reductant Delivery Performance Monitoring

Proper reductant delivery is essential to the NOx conversion performance of both SCR and active/intrusive reductant catalysts. Therefore, the regulation requires for either technology that the mechanism for adding the fuel reductant be monitored for proper function. For 2010- 2012 model year engines, the HD OBD system must indicate a malfunction for any delivery system fault that would cause NOx emissions to exceed the applicable NOx standard by more than 0.3 g/bhp-hr as measured by the applicable FTP or SET test. For 2013 and subsequent model year engines, the OBD system must

[16] Section 1971.1(e)(6).

indicate a malfunction when NOx emissions exceed the applicable NOx standard by more than 0.2 g/bhp-hr. Additionally, for all 2010 and subsequent model year engines, if the reductant tank is separate from the fuel tank, the OBD system must indicate a malfunction when the reductant tank is empty or when the wrong reductant is used.

c. Feedback Control Monitoring

The regulation requires that a NOx conversion catalyst using feedback control monitor for proper feedback performance, except under operating conditions for which the Executive Officer has expressly approved disablement of the monitor, or if the manufacturer elects to monitor the individual parameters and components that are used as inputs for reductant injection feedback control. For those vehicles equipped with a specific monitor for the reductant injection system, the OBD system must indicate a malfunction if the feedback control does not begin within the time designated by the manufacturer, if a failure or deterioration of the system causes open loop or default operation, or if the feedback control has used up all of the adjustment allowed by the manufacturer.

d. Catalyst System Aging

To determine the catalyst malfunction criteria for individually monitored oxidation catalysts, manufacturers must use a catalyst deteriorated to the malfunction threshold using methods that represent real world catalyst deterioration under normal and malfunctioning operating conditions.

For catalysts monitored in combination with other catalysts, the manufacturer must submit a catalyst system aging and monitoring plan to the Executive Officer that identifies and describes each component or combination of components, each component's location and emission control purpose, the manufacturer's monitoring strategy for the component, and the method of deterioration/aging used to determine the malfunction criteria. The Executive Officer will approve the plan upon determining that the monitor(s) would be able to identify the area of malfunction, ensure that correct components are repaired or replaced, and verify that each catalyst component is functioning as designed.

7. NOx Adsorber Monitoring[17]

NOx adsorber systems generally consist of a conventional three-way catalyst with NOx adsorbing materials incorporated into the washcoat. NOx adsorbers trap NOx in the exhaust stream. The adsorbers chemically bind the NOx during lean engine operation. Generally, when the storage capacity of the adsorbers is saturated, regeneration occurs and the stored NOx is released and converted, thereby reducing NOx emissions to the atmosphere. Regeneration occurs under rich exhaust gas conditions, which generally lasts for several seconds. Regeneration typically involves a combination of intake air throttling, EGR flow changes, and post-combustion fuel injection.

---

[17] Section 1971.1(e)(7).

a. Monitoring NOx Adsorber Performance

The regulation requires an HD OBD system to monitor NOx adsorbers for proper performance and to indicate a malfunction when the adsorber capability decreases and NOx emissions exceed the following thresholds: for 2010-2012 model year engines, the threshold is 0.3 g/bhp-hr above the NOx emission standard; for 2013 and subsequent model year engines, the threshold is 0.2 g/bhp-hr above the NOx standard. If a malfunctioning NOx adsorber cannot cause emissions to exceed the applicable malfunction emission threshold, the HD OBD system must monitor the system for proper function and indicate a malfunction when no NOx adsorber conversion capability can be detected.

b. Desorption Monitoring

Additionally, if a NOx adsorber system uses active or intrusive injection (e.g., in-cylinder post-fuel injection) to achieve desorption of the adsorber (i.e., removal of NOx from the adsorber), the HD OBD system must indicate any malfunction of the injection system that prevents necessary desorption from occurring.

c. Feedback Control Monitoring

For engines that use feedback control for the adsorber system or active/intrusive injection for desorbtion, the regulation requires that the OBD system indicate a malfunction if the respective system fails to begin feedback control within a manufacturer specified time interval, if failure or deterioration of components used as part of the feedback control strategy causes the system to go open loop or into default operation, or if the feedback control system has used up all of the adjustment allowed by the manufacturer.

8. PM Filter Monitoring[18]

PM filters are considered the most effective control technology for the reduction of particulate emissions and can typically achieve PM reductions in excess of 90 percent. In general, a PM filter consists of a material that permits exhaust gases to pass through but traps the PM emissions. In order to maintain the performance of the PM filter and the vehicle, the trapped PM must be periodically removed through a regeneration process before the amount of particulate begins to clog the filter and exhaust backpressure reaches unacceptable levels. PM filter regeneration can be passive (i.e., occurring during regular operation of the engine and vehicle when exhaust temperatures are high), active (i.e., occurring periodically through the use of intrusive control strategies designed to raise exhaust temperatures high enough for regeneration to occur), or a combination of the two. It is projected that virtually all PM filter systems will have some sort of active regeneration mechanism.

[18] Section 1971.1(e)(8).

One of the key factors that needs to be addressed in a filter regeneration control system is the amount of soot quantity (i.e., soot loading) that is stored in the PM filter.[19] If too much soot is stored in the PM filter when regeneration is activated, the soot can burn uncontrollably and damage the filter. Too little trapped soot may prevent sufficient regeneration by not allowing a proper burn of the trapped PM.

To address these issues, the regulation requires the HD OBD system to monitor the performance of the PM filter and the regeneration process, and, for catalyzed PM filters, NMHC conversion performance.

a. PM Filter Performance Monitoring

The regulation requires the HD OBD system to indicate a malfunction of the PM filter when the filtering capability decreases and causes PM emissions to exceed the following emission thresholds. Starting in the 2010 model year, all heavy-duty engines must be equipped a PM filter performance monitor that can detect malfunctions (e.g., cracking) before PM emissions exceed 0.05 g/bhp-hr as measured by the applicable FTP or SET test cycle or exceeds the applicable emission standard by more than 0.04 g/bhp-hr, whichever is higher. If no failure or deterioration of the PM filtering performance could result in PM emissions exceeding the above thresholds, the OBD system must detect a malfunction when no detectable amount of PM filtering occurs. These thresholds continue through the 2015 model year for all engines except those engines in the engine family that must meet full OBD compliance in 2013.[20]

For 2013 and subsequent model year engines in the engine family required to meet full HD OBD (i.e., both the parent rated engines and all child rated engines) and for all other 2016 and subsequent model year engines in all other engine families, the OBD system must detect a PM filter performance malfunction prior to PM emissions exceeding 0.03 g/bhp-hr as measured by the applicable FTP or SET test cycles or exceeding the applicable emission standard by more than 0.02 g/bhp-hr, whichever is higher. Again, if no failure or deterioration of the PM filtering performance could result in PM emissions exceeding the above threshold, the OBD system must be able to detect a malfunction when no detectable amount of PM filtering is occurring.

For catalyzed PM filters that can convert NMHC emissions, the regulation requires the OBD system to indicate a malfunction when the NMHC conversion efficiency decreases to the point that emissions exceed 2.0 times the NMHC standard. If malfunctions of the NMHC conversion capability cannot cause NMHC emissions to exceed 2.0 times the standard, the OBD system must indicate a malfunction when there is no detectable amount of NMHC conversion.

---

[19] Salvat, O., Marez, P., and Belot, G., "Passenger Car Serial Application of a Particulate Filter System on a Common Rail Direct Injection Diesel Engine," SAE Paper 2000-01-0473.

[20] See section 1971.1(e)(8.2) and implementation schedule set forth at section 1971.1(d)(7).

The regulation also requires that the HD OBD system be able to detect a destroyed, removed, or missing PM filter substrate or if the PM filter assembly has been replaced with a muffler or straight pipe.

b. PM Filter Regeneration Monitoring

The HD OBD system must monitor PM filter regeneration since the process is vital to maintaining proper performance of the PM filter. The OBD system must indicate a malfunction when regeneration occurs more frequently than that specified by the manufacturer, causing NMHC emissions exceed 2.0 times the NHMC standard. If a high regeneration frequency cannot cause emissions to exceed 2.0 times the NMHC standard, the OBD system must indicate a malfunction when regeneration frequency exceeds the manufacturer's specified design limit for allowable regeneration frequency.

The HD OBD system must also detect a malfunction when incomplete regeneration occurs. That is, the OBD system must indicate a malfunction under those conditions when regeneration has been commanded on but fails to properly or completely do so. For PM filter systems that use active or intrusive injection (e.g., in-cylinder post-fuel injection) to achieve regeneration of the filter, the OBD system must indicate a malfunction of the injection system if failure or deterioration of the injection system prevents proper regeneration of the PM filter.

For feedback-controlled PM filter regeneration systems, the regulation requires that the OBD system indicate a malfunction if the regeneration control system fails to begin feedback control within a manufacturer specified time interval, if failure or deterioration of components used as part of the feedback control strategy causes the system to go open loop or into default operation of the injection system, or if the feedback control system has used up all of the adjustment allowed by the manufacturer. Instead of providing a specific feedback control monitor, a manufacturer may elect to instead monitor individual parameters or components that are used as inputs for PM filter regeneration feedback.

9. Exhaust Gas Sensor Monitoring[21]

Exhaust gas sensors include oxygen sensors, air-fuel ratio (A/F) sensors, and NOx sensors. Engine Manufacturers are expected to use these sensors to optimize their emission control technologies on diesel engines and to satisfy many of the HD OBD monitoring requirements for, among other things, catalysts, NOx adsorbers, and EGR systems. Since exhaust gas sensors are a critical part of a vehicle's emission control system, their proper performance needs to be assured. It is important that any malfunction adversely affecting their performance be detected by the OBD system. The regulation requires that the HD OBD system monitor exhaust sensor performance for, among other things, proper output voltage, resistance, impedance, and response and detect a malfunction before emissions exceed specified thresholds.

---

[21] Section 1971.1(e)(9).

a. A/F Sensor Monitoring

For A/F sensors located upstream of an aftertreatment device, the OBD system must indicate a malfunction before failure or deterioration of the sensor causes emissions to exceed 2.0 times the HC, CO, or NOx standards or the PM standard plus 0.02 g/bhp-hr as measured by either the FTP or SET. For A/F sensors located downstream of the aftertreatment device, the thresholds for 2010 through 2012 model year engines are 2.5 times the NMHC standard and 0.3 g/bhp-hr above the NOx standard as measured by the applicable test cycle. For PM emissions, a malfunction must be indicated before PM emissions exceed either 0.05 g/bhp-hr as measured on the appropriate test cycle or the applicable emission standard[22] by more than 0.04 g/bhp-hr, whichever is higher. For 2013 and subsequent model year engines, the thresholds for downstream monitors are 2.0 times the NMHC standard and 0.2 g/bhp-hr above the NOx standard, as measured by the applicable FTP or SET test cycle. For PM emissions, a malfunction must be indicated before PM emissions exceed either 0.03 g/bhp-hr as measured on the appropriate test cycle or 0.2 g/bhp-hr more than the applicable emission standard, whichever is higher.

b. NOx Sensor Monitoring

For 2010 through 2012 model year engines, the HD OBD system must detect a malfunction by the time any failure or deterioration of the sensor causes NOx emissions to exceed the applicable NOx emission standard by more than 0.3 g/bhp-hr as measured from an applicable FTP or SET cycle emission test. A malfunction must also be detected before PM emissions exceed either 0.05 g/bhp-hr as measured from an applicable emission test cycle or the applicable PM standard by more than 0.04 g/bhp-hr, whichever is higher. For 2013 and subsequent model year engines, the HD OBD system shall detect a malfunction by the time any failure or deterioration of the sensor causes NOx emissions to exceed the applicable PM standard by more than 0.2 g/bhp-hr as measured from an applicable FTP or SET emission test or PM emissions to exceed, 0.03 g/bhp-hr as measured from an applicable FTP or SET test or any applicable PM standard by more than 0.02 g/bhp-hr whichever is higher.

c. Other Exhaust Gas Sensor Monitoring

For other exhaust gas sensors, the manufacturer must submit a monitoring plan to the Executive Officer for approval. The Executive Officer shall approve the request upon determining that the manufacturer has submitted data and an engineering evaluation that adequately demonstrate that the monitoring plan is as reliable and effective as the monitoring plan required for A/F and NOx sensors.

[22] See footnote 7, above.

d. Sensor Heater Monitoring

The regulation requires that the HD OBD system detect a sensor heating performance malfunction when the current or voltage drop in the heater circuit is no longer within the manufacturer's specified limits for normal operation (i.e., within the criteria set by the component vendor for heater circuit performance at high mileage). The manufacturer may request Executive Officer approval to use other malfunction criteria to determine heater performance provided they will be equally effective in detecting malfunctions. The OBD system must also be capable of detecting malfunctions of the heater circuits that conflict with the commanded state of the heater.

e. Circuit Fault Monitoring

The HD OBD system must detect malfunctions of the A/F and NOx sensors evidenced by either a lack of circuit continuity or out-of-range values.

f. Feedback Control Monitoring

The HD OBD system must detect a malfunction of A/F and NOx sensors when sensor failure or deterioration causes an emission control system (e.g., EGR, SCR, or NOx adsorber) to stop using that sensor as a feedback input and results in default or open-loop operation.

10. Variable Valve Timing and/or Control (VVT) System Monitoring[23]

VVT systems are used primarily to optimize engine performance and have many advantages over conventional valve control. Instead of opening and closing the valves by fixed amounts, VVT controls can vary the valve opening and closing timing – and valve lift in some systems – depending on the driving conditions. With more stringent NOx emission standards being phased in, more vehicles are anticipated to utilize VVT. By utilizing VVT to retain some exhaust gas in the combustion chamber to reduce peak combustion temperatures, NOx emissions will be reduced. To ensure that VVT systems work properly and reduce emissions as expected, the regulation requires that the HD OBD system monitor VVT systems for target error and low response malfunctions.

For both target error and slow response malfunctions, the HD OBD system must detect malfunctions when the actual valve timing or lift deviates from the commanded valve timing and/or lift, causing emissions to exceed 2.0 times the HC, CO, or NOx standards or the PM standard plus 0.02 g/bhp-hr, all as measured by either the FTP or SET. For VVT systems that cannot cause emissions to exceed the above thresholds, the OBD system must monitor the VVT system for proper functional response under the comprehensive component monitoring requirements, which are described below. The monitor must operate every time that the manufacturer's monitoring conditions are met.

[23] Section 1971.1(e)(10).

C. Monitoring System Requirements For Gasoline/Spark-Ignited Engines

1. Fuel System Monitoring[24]

a. General Performance Monitoring

Proper delivery of fuel is essential to maintain stoichiometric operation and minimize engine out emissions. Proper stoichiometric control is also critical to maximize catalyst conversion efficiency and reach low tailpipe emission levels. As such, thorough monitoring of the fuel system is an essential element in an OBD system. For gasoline engines, the fuel system generally includes a fuel pump, fuel pressure regulator, fuel rail, individual injectors for each cylinder, and a closed-loop feedback control system that use oxygen or A/F sensors. The regulation requires that the HD OBD system monitor the fuel delivery system continuously and detect a malfunction when failure or deterioration causes emissions to exceed 1.5 times the applicable standards.

b. Feedback Control Monitoring

If the engine is equipped with adaptive feedback (i.e., using oxygen sensors or another type sensor for feedback that allows the fuel delivery system to make changes to the adaptive short- and long-term correction values), the OBD system must also verify that the feedback system. Except for feedback control using secondary oxygen sensors (or equivalent technology), the OBD system must indicate a malfunction when adaptive feedback control has used up all of the adjustment allowed by the manufacturer. If the feedback control system uses secondary oxygen sensors, a malfunction must be indicated if fuel system deterioration or failure causes emissions to exceed 1.5 times the applicable emission standard thresholds. The OBD system must also indicate a malfunction whenever the fuel control system fails to enter closed-loop operation within an Executive Officer approved time interval after engine start.

2. Misfire Monitoring[25]

When misfire occurs, unburned fuel and air are pumped into the catalyst, greatly increasing its operating temperature to the point where damage can occur to the catalyst. Engine misfire also contributes to excess emissions, especially when the misfire is present during engine warm-up when the catalyst has not reached its operating temperature. Accordingly, the regulation requires that the HD OBD system continuously monitor for engine misfire at all positive torque engine speeds and load conditions.[26] Additionally, the OBD system must identify which cylinder is misfiring or indicate if multiple cylinder misfiring is occurring through the storage of appropriate fault codes. For catalyst-damaging misfire, manufacturers must, in general, determine the

---

[24] Section 1971.1(f)(1).
[25] Section 1971.1(f)(2).
[26] Although the proposal would require misfire monitoring to occur continuously, the regulation allows manufacturers to temporarily disable misfire monitoring during certain operating conditions where misfire cannot be reliably detected.

percentage of misfire per 200 revolution increments for each engine speed and load condition that would result in a temperature high enough to cause catalyst damage. The OBD system must indicate a malfunction if that calculated percentage of misfire is exceeded.

For lower levels of misfire, that can cause excess emissions, manufacturers must, in general, determine the level of misfire per 1000 revolution increments that would cause emissions to exceed 1.5 times the applicable standards. To establish this percentage of misfire, manufacturers would utilize misfire events occurring at equally spaced, complete engine cycle intervals, across randomly selected cylinders throughout each 1000-revolution increment. The regulation sets a lower limit on the level of misfire, below which misfire is not required to be detected (i.e., five percent for misfire causing catalyst damage, and one percent for misfire causing emissions to exceed 1.5 times the standards), due to the increased difficulty in diagnosing misfire at such low percentages.

3. EGR System Monitoring[27]

Similar to their impact on diesel engines, EGR systems help control gasoline engine NOx emissions by redirecting spent combustion gases from the exhaust stream to the intake system, which dilutes the oxygen concentration and increases the heat capacity of the air/fuel charge. This effectively reduces the combustion temperature, which results in lower levels of NOx emissions. The regulation requires that the HD OBD system monitor gasoline engines equipped with EGR systems for low and high flow rate malfunctions at least once per driving cycle in which the monitoring conditions are met. The OBD system must detect malfunctions triggering low or high flow rates that cause emissions to exceed 1.5 times any of the applicable standards. For engines in which decreased EGR flow rate cannot cause an engine's emissions to exceed 1.5 times any of the applicable standards, the OBD system must detect a malfunction when the system has no detectable amount of EGR flow. For engines in which an increase in the EGR flow rate cannot cause an engine's emissions to exceed 1.5 times any of the applicable standards, the OBD system must detect a malfunction when the system has reached its control limits such that it cannot reduce EGR flow.

4. Cold Start Emission Reduction Strategy Monitoring[28]

If an engine incorporates an engine control strategy to reduce cold start emissions, the HD OBD system must monitor the key components of the strategy (e.g., idle air control valve) while the control strategy is active.[29] The HD OBD system must detect a malfunction prior to any failure or deterioration of the individual components causing an engine's emissions to exceed 1.5 times the applicable standards. Where the failure or deterioration of a component cannot result in an engine's emissions exceeding 1.5 times the applicable standards, the component must be monitored while the control

[27] Section 1971.1(f)(3).
[28] Section 1971.1(f)(4).
[29] This requirement does not apply to secondary air systems that have separate monitoring requirements, which are summarized in the section that immediately follows.

strategy is active for proper functional response in accordance with the malfunction criteria for comprehensive components described below.

5. Secondary Air System Monitoring[30]

Secondary air systems are used to reduce HC and CO cold start exhaust emissions. Although many of today's vehicles operate near stoichiometric after a cold engine start, more stringent emission standards may require secondary air systems, generally in combination with a richer than stoichiometric cold start mixture, to more quickly warm up the catalyst for improved cold start emission performance. Secondary air systems typically consist of an electric air pump, various hoses, and check valves to deliver outside air to the exhaust system upstream of the catalytic converters. Problems with the secondary air systems may include corroded check valves, damaged tubing and hoses, and malfunctioning air switching valves.

Given the importance of properly functioning secondary air systems to emission performance, the regulation requires that the HD OBD system monitor secondary air delivery to the exhaust system during cold engine start. Specifically, the OBD system must indicate a malfunction before airflow has decreased from manufacturer specified levels during normal operation (e.g., during vehicle warm-up following engine start) to the extent that vehicle emissions exceed 1.5 times an applicable standard. Manufacturers would be required to monitor the secondary air system at least once per driving cycle in which the monitoring conditions are met. If a malfunctioning secondary air system cannot cause emissions to exceed the emission threshold of 1.5 times the applicable standards, a manufacturer would only be required to perform functional monitoring of the system and indicate a malfunction when no detectable amount of air flow is delivered during normal operation.

6. Catalyst System Monitoring[31]

Three-way catalysts are one of the most important emission-control components utilized by gasoline engines. Three-way conversion activity takes place most efficiently when the fuel system operates at stoichiometric. Manufacturers achieve and maintain stoichiometric fuel delivery by incorporating closed-loop fuel control systems that utilize an exhaust gas oxygen sensor or air/fuel ratio sensor to provide feedback on the status of the air-fuel ratio being achieved. Most closed-loop fuel control systems actively cycle the air-fuel ratio slightly above and below the stoichiometric point to maximize three-way catalyst conversion efficiency. While improvements to catalysts over the years have increased their durability, catalysts are still subject to thermal deterioration that occurs when the catalyst is exposed to high exhaust temperatures (e.g., during misfire, unburned fuel and air are pumped into the catalyst), which result in reduced catalyst conversion efficiency. Catalyst performance can also deteriorate due to catalyst deactivation from poisoning (e.g., lead, phosphorus). Additionally, catalysts can also fail

[30] Section 1971.1(f)(5).
[31] Section 1971.1(f)(6).

due to mechanical problems, such as excessive vibration or damage to the catalyst itself.

a. Catalyst Performance Monitoring

The regulation requires an HD OBD system to indicate a catalyst malfunction when the catalyst system's conversion capability decreases to the point that emissions exceed 1.75 times the applicable NMHC or NOx standards to which the engine has been certified, or when the average FTP test NMHC conversion efficiency of the monitored portion of the catalyst system falls below 50 percent. Regarding the latter threshold, the Executive Officer may approve a lower percentage of conversion if the manufacturer can provide assurance that replacement of the monitored portion of the catalyst system would also require replacement of an adjacent portion of the catalyst system and that the total replaced portion will meet the 50 percent conversion efficiency requirement.

The catalyst monitor must run at least once per driving cycle during which the manufacturer defined monitoring conditions are met. The regulation allows manufacturers that use multiple catalysts in series to conduct catalyst monitoring only on the furthest upstream catalyst(s), which are the catalysts that are most likely to be damaged first because they are exposed to the highest exhaust temperatures and untreated exhaust gas. Replacement of these catalysts would restore high conversion efficiency to the system because, under most conditions, including cold start conditions, the front catalysts convert the majority of emissions that come from the engine.

b. Catalyst Aging

When determining the proper OBD malfunction threshold for catalysts, manufacturers would progressively deteriorate or "age" catalysts by replicating excessive temperature conditions in a way that closely represents real world deterioration, such as oven aging or misfire aging, to the point where emissions reach 1.75 times the standard. With the exception of engines that shutoff fuel to misfiring cylinders, the regulation requires that the catalyst system be aged as a whole (i.e., simultaneously aging of the monitored and unmonitored catalysts) to the malfunction criteria. Engines that use fuel shutoff when misfire conditions appear are provided greater flexibility because the rear catalysts are less likely to deteriorate when misfire actually occurs in-use.

7. Evaporative System Monitoring[32]

Evaporative system leaks (e.g., cracked or disconnected evaporative system hoses) can cause HC emissions to vent to the atmosphere at levels many times higher than the evaporative emission standards. Evaporative purge system defects such as deteriorated vacuum lines, damaged canisters, and non-functioning purge control valves may also result in high evaporative emissions. To address these conditions, the regulation requires that the HD OBD system verify purge flow from the evaporative system and detect a malfunction when either of the following occurs: (1) no purge flow

[32] Section 1971.1(f)(7).

from the evaporative system to the engine can be detected or (2) the complete evaporative system contains a leak or leaks that are cumulatively greater than or equal to a leak caused by a 0.150 inch diameter orifice. The monitoring system must operate at least once per driving cycle during which the manufacturer defined monitoring conditions are met.

8. Exhaust Gas Sensor Monitor[33]

As with diesel engines, exhaust gas sensors are important to the emission control system of these engines. In addition to maintaining the air-fuel ratio at stoichiometric, these sensors are also used for enhancing the performance of several emission control technologies, including catalyst and EGR systems. Many modern vehicles traditionally perform fuel control with an oxygen sensor feedback system. In order for the emission control system to operate most efficiently, the air-fuel ratio must remain within a very narrow range (less than one percent deviation) around the stoichiometric ratio. Oxygen sensors are typically located in the exhaust system upstream and downstream of catalytic converters. The front (or upstream) oxygen sensor is generally used for fuel control, while the rear (or downstream) oxygen sensor is generally used for adjusting the front oxygen sensor as it ages and for monitoring the catalyst system. Many vehicles use A/F sensors, which provide a precise reading of the actual air-fuel ratio, in lieu of conventional oxygen sensors for fuel control and catalyst monitoring. Both of these sensors are expected to be used by the heavy-duty manufacturers to optimize their emission control technologies and to satisfy many of the HD OBD monitoring requirements, such as fuel system, catalyst, and EGR system monitoring. Since an exhaust gas sensor can be a critical component of a vehicle's fuel and emission control system, the proper performance of this component needs to be assured in order to maintain low emissions. With the exception of circuit continuity faults, out-of-range values, and faults that prevent the sensor from being used as a feedback input, which must be continuously monitored, the regulation requires that exhaust gas sensor monitors operate at least once per driving cycle.

a. Primary Sensor Monitoring

The HD OBD system must detect a malfunction of all primary fuel control sensors, which include oxygen and wide-range A/F sensors. The OBD system must detect a malfunction of the exhaust gas sensor prior to any failure or deterioration to its output voltage, resistance, impedance, current, response rate, amplitude, offset, or other characteristic that would cause emissions to exceed 1.5 times any of the applicable standards. The OBD system must also detect malfunctions of the exhaust gas sensor caused by either a lack of circuit continuity or out-of-range values. Finally, the regulation requires the OBD system to detect a malfunction of the exhaust gas sensor when it causes the fuel system to stop using that sensor as a feedback input.

---

[33] Section 1971.1(f)(8).

b. Secondary Sensor Monitoring

For secondary exhaust gas sensors that are used for secondary fuel trim control or as an OBD monitoring device, the regulation requires that the HD OBD system detect a malfunction of a sensor that affects, among other things, the sensor's voltage, resistance, current, response rate, amplitude, or offset, causing emissions to exceed 1.5 times any of the applicable standards. The OBD system must also detect malfunctions of the secondary exhaust gas sensor that cause a lack of circuit continuity or cause the fuel system to stop using that sensor as a feedback input. To the extent feasible, the OBD system must detect malfunctions that affect sensor output voltage, resistance, impedance, current, amplitude, activity, offset, or other characteristics that prevent the exhaust gas sensor from being sufficiently accurate for use as an OBD system monitoring device. Finally, the HD OBD system must also be able to detect malfunctions to the exhaust gas sensor resulting in out-of-range values.

9. VVT System Monitoring[34]

As with diesel engines, the regulation requires that the HD OBD system be monitored to detect target error and slow response malfunctions. In contrast to diesel engines, the malfunction threshold is 1.5 times applicable standards. The OBD monitor must operate every time that the monitoring conditions are met during the driving cycle.

D. Monitoring Requirements that Apply to Both Diesel and Gasoline Engines

1. Engine Cooling System Monitoring[35]

a. Thermostat Monitoring

Manufacturers typically use a thermostat to restrict the flow of coolant within the engine block on cold starts to promote rapid warming of the engine. As the coolant approaches a specific temperature, the thermostat begins to open and allows circulation of coolant through the radiator. The thermostat then acts to regulate the coolant to the specified temperature. If the temperature rises above the regulated temperature, the thermostat opens further to allow more coolant to circulate, thus reducing the temperature. If the temperature drops below the regulated temperature, the thermostat partially closes to reduce the amount of coolant circulating, thereby increasing the temperature. If a thermostat malfunctions in such a manner that it does not adequately restrict coolant flow during vehicle warm-up, an increase in emissions could occur do to the prolonged operation of the vehicle at temperatures below the stabilized, warmed-up value, below which cold start engine control strategies function. Further, since the engine coolant temperature will likely be used as an enable criterion for other OBD diagnostics, if the vehicle's coolant temperature does not reach a manufacturer-specified warmed-up value, several diagnostics may effectively be permanently disabled from identifying other emission-related malfunctions.

[34] Section 1971.1(f)(9).
[35] Section 1971.1(g)(1).

The regulation requires that the HD OBD system monitor the thermostat for proper performance. The OBD system must indicate a malfunction if, within a specified period of time after engine start, the engine coolant temperature does not achieve the highest temperature required to enable other OBD monitors or come within 20 degrees Fahrenheit (F.) of the manufacturer-specified thermostat regulating temperature. The malfunction time period would be a function of starting engine coolant temperature and vehicle operating conditions that contribute to coolant temperature warm-up. Subject to Executive Officer approval, a manufacturer would be permitted to monitor the thermostat using a greater deviation than 20 degrees F. if it adequately demonstrates that a thermostat operating at the lower temperature would not cause an emission increase of 50 percent or more of any applicable standard. Further, a manufacturer may obtain Executive Officer approval to be exempt from this requirement if it can demonstrate that a malfunctioning thermostat could not cause a measurable increase in emissions during any reasonable driving condition or disable other monitors.

b. Engine Coolant Temperature (ECT) Sensor Monitoring

Manufacturers utilize ECT sensors as an input for many of the emission-related engine control systems. For gasoline engines, the ECT is often one of the most important factors in determining if the engine's powertrain computer will allow closed-loop fuel control. Since open-loop fuel control does not provide precise fuel control, increased emissions result if closed-loop operation does not occur.

Diesel engines generally use ECT to initiate closed-loop control of emission control systems like EGR. Similar to closed-loop fuel control on gasoline engines, if the coolant temperature does not warm up, closed-loop control of these emission control systems will typically not begin, resulting in increased emissions. For both gasoline and diesel engines, ECT will likely be used to enable many of the diagnostics that are required by the heavy-duty OBD regulation. Therefore, if an ECT sensor malfunctions, it could prevent many diagnostics from becoming operational.

The regulation requires the HD OBD system on gasoline and diesel vehicles to monitor the ECT sensor for proper performance to ensure that the ECT reading reaches the highest minimum temperature needed for closed-loop control of all emission control systems. Manufacturers must design the OBD system to detect a malfunction within an Executive Officer-approved time after start-up. The regulation exempts vehicles that do not utilize engine coolant temperature to enable closed-loop control of any emission control system.

Additionally, the regulation requires that the OBD system monitor the ECT for circuit continuity and out-of-range values. To the extent feasible, the regulation further requires the HD OBD system to monitor whether the ECT sensor indicates a temperature inappropriately below the highest minimum enable temperature or above the lowest maximum enable temperature required by the OBD system to enable another diagnostic.

2. Crankcase Ventilation (CV) System Monitoring[36]

Combustion in each cylinder is achieved by drawing air and fuel into the cylinder, compressing the mixture with a piston, and then igniting the mixture. After the combustion event, the mixture is exhausted from the cylinder with another stroke of the piston. However, during the combustion process, exhaust gases can escape past (blow-by) the piston into the crankcase and subsequently be vented into the atmosphere. The CV system generally captures and directs the blow-by from the crankcase to the intake manifold where it is burned by the engine. The CV system typically consists of a fresh air inlet hose, a crankcase vapor outlet hose, and a CV valve to control the flow through the system. Fresh air is introduced to the crankcase via the inlet, which is typically a connection from the intake air cleaner assembly. On the opposite side of the crankcase, vapors are vented from the crankcase through the valve by way of the outlet hose to the intake manifold.

For gasoline engines, the valve is used to regulate the amount of flow based on engine speed. During low engine load operation (e.g., idle), the valve is nearly closed allowing only a small portion of air to flow through the system. With open throttle conditions, the valve opens to allow more air into the system. At high engine load operation (i.e., hard accelerations), the valve begins to close again to limit airflow. For most systems, a mechanical valve is all that is necessary to adequately regulate CV system airflow. The CV system on diesel engines performs in a similar manner, but, because of different intake airflow characteristics, relies on slightly different hose routing and operating conditions for introducing blow-by gasses into the engine.

To ensure that the CV system works properly, the regulation requires that the HD OBD system monitor engines equipped with CV systems for system integrity. In general, the OBD system must detect a malfunction of the CV system when a disconnection of the system occurs between the crankcase and the CV valve or between the CV valve and the intake manifold. The regulation provides that the Executive Officer may exempt a CV system from monitoring disconnections between the CV valve and the crankcase if the system is designed so that CV valve is fastened directly to the crankcase or meets certain other specified conditions that makes the connection unlikely to be disconnected. The regulation also provides for certain exceptions to monitoring disconnections between the CV valve and the intake manifold if disconnection is unlikely to occur or is likely to cause drivability problems.

3. Comprehensive Component Monitoring[37]

Similar to the OBD II requirements for light- and medium-duty vehicles, the regulation requires that the HD OBD system monitor for malfunctions of comprehensive components. Comprehensive components are generally identified as input components, which provide input directly or indirectly to the on-board computer, or as output components/systems, which receive commands from the on-board computer.

[36] Section 1971.1(g)(2).
[37] Section 1971.1(g)(3).

The OBD system must monitor those electronic components that either directly or indirectly provide input to or receive commands from the on-board computer(s), and (1) can affect emissions during any reasonable in-use driving condition, or (2) are part of the diagnostic strategy for any other monitored system or component. Typical examples of input components include temperature sensors and pressure sensors, while examples of output components/systems include the idle control system, glow plugs, and wait-to-start lamps. In addition to all electronic components that meet the above criteria, the OBD system must monitor the individual input and output electronic components that are part of systems for which the monitoring requirements have been previously identified, such as fuel system monitoring, VVT monitoring, and boost control monitoring.

a. Input Component Monitoring

The regulation requires that the HD OBD system monitor input components continuously for out-of-range and circuit continuity faults (short circuits, open circuits, etc.). Additionally, the OBD system must monitor, to the extent feasible, such components for rationality faults (e.g., a sensor which reads inappropriately high or low but, unlike out-of-range faults, is still within the valid operating range of the sensor). Rationality monitoring must take place whenever the monitoring conditions for such components are met.

For input components that activate alternate strategies that can affect emissions (e.g., auxiliary emission control devices, engine shutdown systems or strategies to meet NOx idling standards required by title 13, CCR section 1956.8), the OBD system shall detect rationality malfunctions that cause the system to erroneously activate or deactivate the alternate strategy. To the extent feasible, the rationality fault diagnostics shall detect a malfunction if the input component inappropriately indicates a value that activates or deactivates the alternate strategy.

b. Output Component Monitoring

The HD OBD system must monitor output components for proper functional response. In other words, has the component properly carried out a command from the on-board computer? The regulation requires that the OBD system monitor these components as they normally activate, but, in general, does not require intrusive activation to enable monitoring of output components. To the extent that functional monitoring is not feasible, the OBD system must monitor for circuit continuity. The regulation contains more specific monitoring requirements for the idle control system, glow plugs, and intake air heater system monitors.

4. Other Emission Control System Monitoring[38]

While the HD OBD regulation lists very specific monitoring requirements for most emission control systems commonly used today, the regulation recognizes that

[38] Section 1971.1(g)(4).

manufacturers are continually innovating new emission control technologies in addition to refining existing ones. In cases where the technology simply reflects refinements over current technology, the HD OBD monitoring requirements are generally sufficient to ensure the improved devices are properly monitored. However, in cases where the new technology represents a completely different type of emission control device, the monitoring requirements for existing emission controls may not be easily applied. To address this, the regulation requires that manufacturers submit a monitoring plan for any new emission control technology to the Executive Officer for review and approval prior to introducing control devices on any future model year vehicles.

E. Standardization Requirements

The regulation incorporates a number of different Society of Automotive Engineers and International Organization of Standards documents that manufacturers must follow in designing HD OBD systems. Among the specific standardization requirements are: type and placement of the diagnostic data link connector, communication protocols, and specific emission related functions for readiness status, data stream, freeze frame and fault code information, test results of most recent monitoring, test limits for monitoring different components, software calibration identification and verification numbers, and vehicle identification numbers.

F. Enforcement Procedures

The regulation includes enforcement procedures to ensure that the HD OBD requirements are properly carried-out and effective. To ensure that monitors properly operate during "real world" in-use operation, the regulation includes provisions that the OBD system be capable of tracking monitor operational performance by comparing monitor-specific operation frequency with engine run-time. Also, the regulation requires manufacturers to certify HD OBD systems by submitting emission test data from one or more durability demonstration test engines. To be certified, manufacturers must submit test data from the various monitored emission systems to demonstrate that the OBD system properly detects malfunctions before the required malfunction threshold is reached. The regulation also requires manufacturers to provide specific documentation on how the OBD system operates. Finally, the regulation requires manufactures to conduct production engine/vehicle evaluation testing, which includes verification of standardization and monitoring requirements and verification and reporting of in-use monitoring performance.

III. WAIVER ANALYSIS

A. Introduction

Section 209(b) of the CAA establishes the mechanism for granting California waivers to the general preemption of section 209(a), which prohibits states and their local subdivisions from adopting and enforcing standards and other requirements relating to the control of emissions from motor vehicles. Under section 209(b), the Administrator must grant a waiver to California if the state has determined that its standards will be, in the aggregate, at least as protective of public health and welfare as applicable federal standards, unless the Administrator finds that (1) the state's protectiveness determination is arbitrary and capricious, (2) California does not need separate state standards to meet compelling and extraordinary conditions, or (3) the state's standards and accompanying enforcement procedures are not consistent with section 202(a) of the CAA.

B. Principles Followed in Granting Section 209(b) Waivers

1. The Scope of the Waiver Hearing Should Be Limited

As indicated above, the scope of the Administrator's inquiry in determining whether to deny a waiver request is limited by the express terms of section 209(b)(1). Once California determines that its standards are, in the aggregate, at least as protective of public health and welfare as applicable federal standards, the Administrator must grant the waiver unless one of the three specified findings can be made.

This reading of the statute is consistent with the decision in *Motor and Equipment Manufacturers Association v. EPA*, 627 F.2d 1095 (D.C. Circuit 1979) (*MEMA I*) and prior U.S. EPA waiver decisions interpreting section 209(b), which hold that the review of California's decision to adopt separate standards is a narrow one.[39] In granting the waiver for the OBD II regulation in 1996, the Administrator concluded that she must grant a waiver if she could not find sufficient evidence in the record to support any of the above listed criteria that would dictate not granting the waiver.[40] As early as 1971 then Administrator William D. Ruckleshaus stated:

> The law makes it clear that the waiver request cannot be denied unless the specific findings designated in the statute can properly be made. The issue of whether a proposed California requirement is likely to result in only marginal improvement in air quality not commensurate with its cost or is otherwise an arguably unwise exercise of regulatory power is not legally pertinent to my decision under section 209 . . . .[41]

2. Deference Given to California's Policy Judgments

As indicated in the waiver decisions cited above, in granting waivers to California's motor vehicle program, U.S. EPA has routinely deferred to the policy judgments of California's decision-makers. U.S. EPA has recognized that the intent of Congress in creating a limited review of California's determinations regarding its need for separate

---

[39] See 40 Fed.Reg. 23102, 23103 (May 28, 1975).
[40] 61 Fed.Reg. 53371 (October 11, 1996).
[41] 36 Fed.Reg. 17158 (August 31, 1971). See also 40 Fed.Reg. 23102, 23104; 58 Fed.Reg. 4166 (January 7, 1993), Decision Document, at p. 20.

standards was to ensure that the federal government did not second-guess the wisdom of state policy.[42] Administrators have recognized that the deference is wide-ranging:

> The structure and history of the California waiver provision clearly indicate both a Congressional intent and an EPA practice of leaving the decision on ambiguous and controversial matters of public policy to California's judgment.
>
> * * * * * *
>
> It is worth noting . . . I would feel constrained to approve a California approach to the problem which I might also feel unable to adopt at the federal level in my own capacity as a regulator. The whole approach of the Clean Air Act is to force the development of new types of emission control technology where that is needed by compelling the industry to "catch up" to some degree with newly promulgated standards. Such an approach . . . may be attended with costs, in the shape of a reduced product offering, or price or fuel economy penalties, and by risks that a wider number of vehicle classes may not be able to complete their development work in time. Since a balancing of these risks and costs against the potential benefits from reduced emissions is a central policy decision for any regulatory agency under the statutory scheme outlined above, I believe <u>I am required to give very substantial deference to California's judgments on this score.</u>[43]

3. Burden of Proof Should Be on Those Opposed to the Waiver Request

As stated above, under section 209(b), the Administrator must deny a waiver if he makes one of the three findings set forth in that section. In interpreting the language of 209(b)(1), it has been held that the burden of proof to show that there is a basis for making one of the three findings is squarely on the opponents of a waiver. As the appellate court stated in *MEMA,* at 1120-21:

> It is not necessary for the Administrator affirmatively to find that these conditions do not exist before granting a waiver. The statute does not say, "the Administrator shall grant a waiver only if he makes the negative of these findings. That he must deny a waiver if certain facts exist does not mean that he must independently proceed to make the opposite of those findings before he grants the waiver regardless of the state of the record . . . The language of the statute and its legislative history indicate that California's regulations, and California's determination that they comply with the statute, when presented to the Administrator are presumed to satisfy the waiver requirements and that the burden of proving otherwise is

[42] 40 Fed.Reg. 23102, 23103.

[43] 40 Fed.Reg. 23102, 23104 (emphasis added). See also 58 Fed.Reg. 4166, Decision Document, at p. 64.

on whoever attacks them. California must present its regulations and findings at the hearing, and thereafter the parties opposing the waiver request bear the burden of persuading the Administrator that the waiver request should be denied.

C. The Administrator Must Grant California's Waiver Request for the HD OBD Requirements and Enforcement Procedures

1. Protectiveness

In adopting Resolution 05-38, the Board expressly found that the HD OBD standards set forth in title 13, CCR, section 1971.1 are, in the aggregate, at least as protective of the public health and welfare as applicable federal standards. That determination is clearly not arbitrary and capricious.

In reviewing California's protectiveness finding for a newly adopted regulation, the Administrator must find that those challenging the waiver have presented clear and convincing evidence that the Board's protectiveness finding is arbitrary and capricious.[44] This standard is in accord with "Congressional intent to provide California with the broadest possible discretion in setting regulations it finds protective of the public health and welfare."[45] There is no question that the Board's finding is justified and correct in that, to date, U.S. EPA has not adopted OBD standards for heavy-duty engines having a gross vehicle weight rating (GVWR) in excess of 14,000 pounds. Accordingly, California was neither arbitrary nor capricious in finding that the adopted HD OBD regulation is, in the aggregate, at least as stringent as comparable federal regulations.

2. The Adopted Regulation is Necessary to Meet Compelling and Extraordinary Circumstances

In Resolution 05-38, the Board confirmed the ARB's longstanding position that California continues to need its own onroad motor vehicle and motor vehicle engine program to meet serious air pollution problems unique to the State. The Administrator has previously and consistently recognized California's unique needs when granting waivers for motor vehicles under section 209(b) of the CAA.

The relevant inquiry under section 209(b)(2) is whether California needs its own emission control program to meet compelling and extraordinary conditions, not whether any given standard is necessary to meet such conditions.[46] In approving waivers under section 209(b), the Administrator has confirmed that:

> "[C]ompelling and extraordinary conditions" does not refer to levels of pollution directly, but primarily to the factors that tend to produce them: geographical and climatic conditions that, when combined with large

---

[44] *MEMA,* 627 F.2d at 1122, Decision Document accompanying OBD II Waiver Determination, at p. 14.
[45] *Id.*
[46] 49 Fed. Reg. 1887, 1882 (May 3, 1984).

numbers and high concentrations of automobiles, create serious air pollution problems.[47]

California and the South Coast and San Joaquin Valley air basins, in particular, continue to experience some of the worst air quality in the nation.[48] As of March 2, 2006, U.S. EPA's "Green Book" listing of non-attainment areas of the 8-hour ozone standard identified both air basins as severe.[49] Both basins also continue to be identified as non-attainment for $PM_{2.5}$.[50] Thus, the unique geographical and climatic conditions, and the tremendous growth in vehicle population and use that moved Congress to authorize California to establish separate vehicle standards in 1967 still exist today. U.S. EPA recently affirmed ARB's judgment, on behalf of the State of California, on this matter.[51]

In the California Clean Air Act of 1988, the California Legislature found that:

> [D]espite the significant reductions in vehicle emissions which have been achieved in recent years, continued growth in population and vehicle miles traveled throughout California have the potential not only to prevent attainment of the state standards, but in some cases, to result in worsening of air quality.[52]

The Administrator has repeatedly agreed with the ARB that California's continuing extraordinary conditions justify separate California nonroad programs.[53] Nothing with respect to these conditions has changed to warrant a change in this determination. Accordingly, for all the aforementioned reasons, there can be no doubt of the continuing existence of compelling and extraordinary conditions justifying California's need for its own nonroad vehicle and engine emissions control program.

3. Consistency with CAA Section 202(a)

a. General

The HD OBD regulation is consistent with section 202(a) of the CAA. U.S. EPA has historically interpreted consistency with section 202(a) under a two-prong test: (1) that there is sufficient lead time to permit the development of technology necessary to meet the standards and other requirements, giving appropriate consideration to the cost of compliance in the time frame provided and (2) that the California and federal test

---

47 *Id.*

48 See e.g. *Approval and Promulgation of State Implementation Plans; California--South Coast*, 64 Fed.Reg.1770, 1771 (January 12, 1999).

49 http://www.epa.gov/oar/oaqps/greenbk/gncs.html#CALIFORNIA

50 *Id.*

51 *California State Motor Vehicle Pollution Control Standards; Waiver of Federal Preemption--Notice of Decision*, 68 Fed.Reg.19811,19812 (April 22, 2003).

52 California Health and Safety Code section 43000.5.

53 *OBD II Waiver Decision*; Decision Document at pp. 36-40.

procedures are sufficiently compatible to permit manufacturers to meet both the state and federal test requirements with one test vehicle or engine.[54]

b. Technical Feasibility of Monitoring Requirements

In the OBD II waiver, the Administrator agreed with the ARB that in considering OBD II requirements, the U.S. EPA should evaluate technological feasibility "based on a continuum or sliding scale", explaining:

> [A] showing of more certain technological solutions is necessary for monitoring requirements which are near implementation and a showing of theoretical solutions and responses to technological concerns would be necessary for monitoring requirements which are either first implemented several model years from [ARB] adoption of the requirement or for a monitoring requirements with phase-ins where more theoretical solutions for later years of the phase-in would be allowed.[55]

Additionally, as long recognized by U.S. EPA, California should be given broad deference in its approach to addressing the significant air pollution confronting the state. As stated, the Administrators concluded in 1975 and reaffirmed in 1995:

> [E]ven on this issue of technological feasibility, I would feel constrained to approve a California approach to the problem which I might also feel unable to adopt at the Federal level in my own capacity as a regulator. The whole approach of the Clean Air Act is to force the development of new types of emission control technology where that is needed by compelling the industry to 'catch up' to some degree with newly promulgated standards. Such an approach to automotive emission control might be attended with costs, in the shape of a reduced product offering, or price or fuel economy penalties, and by risks that a wider number of vehicle classes may not be able to complete their development work in time. Since a balancing of these risks and costs against the potential benefits from reduced emissions is a central policy decision for any regulatory agency, under the statutory scheme outlined above I believe I am required to give very substantial deference to California's judgment on that score.[56] (Emphasis in original.)

For the HD OBD regulation, most monitoring requirements do not become effective until the 2010 model year, more than five years from ARB's adoption of the regulation. Even then, compliance with all requirements under the regulation is applicable for only a small

---

[54] *Id.*, at 2.
[55] *Id.* at p. 73; see also *International Harvester Company* v. *Ruckelshaus (International Harvester)* (D.C. Cir. 1973) 478 F.2d 615, 642 and *Natural Resources Defense Counsel* v. *U.S. EPA (NRDC) (D.C. Cir. 1981) 655 F.2d 318, 331-332.*
[56] *OBD II Waiver Decision* at p. 72, citing 1975 waiver decision at 40 Fed.Reg. 23102, 23103 (emphasis added by U.S. EPA in *OBD II Waiver Decision*).

portion of the heavy-duty engine fleet (i.e., one engine rating in an engine family). As described in more detail below, the regulation does not require most engine families to have fully compliant HD OBD systems until 2016. Therefore, a projection of the state of monitoring technology even beyond 2010 should be relied upon when considering technological feasibility as opposed to an assessment of available monitoring technologies today. This is fully consistent with previous decisions by the Administrator. For example, the Administrator affirmed with respect to the OBD II waiver for light-duty vehicles that she would follow the D.C. Circuit's opinion in *NRDC* in analyzing technical feasibility and lead-time.[57] As quoted by the Administrator, *NRDC* held:

> Given this time frame [a 1980 decision on 1985 model year standards, we feel that there is <u>substantial room for deference</u> to the EPA's expertise in projecting the likely course of development. The essential question in this case is the pace of that development, and absent a revolution in the study of industry, defense of such a projection can never possess the inescapable logic of a mathematical deduction. We think that the EPA will have demonstrated the reasonableness of its basis for prediction if it answers any theoretical objections to the (projected control technology), identifies the major steps necessary in refinement of the technology, and offers plausible reasons for believing that each of those steps can be completed in the time available.'[58] (Emphasis added by U.S. EPA)

Consistent with *NRDC*, ARB has presented in its Staff Report: Initial Statement of Reasons for Proposed Rulemaking (Staff Report) and Final Statement Of Reasons (FSOR), a reasonable basis for predicting future technology by answering all theoretical objections raised by manufacturers regarding the projected control technology, identifying the major steps necessary in refinement of the technology, and offering plausible reasons for believing that each of those steps can be completed in the time available.

To ensure that manufacturers have sufficient lead-time and resources to develop the predicted technology that will meet its requirements, the regulation allows manufacturers to phase-in implementation. As stated, for the 2010 through 2012 model years, manufacturers are only required to implement full HD OBD monitoring requirements on one engine rating (OBD parent rating) within one engine family. And, while manufacturers must implement HD OBD systems for other engine ratings within that family (OBD child ratings), the OBD systems need not detect malfunctions prior to emissions exceeding the monitor-specific emission threshold specified in the regulation. Rather, manufacturers may submit a plan to the Executive Officer that will allow for less rigorous, but robust detection of malfunctions. The regulation further delays implementation of all of the standardization requirements during the 2010 through 2012 model years. For the first three years of implementation, the regulation also does not require other engine families to have HD OBD systems. These families will continue to use HD EMD systems that were first implemented for the 2007 model year.

---

[57] *Id.*, at p. 73.
[58] *Id.*, citing *NRDC*, 656 F.2d at 331-332.

diesel and gasoline engines until the 2016 model year.

Additionally, small volume manufacturers would be exempt from the provisions of the regulation until 2013. The regulation defines a small volume manufacturer as one who is projected to produce less than 1200 engines for sale in California in the 2010 model requirements and that functionality monitors [illegible] the regulation for the 2010 through and adsorbers) on engines so equipped. It would not be until the 2020 model year that manufacturers must implement HD OBD systems on their alternate fueled vehicles.

The above description of the HD OBD phase-in requirements demonstrates that ARB has been extremely responsive to manufacturer concerns regarding technical feasibility. During the course of the rulemaking, ARB revised the proposed regulations to provide greater lead-time for implementing certain requirements and more liberal phase-in schedules, more flexibility in requesting the use of alternative strategies for implementation, increased interim and long-term malfunction thresholds, and less stringent thresholds for "child-rated" HD OBD systems. For example, the staff initially proposed that manufacturers implement HD OBD on almost all engine models during the 2010 model year.[62] However, after closely working with heavy-duty engine manufacturers for extended periods of time, the final HD OBD regulation provides manufacturers with significant flexibility by limiting full implementation of HD OBD to just one engine rating from one engine family for the 2010 through 2012 model years, and by delaying full implementation for most engine families until the 2016 model year.[63]

---

[59] Section 1971.1(d)(7.2.2).
[60] *Id.*
[61] Section 1971.1(b).
[62] *Draft On-Board Diagnostic System Requirements for 2010 and Subsequent Model Year Heavy-Duty Engines*, section 1971.1(b), February 15, 2005.
[63] Section 1971.1(d)(7.1) and (7.2).

The Board approved final regulation also provides manufacturers with significant flexibility in designing monitoring strategies that comply with the regulation. For example, for several different monitors, a manufacturer may request Executive Officer approval to temporarily disable monitors during operating conditions that cannot robustly distinguish between a malfunctioning system and a properly operating system.[64] Similarly, for evaporative system monitors, manufacturers may request approval to revise the required evaporative orifice leak size, if the most reliable monitoring method available cannot reliably detect a system leak of the magnitude of the required leak size.[65] The regulation also provides manufacturers with additional flexibility by allowing them to use alternative malfunction criteria in monitoring certain components when the criteria chosen by the manufacturer will yield equally reliable results.[66]

When initially proposed, the regulation would have required that malfunctions must be detected prior to emissions exceeding 1.5 times applicable standards for most monitors.[67] In adopting the final regulation, the Board modified the thresholds for most monitors on diesel-powered engines by increasing the threshold to 2.0 times the standard for NMHC, CO, and NOx emissions and to 0.02 g/bhp-hr for PM emissions.[68] The malfunction thresholds for PM filter monitors were also adjusted upward, and the higher interim threshold was extended through the 2015 model year. Specifically, the interim threshold was changed from an absolute level of 0.05 g/bhp-hr for PM to one of the following two levels, whichever is higher: 0.05 g/bhp-hr or the family emission limit (FEL) plus 0.04 g/bhp hr.[69] The final malfunction level for 2016 and subsequent model year HD OBD systems was modified from an absolute level of 0.025 g/bhp-hr for PM to one of the following two levels, whichever is higher: 0.03 g/bhp-hr or the FEL PM level plus 0.02 g/bhp-hr.[70] Also, in response to manufacturer concerns with monitoring PM filters, the proposed regulation was modified to allow the Executive Officer to revise the PM filter's malfunction criteria to exclude specific failure modes of the PM filter if the most reliable monitoring methods available are unable to detect those failure modes.[71]

The final regulation similarly adjusted the PM malfunction thresholds applicable to A/F and NOx sensors to align them with the PM thresholds for PM filters.[72] The Board also addressed manufacturer technical feasibility concerns regarding monitoring the evaporative system on gasoline-powered engines. The Board provided manufacturers

---

[64] See section 1971.1(e)(1.2.5), (e)(2.3.3)(B), (e)(4.2.6), (e)(6.2.2)(E), (e)(7.2.4), (e)(8.2.8), (e)(9.3.1)(D), (f)(2.3.4), (f)(8.3.1)(C), (f)(8.3.2)(C). See also section (g)(5), which allows the Executive Officer to allow disablement under certain temperature, low fuel levels, and battery conditions.
[65] Section 1971.1(f)(7.2.3).
[66] Section 1971.1(e)(2.3.2), (9.2.4)(A) and (g)(1.2.1)(C),
[67] Attachment A to *Staff Report.*
[68] See Attachment II to *Proposed Modifications to On-Board Diagnostic System Requirements for 2010 and Subsequent Model-Year Heavy-duty Engines* (*Proposed Modifications*) and sections 1971.1(e)(1.2), (2.2.2), (3.2), (4.2), (9.2.1), (10.2).
[69] *Proposed Modifications*, at section 1971.1(e)(8.2.1).
[70] *Id.*
[71] *Id.*, section 1971.1(g)(5.1).
[72] *Id.*, section 1971.1(e)(9.2.1) and (9.2.2).

with more flexibility in the design of the evaporative system monitor by adjusting the malfunction threshold upward from a 0.090 inch diameter orifice leak to 0.150 inches.[73]

Fully cognizant that the regulation is technically challenging, especially for diesel-powered engines, in the initial years of implementation, the Board included broad-based interim monitoring thresholds for many monitors. For the 2010 through 2012 model years, the malfunction threshold for identified monitors is 2.5 times the NMHC, CO, or NOx standards instead of 2.0 times the standard.[74] In addition, during the interim period and after, the regulation specifically provides relief to manufacturers experiencing technical feasibility difficulties by permitting the Executive Officer to revise emission thresholds upward if the most reliable monitoring method developed requires a higher threshold.[75]

The regulation further provides flexibility to manufacturers in certifying "child-rated" engines. For extrapolated, child-rated engines, the Executive Officer will not consider an HD OBD system non-compliant based on emission levels.[76] Rather, the regulation allows manufacturers to submit a plan to the Executive to establish the appropriate monitoring thresholds for these engines.[77] The sole purpose of these numerous modifications was to ensure that manufacturers have sufficient leadtime and available resources to cost effectively develop and implement reliable and compliant HD OBD monitoring technology.

Finally, the HD OBD regulation, like OBD II, allows manufacturers to obtain deficiencies, which the Administrator has found to be similar to the "safety valves" described in *International Harvester*.[78] As under section 1968.1, a manufacturer will be able to obtain a deficiency if it is unable to fully comply with a monitoring requirement, even if technology exists and has been successfully applied by other manufacturers.[79] For the 2010 through 2013 model years, a manufacturer that has attempted to comply with the monitoring requirements in good faith and has sufficiently demonstrated how it will come into compliance as expeditiously as possible may, nonetheless, certify the HD OBD system. Starting with the 2013 model year, the regulation provides that a manufacturer may still certify the OBD system with deficiencies upon demonstrating the above but will be subject to penalties for three or more deficiencies. The deficiency provision allows manufacturers to carryover deficiencies for two model years, unless the manufacturer can demonstrate that it would have to undertake substantial engine hardware modifications and more than two years of lead-time is necessary to correct the deficiency. In addition to the availability of deficiencies, the ARB will be conducting regular biennial reviews to consider manufacturer progress in achieving compliance with

---

[73] *Id.*, section 1971.1(f)(7.2.2).
[74] Section 1971.1(g)(5.2).
[75] Section 1971.1(g)(5.1.)
[76] Section 1971.1(d)(7.1.2).
[77] *Id.*
[78] *OBD II Waiver Decision* at 116-117, citing *International Harvester* 478 F.2d at 641.
[79] Section 1971.1(k).

the HD OBD regulation, to address manufacturer concerns, and to consider further amendments to the regulations where needed.[80] As recognized by the D.C. Circuit:

> Considerations of fairness will support comprehensive and firm, even drastic, regulations, provided a "safety valve" is also provided. . . .The limited safety valve permits a more rigorous adherence to an effective regulation. [Citation omitted.][81]

b. Compatible Test Procedures

As stated, at this time there are no federal OBD requirements for heavy-duty vehicles over 14,000 pounds GVWR. Accordingly, no issue of incompatible federal and California test procedures or that manufacturers must use different test vehicles exists.

CONCLUSION

Based on the foregoing, ARB respectfully requests that the Administrator grant California a new waiver for the HD OBD regulation. Any party opposed to granting the waiver will not be able to meet its burden of demonstrating that the waiver should be denied based on the criteria set forth in CAA section 209(b). To assist you in reviewing the regulation, ARB is enclosing the following documents that it is incorporating into the record of this waiver proceeding.

1. Notice of Public Hearing to Consider Malfunction and Diagnostic System Requirements for 2010 and Subsequent Model Year Heavy Duty Engines (HD OBD), issued June 3, 2005.

2. Staff Report: Initial Statement of Reasons for Proposed Rulemaking, issued June 3, 2005, with Appendices.

3. Resolution 05-38, dated July 21, 2005.

4. Notice of Availability of Modified Text, issued September 9, 2005.

6. Executive Order R-05-010, dated December 28, 2005.

7. Final Statement of Reasons for Rulemaking Including Summary of Comments and Agency Response.

8. Final Regulation Order for title 13, California Code of Regulations, section 1971.1.

---

[80] Board Resolution 05-38.
[81] *International Harvester* 478 F.2d at 641.

If you should require additional technical information on this item, please have your staff contact Mike McCarthy, Manager of the Advanced Engineering Section, Engineering Studies Branch, Mobile Source Control Division, at (626) 771-3614. You should address legal questions to Michael Terris, at (916) 445-9815.