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Part II

Environmental Protection Agency

40 CFR Part 86

Control of Air Pollution From New Motor Vehicles and New Motor Vehicle Engines—Heavy-Duty Vehicle and Engine Standards; Onboard Diagnostic Requirements; Proposed Rule

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 86

[OAR–2005–0047; FRL–8256–9]

RIN 2060–AL92

Control of Air Pollution From New Motor Vehicles and New Motor Vehicle Engines; Regulations Requiring Onboard Diagnostic Systems on 2010 and Later Heavy-Duty Engines Used in Highway Applications Over 14,000 Pounds; Revisions to Onboard Diagnostic Requirements for Diesel Highway Heavy-Duty Vehicles Under 14,000 Pounds

AGENCY: Environmental Protection Agency (EPA).

ACTION: Notice of proposed rulemaking.

SUMMARY: In 2001, EPA finalized a new, major program for highway heavy-duty engines. That program, the Clean Diesel Trucks and Buses program, will result in the introduction of advanced emissions control systems such as catalyzed diesel particulate filters (DPF) and catalysts capable of reducing harmful nitrogen oxide (NO_X) emissions. This proposal would require that these advanced emissions control systems be monitored for malfunctions via an onboard diagnostic system (OBD), similar to those systems that have been required on passenger cars since the mid-1990s. This proposal would require manufacturers to install OBD systems that monitor the functioning of emission control components and alert the vehicle operator to any detected need for emission related repair. This proposal would also require that manufacturers make available to the service and repair industry information necessary to perform repair and maintenance service on OBD systems and other emission related engine components. Lastly, this proposal would revise certain existing OBD requirements for diesel engines used in heavy-duty vehicles under 14,000 pounds.

DATES: If we do not receive a request for a public hearing, written comments are due March 26, 2007. Requests for a public hearing must be received by February 8, 2007. If we do receive a request for a public hearing, we will publish a notice in the **Federal Register** and on the Web at *http://www.epa.gov/obd/regtech/heavy.htm* containing details regarding the location, date, and time of the public hearing. In that case, the public comment period would close 30 days after the public hearing. Under the Paperwork Reduction Act, comments on the information collection provisions must be received by OMB on or before February 23, 2007.

ADDRESSES: Submit your comments, identified by Docket ID No. EPA–HQ–OAR–2005–0047, by one of the following methods:

• *http://www.regulations.gov:* Follow the on-line instructions for submitting comments.

• *Mail:* Onboard Diagnostic (OBD) Systems on 2010 and Later Heavy-Duty Highway Vehicles and Engines, Environmental Protection Agency, Mailcode: 6102T, 1200 Pennsylvania Ave., NW., Washington, DC, 20460, Attention Docket ID No. EPA–HQ–OAR–2005–0047. In addition, please mail a copy of your comments on the information collection provisions to the Office of Information and Regulatory Affairs, Office of Management and Budget (OMB), Attn: Desk Officer for EPA, 725 17th St. NW., Washington, DC 20503.

Instructions: Direct your comments to Docket ID No. EPA–HQ–OAR–2005–0047. EPA's policy is that all comments received will be included in the public docket without change and may be made available online at *http://www.regulations.gov,* including any personal information provided, unless the comment includes information claimed to be Confidential Business Information (CBI) or other information whose disclosure is restricted by statute. Do not submit information that you consider to be CBI or otherwise protected through *http://www.regulations.gov* or e-mail. The *http://www.regulations.gov* Web site is an ''anonymous access'' system, which means EPA will not know your identity or contact information unless you provide it in the body of your comment. If you send an e-mail comment directly to EPA without going through *http://www.regulations.gov* your e-mail address will be automatically captured and included as part of the comment that is placed in the public docket and made available on the Internet. If you submit an electronic comment, EPA recommends that you include your name and other contact information in the body of your comment and with any disk or CD–ROM you submit. If EPA cannot read your comment due to technical difficulties and cannot contact you for clarification, EPA may not be able to consider your comment. Electronic files should avoid the use of special characters, any form of encryption, and be free of any defects or viruses.

Docket: All documents in the docket are listed in the *http://www.regulations.gov* index. Although listed in the index, some information is not publicly available, e.g., CBI or other information whose disclosure is restricted by statute. Certain other material, such as copyrighted material, will be publicly available only in hard copy. Publicly available docket materials are available either electronically in *http://www.regulations.gov* or in hard copy at the Air Docket, EPA/DC, EPA West, Room B102, 1301 Constitution Ave., NW., Washington, DC. The Public Reading Room is open from 8:30 a.m. to 4:30 p.m., Monday through Friday, excluding legal holidays. The telephone number for the Public Reading Room is (202) 566–1744, and the telephone number for the Air Docket is (202) 566–1742.

Note: The EPA Docket Center suffered damage due to flooding during the last week of June 2006. The Docket Center is continuing to operate. However, during the cleanup, there will be temporary changes to Docket Center telephone numbers, addresses, and hours of operation for people who wish to make hand deliveries or visit the Public Reading Room to view documents. Consult EPA's **Federal Register** notice at 71 FR 38147 (July 5, 2006) or the EPA Web site at *http://www.epa.gov/epahome/dockets.htm* for current information on docket operations, locations and telephone numbers. The Docket Center's mailing address for U.S. mail and the procedure for submitting comments to *www.regulations.gov* are not affected by the flooding and will remain the same.

FOR FURTHER INFORMATION CONTACT: U.S. EPA, National Vehicle and Fuel Emissions Laboratory, Assessment and Standards Division, 2000 Traverwood Drive, Ann Arbor, MI 48105; telephone (734) 214–4405, fax (734) 214–4816, email *sherwood.todd@epa.gov.*

SUPPLEMENTARY INFORMATION:

Regulated Entities

This action will affect you if you produce or import new heavy-duty engines which are intended for use in highway vehicles such as trucks and buses, or produce or import such highway vehicles, or convert heavy-duty vehicles or heavy-duty engines used in highway vehicles to use alternative fuels.

The following table gives some examples of entities that may have to follow the regulations. But because these are only examples, you should carefully examine the regulations in 40 CFR part 86. If you have questions, call the person listed in the **FOR FURTHER INFORMATION CONTACT** section of this preamble:

Category	NAICS Codes[a]	SIC Codes[b]	Examples of potentially regulated entities
Industry	336111	3711	Motor Vehicle Manufacturers; Engine and Truck Manufacturers.
	336112		
	336120		
Industry	811112	7533	Commercial Importers of Vehicles and Vehicle Components.
	811198	7549	
	541514	8742	
Industry	336111	3592	Alternative fuel vehicle converters.
	336312	3714	
	422720	5172	
	454312	5984	
	811198	7549	
	541514	8742	
	541690	8931	

[a]North American Industry Classification Systems (NAICS).
[b]Standard Industrial Classification (SIC) system code.

What Should I Consider as I Prepare My Comments for EPA?

Submitting CBI. Do not submit this information to EPA through *www.regulations.gov* or e-mail. Clearly mark the part or all of the information that you claim to be CBI. For CBI information in a disk or CD ROM that you mail to EPA, mark the outside of the disk or CD ROM as CBI and then identify electronically within the disk or CD ROM the specific information that is claimed as CBI). In addition to one complete version of the comment that includes information claimed as CBI, a copy of the comment that does not contain the information claimed as CBI must be submitted for inclusion in the public docket. Information so marked will not be disclosed except in accordance with procedures set forth in 40 CFR part 2.

Tips for Preparing Your Comments. When submitting comments, remember to:

- Identify the rulemaking by docket number and other identifying information (subject heading, **Federal Register** date and page number).
- Follow directions—The agency may ask you to respond to specific questions or organize comments by referencing a Code of Federal Regulations (CFR) part or section number.
- Explain why you agree or disagree; suggest alternatives and substitute language for your requested changes.
- Describe any assumptions and provide any technical information and/or data that you used.
- If you estimate potential costs or burdens, explain how you arrived at your estimate in sufficient detail to allow for it to be reproduced.
- Provide specific examples to illustrate your concerns, and suggest alternatives.
- Explain your views as clearly as possible, avoiding the use of profanity or personal threats.
- Make sure to submit your comments by the comment period deadline identified.

Outline of this Preamble

I. Overview

A. Background

Section 202(m) of the CAA, 42 U.S.C. 7521(m), directs EPA to promulgate regulations requiring 1994 and later model year light-duty vehicles (LDVs) and light-duty trucks (LDTs) to contain an OBD system that monitors emission-related components for malfunctions or deterioration ''which could cause or result in failure of the vehicles to comply with emission standards established'' for such vehicles. Section 202(m) also states that, ''The Administrator may, in the Administrator's discretion, promulgate regulations requiring manufacturers to install such onboard diagnostic systems on heavy-duty vehicles and engines.''

On February 19, 1993, we published a final rule requiring manufacturers of light-duty applications to install such OBD systems on their vehicles beginning with the 1994 model year (58 FR 9468). The OBD systems must monitor emission control components for any malfunction or deterioration that could cause exceedance of certain emission thresholds. The regulation also required that the driver be notified of any need for repair via a dashboard light, or malfunction indicator light (MIL), when the diagnostic system detected a problem. We also allowed optional compliance with California's second phase OBD requirements, referred to as OBDII (13 CCR 1968.1), for purposes of satisfying the EPA OBD requirements. Since publishing the 1993 OBD final rule, EPA has made several revisions to the OBD requirements, most of which served to align the EPA OBD requirements with revisions to the California OBDII requirements (13 CCR 1968.2).

On August 9, 1995, EPA published a final rulemaking that set forth service information regulations for light-duty vehicles and light-duty trucks (60 FR 40474). These regulations, in part, required each Original Equipment Manufacturer (OEM) to do the following: (1) List all of its emission-related service and repair information on a Web site called FedWorld (including the cost of each item and where it could be purchased); (2) either provide enhanced information to equipment and tool companies or make its OEM-specific diagnostic tool available for purchase by aftermarket technicians, and (3) make reprogramming capability available to independent service and repair professionals if its franchised dealerships had such capability. These requirements are intended to ensure that aftermarket service and repair facilities have access to the same emission-related service information, in the same or similar manner, as that provided by OEMs to their franchised dealerships. These service information availability requirements have been revised since that first final rule in response to changing technology among other reasons. (68 FR 38428)

In October of 2000, we published a final rule requiring OBD systems on heavy-duty vehicles and engines up to 14,000 pounds GVWR (65 FR 59896). In that rule, we expressed our intention of developing OBD requirements in a future rule for vehicles and engines used in vehicles over 14,000 pounds. We expressed this same intention in our 2007HD highway final rule (66 FR 5002) which established new heavy-duty highway emissions standards for 2007 and later model year engines. In June of 2003, we published a final rule extending service information availability requirements to heavy-duty vehicles and engines weighing up to 14,000 pounds GVWR. We declined extending these requirements to engines above 14,000 pounds GVWR at least until such engines are subject to OBD requirements.

On January 18, 2001, EPA established a comprehensive national control program—the Clean Diesel Truck and Bus program—that regulates the heavy-duty vehicle and its fuel as a single system. (66 FR 5002) As part of this program, new emission standards will begin to take effect in model year 2007 and will apply to heavy-duty highway engines and vehicles. These standards are based on the use of high-efficiency catalytic exhaust emission control devices or comparably effective advanced technologies. Because these devices are damaged by sulfur, the regulation also requires the level of sulfur in highway diesel fuel be reduced by 97 percent.[1]

Today's action proposes new OBD requirements for highway engines used in vehicles greater than 14,000 pounds. Today's action also proposes new availability requirements for emission-related service information that will make this information more widely available to the industry servicing vehicles over 14,000 pounds.

In addition to these proposed requirements and changes, we are seeking comment on possible future regulations that would require OBD systems on heavy-duty diesel engines used in nonroad equipment. Diesel engines used in nonroad equipment are, like highway engines, a major source of NO_X and particulate matter (PM) emissions, and the diesel engines used in nonroad equipment are essentially the same as those used in heavy-duty highway trucks. Further, new regulations applicable to nonroad diesel engines will result in the introduction of advanced emissions control systems like those expected for highway diesel engines. (69 FR 38958) Therefore, having OBD systems and OBD regulations for nonroad engines seems to be a natural progression from the proposed requirements for heavy-duty highway engines. We discuss this issue in greater detail in section I of this preamble with the goal of soliciting public comment regarding how we should proceed with respect to nonroad OBD.

B. What Is EPA Proposing?

1. OBD Requirements for Engines Used in Highway Vehicles Over 14,000 Pounds GVWR

We believe that OBD requirements should be extended to include over 14,000 pound heavy-duty vehicles and engines for many reasons. In the past, heavy-duty diesel engines have relied primarily on in-cylinder modifications to meet emission standards. For example, emission standards have been met through changes in fuel timing, piston design, combustion chamber design, charge air cooling, use of four valves per cylinder rather than two valves, and piston ring pack design and location improvements. In contrast, the 2004 and 2007 emission standards represent a different sort of technological challenge that are being met with the addition of exhaust gas recirculation (EGR) systems and the addition of exhaust aftertreatment devices such as diesel particulate filters (DPF), sometimes called PM traps, and NO_X catalysts. Such ''add on'' devices can experience deterioration and malfunction that, unlike the engine design elements listed earlier, may go unnoticed by the driver. Because deterioration and malfunction of these devices can go unnoticed by the driver, and because their primary purpose is emissions control, and because the level of emission control is on the order of 50 to 99 percent, some form of diagnosis and malfunction detection is crucial. We believe that such detection can be effectively achieved by employing a well designed OBD system.

The same is true for gasoline heavy-duty vehicles and engines. While emission control is managed with both engine design elements and aftertreatment devices, the catalytic converter is the primary emission control feature accounting for over 95 percent of the emission control. We believe that monitoring the emission control system for proper operation is critical to ensure that new vehicles and engines certified to the very low emission standards set in recent years continue to meet those standards throughout their full useful life.

Further, the industry trend is clearly toward increasing use of computer and electronic controls for both engine and powertrain management, and for emission control. In fact, the heavy-duty industry has already gone a long way, absent any government regulation, to standardize computer communication protocols.[2] Computer and electronic control systems, as opposed to mechanical systems, provide improvements in many areas including, but not limited to, improved precision and control, reduced weight, and lower cost. However, electronic and computer controls also create increased difficulty in diagnosing and repairing the malfunctions that inevitably occur in any engine or powertrain system. Today's proposed OBD requirements would build on the efforts already undertaken by the industry to ensure that key emissions related components will be monitored in future heavy-duty vehicles and engines and that the diagnosis and repair of those components will be as efficient and cost effective as possible.

Lastly, heavy-duty engines and, in particular, diesel engines tend to have very long useful lives. With age comes deterioration and a tendency toward increasing emissions. With the OBD systems proposed today, we expect that these engines will continue to be properly maintained and therefore will continue to emit at low emissions levels even after accumulating hundreds of thousands and even a million miles.

For the reasons laid out above, most manufacturers of vehicles, trucks, and engines have incorporated some type of OBD system into their products that are capable of identifying when certain types of malfunctions occur, and in what systems. In the heavy-duty industry, those OBD systems traditionally have been geared toward

[1] Note that the 2007HD highway rule contained new emissions standards for gasoline engines as well as diesel engines.

[2] See ''On-Board Diagnostics, A Heavy-Duty Perspective,'' SAE 951947; ''Recommended Practice for a Serial Control and Communications Vehicle Network,'' SAE J1939 which may be obtained from Society of Automotive Engineers International, 400 Commonwealth Dr., Warrendale, PA, 15096–0001; and ''Road Vehicles-Diagnostics on Controller Area Network (CAN)—Part 4: Requirements for emission-related systems,'' ISO 15765–4:2001 which may be obtained from the International Organization for Standardization, Case Postale 56, CH–1211 Geneva 20, Switzerland.

detecting malfunctions causing drivability and/or fuel economy related problems. Without specific requirements for manufacturers to include OBD mechanisms to detect emission-related problems, those types of malfunctions that could result in high emissions without a corresponding adverse drivability or fuel economy impact could go unnoticed by both the driver and the repair technician. The resulting increase in emissions and detrimental impact on air quality could be avoided by incorporating an OBD system capable of detecting emission control system malfunctions.

2. Requirements That Service Information Be Made Available

We are proposing that makers of engines that go into vehicles over 14,000 pounds make available to any person engaged in repair or service all information necessary to make use of the OBD systems and for making emission-related repairs, including any emissions-related information that is provided by the OEM to franchised dealers. This information includes, but is not limited to, manuals, technical service bulletins (TSBs), a general description of the operation of each OBD monitor, etc. We discuss the proposed requirements further in section IV of this preamble.

The proposed requirements are similar to those required currently for all 1996 and newer light-duty vehicles and light-duty trucks and 2005 and newer heavy-duty applications up to 14,000 pounds. While EPA understands that there may be some differences between aftermarket service for the under 14,000 pound and over 14,000 pound applications, we believe that any such differences would not substantially affect the implementation of such requirements and that, therefore, it is reasonable to use EPA's existing service information regulations as a basis for proposing service information requirements for the over 14,000 pound arena. See section IV for a complete discussion of the service information provisions being proposed for the availability of over 14,000 pound service information.

Note that information for making emission-related repairs does not include information used to design and manufacture parts, but it may include OEM changes to internal calibrations and other indirect information, as discussed in section IV.

3. OBD Requirements for Diesel Heavy-Duty Vehicles and Engines Used in Vehicles Under 14,000 Pounds

We are also proposing some changes to the existing diesel OBD requirements for heavy-duty applications under 14,000 pounds (i.e., 8,500 to 14,000 pounds). Some of these changes are being proposed for the 2007 and later model years (i.e., for immediate implementation) because we believe that some of the requirements that we currently have in place for 8,500 to 14,000 pound applications cannot be met by diesels without granting widespread deficiencies to industry. Other changes are being proposed for the 2010 and later model years since they represent an increase in the stringency of our current OBD requirements and, therefore, some leadtime is necessary for manufacturers to comply. All of the changes being proposed for 8,500 to 14,000 pound diesel applications would result in OBD emissions thresholds identical, for all practical purposes, to the OBD thresholds being proposed for over 14,000 pound applications.

C. Why Is EPA Making This Proposal?

1. Highway Engines and Vehicles Contribute to Serious Air Pollution Problems

The pollution emitted by heavy-duty highway engines contributes greatly to our nation's continuing air quality problems. Our 2007HD highway rule was designed to address these serious air quality problems. These problems include premature mortality, aggravation of respiratory and cardiovascular disease, aggravation of existing asthma, acute respiratory symptoms, chronic bronchitis, and decreased lung function. Numerous studies also link diesel exhaust to increased incidence of lung cancer. We believe that diesel exhaust is likely to be carcinogenic to humans by inhalation and that this cancer hazard exists for occupational and environmental levels of exposure.

Our 2007HD highway rule will regulate the heavy-duty vehicle and its fuel as a single system. As part of this program, new emission standards will begin to take effect in model year 2007 and phase-in through model year 2010, and will apply to heavy-duty highway engines and vehicles. These standards are based on the use of high-efficiency catalytic exhaust emission control devices or comparably effective advanced technologies and a cap on the allowable sulfur content in both diesel fuel and gasoline.

In the 2007HD highway final rule, we estimated that, by 2007, heavy-duty trucks and buses would account for about 28 percent of nitrogen oxides emissions and 20 percent of particulate matter emissions from mobile sources. In some urban areas, the contribution is even greater. The 2007HD highway program will reduce particulate matter and oxides of nitrogen emissions from heavy-duty engines by 90 percent and 95 percent below current standard levels, respectively. In order to meet these more stringent standards for diesel engines, the program calls for a 97 percent reduction in the sulfur content of diesel fuel. As a result, diesel vehicles will achieve gasoline-like exhaust emission levels. We have also established more stringent standards for heavy-duty gasoline vehicles, based in part on the use of the low sulfur gasoline that will be available when the standards go into effect.

2. Emissions Control of Highway Engines and Vehicles Depends on Properly Operating Emissions Control Systems

The emissions reductions and resulting health and welfare benefits of the 2007HD highway program will be dramatic when fully implemented. By 2030, the program will reduce annual emissions of nitrogen oxides, nonmethane hydrocarbons, and particulate matter by a projected 2.6 million, 115,000 and 109,000 tons, respectively. However, to realize those large emission reductions and health benefits, the emission control systems on heavy-duty highway engines and vehicles must continue to provide the 90 to 95 percent emission control effectiveness throughout their operating life. Today's proposed OBD requirements will help to ensure that emission control systems continue to operate properly by detecting when those systems malfunction, by then notifying the driver that a problem exists that requires service and, lastly, by informing the service technician what the problem is so that it can be properly repaired.

3. Basis for Action Under the Clean Air Act

Section 202(m) of the CAA, 42 U.S.C. 7521(m), directs EPA to promulgate regulations requiring 1994 and later model year light-duty vehicles (LDVs) and light-duty trucks (LDTs) to contain an OBD system that monitors emission-related components for malfunctions or deterioration "which could cause or result in failure of the vehicles to comply with emission standards established" for such vehicles. Section

202(m) also states that, ''The Administrator may, in the Administrator's discretion, promulgate regulations requiring manufacturers to install such onboard diagnostic systems on heavy-duty vehicles and engines.''

Section 202(m)(5) of the CAA states that the Administrator shall require manufacturers to, ''provide promptly to any person engaged in the repairing or servicing of motor vehicles or motor vehicle engines * * * with any and all information needed to make use of the emission control diagnostics system prescribed under this subsection and such other information including instructions for making emission related diagnosis and repairs.''

D. How Has EPA Chosen the Level of the Proposed Emissions Thresholds?

The OBD emissions thresholds that we are proposing are summarized in Tables II.B–1, II.C–1, II.H–1 and II.H–2. These tables show the actual threshold levels and how they relate to current emissions standards. Here, we wish to summarize how we chose those proposed thresholds. First, it is important to note that OBD is more than emissions thresholds. In fact, most OBD monitors are not actually tied to an emissions threshold. Instead, they monitor the performance of a given component or system and evaluate that performance based on electrical information (e.g., voltage within proper range) or temperature information (e.g., temperature within range), etc. Such monitors often detect malfunctions well before emissions are seriously compromised. Nonetheless, emissions thresholds are a critical element to OBD requirements since some components and systems, most notably any aftertreatment devices, cannot be monitored in simple electrical or temperature related terms. Instead, their operating characteristics can be measured and correlated to an emissions impact. This way, when those operating characteristics are detected, an unacceptable emissions increase can be inferred and a malfunction can be noted to the driver.

Part of the challenge in establishing OBD requirements is determining the point—the OBD threshold—at which an unacceptable emissions increase has occurred that is detectable by the best available OBD technology. Two factors have gone into our determination of the emissions thresholds we are proposing: technological feasibility; and the costs and emissions reductions associated with repairs initiated as a result of malfunctions found by OBD systems. The first of these factors is discussed in more detail in section III where we present our case for the technological feasibility of the thresholds. In summary, we believe that the thresholds we are proposing are, while challenging, technologically feasible in the 2010 and later timeframe. We have carefully considered monitoring system capability, sensor capability, emissions measurement capability, test-to-test variability and, perhaps most importantly, the manufacturers' engineering and test cell resources and have arrived at thresholds we believe can be met on one engine family per manufacturer in the 2010 model year and on all engine families by the 2013 model year.

We believe that the proposed thresholds strike the proper balance between environmental protection, OBD and various sensor capabilities, and avoidance of repairs whose costs could be high compared to their emission control results. One must keep in mind that increasingly stringent OBD thresholds (i.e., OBD detection at lower emissions levels) may lead to more durable emission controls due to a manufacturer's desire to avoid the negative impression given their product upon an OBD detection. Such an outcome would result in lower fleetwide emissions while increasing costs to manufacturers. However, increasingly stringent OBD thresholds may also lead to more OBD detections and more OBD induced repairs and, perhaps, many OBD induced repairs for malfunctions having little impact on emissions. Such an outcome would result in lower fleetwide emissions while increasing costs to both manufacturers and truck owners.

E. World Wide Harmonized OBD (WWH–OBD)

Within the United Nations (UN), the World Forum for Harmonization of Vehicle Regulations (WP.29) administers the 1958 Geneva Agreement (1958 Agreement) to facilitate the adoption of uniform conditions of approval and reciprocal recognition of approval for motor vehicle equipment and parts. As a result, WP.29 has responsibility for vehicle regulations within Europe and, indirectly, many countries outside of Europe that have voluntarily adopted the WP.29 regulations. The United States was never a party to the 1958 Agreement, but EPA has monitored the WP.29 regulations developed under the 1958 Agreement and we have benefited from a reciprocal consultative relationship with our European counterparts. More recently, WP.29 took on the responsibility of administering the 1998 Global Agreement that established a process to permit all regions of the world to jointly develop global technical regulations without required mutual recognition of approvals or designated compliance and enforcement. The United States is a signatory of the 1998 Global Agreement (1998 Agreement), and EPA has responsibility for representing the U.S. with respect to environmental issues within WP.29 as they pertain to the 1998 Agreement.

During the one-hundred-and-twenty-sixth session of WP.29 of March 2002, the Executive Committee (AC.3) of the 1998 Global Agreement (1998 Agreement) adopted a Programme of Work, which includes the development of a Global Technical Regulation (GTR) concerning onboard diagnostic systems for heavy-duty vehicles and engines. An informal working group—the WWH–OBD working group—was established to develop the GTR. The working group was instructed that the OBD system should detect failures from the engine itself, as well as from the exhaust aftertreatment systems fitted downstream of the engine, and from the package of information exchanged between the engine electronic control unit(s) and the rest of vehicle and/or powertrain. The working group was also instructed to base the OBD requirements on the technologies expected to be industrially available at the time the GTR would be enforced, and to take into account both the expected state of electronics in the years 2005–2008 and the expected newest engine and aftertreatment technologies.

In November 2003, AC.3 further directed the working group to structure the GTR in such a manner as to enable its future extension to other functions of the vehicle. In so doing, AC.3 did not revise the scope of the task given to the working group (i.e., the scope remained emissions-related heavy-duty OBD). As a result, the GTR is structured such that OBD monitoring and communications could be extended to other systems such as vehicle safety systems. This has been achieved by dividing the GTR into a set of generic OBD requirements to be followed by specific OBD requirements concerning any future desired OBD systems. The generic OBD requirements contain definitions and other OBD regulatory elements that are meant to be applicable throughout the GTR and all of its modules, annexes, and appendices. This generic section is followed by the first specific OBD section—emission-related OBD—which contains definitions and OBD regulatory elements specific to emissions-related OBD.

EPA has been active in the WWH–OBD working group for more than three years. Because that group has been developing a regulation at the same time that we have been developing the requirements in this proposal, our proposed OBD requirements are consistent, for the most part, with the current efforts of the WWH–OBD group.

The WWH–OBD working group submitted a draft GTR as a formal document in March of 2006. During the months immediately following, the WWH–OBD working group has made final revisions to the GTR and will submit it to WP.29 for consideration. If approved by WP.29 and adopted as a formal global technical regulation, we would intend to propose any revisions to our OBD regulations that might be necessary to make them consistent with WWH–OBD.[3]

The latest version of the draft WWH–OBD GTR has been placed in the docket for this rule.[4] While it is not yet a final document, we are nonetheless interested in comments regarding the current version. More specifically, we are interested in comments regarding any possible inconsistencies between the requirements of the draft GTR and the requirements being proposed today. We believe that if such inconsistencies exist, they are minor. WWH–OBD provides a framework for nations to establish a heavy-duty OBD program. It has the potential to result in similar OBD systems, but the WWH–OBD GTR must fit into the context of any country's existing heavy-duty emissions regulations. For example, at this time, the draft GTR does not specify emissions threshold levels, implementation dates, or phase-in schedules. As such, our proposal today is much more detailed than the draft WWH–OBD GTR, but we believe there exist no major inconsistencies between the two regulations.

F. Onboard Diagnostics for Diesel Engines Used in Nonroad Land-Based Equipment

We are also considering regulations—although we are not making any proposals today—that would require OBD systems on heavy-duty diesel engines used in nonroad land-based equipment. The pollution emitted by diesel nonroad engines contributes greatly to our nation's continuing air quality problems. Our recent Nonroad Tier 4 rulemaking was designed to address these serious air quality problems from land-based diesel engines. (69 FR 38958) Like with diesel highway emissions, these problems include premature mortality, aggravation of respiratory and cardiovascular disease, aggravation of existing asthma, acute respiratory symptoms, chronic bronchitis, and decreased lung function. And, as noted above, we believe that diesel exhaust is likely to be carcinogenic to humans by inhalation and that this cancer hazard exists for occupational and environmental levels of exposure.

In our preamble to the Nonroad Tier 4 final rule, we estimated that, absent the nonroad Tier 4 standards, by 2020, land based nonroad diesel engines would account for as much as 70 percent of the diesel mobile source PM inventory. As part of our nonroad Tier 4 program, new emission standards will begin to take effect in calendar year 2011 that are based on the use of high-efficiency catalytic exhaust emission control devices or comparably effective advanced technologies. As with our 2007HD highway program, a cap is also included on the allowable sulfur content in nonroad diesel fuel.

The diesel engines used in nonroad land-based equipment are, in certain horsepower ranges, often essentially the same as those used in heavy-duty highway trucks. In other horsepower ranges—e.g., very large nonroad machines with engines having more than 1,500 horsepower—the engine is quite different. Such differences can include the addition of cylinders and turbo chargers among other things. Notably, the new nonroad Tier 4 regulations will result in the introduction of advanced emissions control systems on nonroad land-based equipment; those advanced emissions control systems will be the same type of systems as those expected for highway diesel engines.

Therefore, having OBD systems and OBD regulations for nonroad diesel engines seems to be a natural progression from the proposed requirements for heavy-duty highway engines. Nonetheless, we believe that there are differences between nonroad equipment and highway applications, and differences between the nonroad market and the highway market such that proposing the same OBD requirements for nonroad as for highway may not be appropriate. Therefore, we are providing advance notice to the public with the goal of soliciting public comment regarding how we should proceed with respect to nonroad OBD. This section presents issues we have identified and solicits comment. We also welcome comment with respect to other issues we have not addressed here, such as service information availability.

1. What Is the Baseline Nonroad OBD System?

We know that highway diesel engines already use a sophisticated level of OBD system. For nonroad diesel engines in the 200 to 600 horsepower range—i.e., the typical range of highway engines—are the current OBD system identical to their highway counterparts? How would the proposed highway OBD requirements change this, if at all? Do diesel engines outside the range typical of highway engines use OBD?

2. What Is the Appropriate Level of OBD Monitoring for Nonroad Diesel Engines?

The proposed OBD requirements for highway engines are very comprehensive and would result in virtually every element of the emissions control system being monitored. Is this appropriate for nonroad diesel engines? And to what degree should such monitoring be required? The emissions thresholds proposed for highway engines will push OBD and sensor technology beyond where it is today because of their stringency. Is a similar level of stringency appropriate for nonroad engines? Should emissions thresholds analogous to those presented in Table II.B–1 of this preamble even be a part of any potential nonroad OBD requirements or should nonroad OBD rely more heavily on comprehensive component monitoring as discussed in section II.D.4 of this preamble? This latter question is particularly compelling given the incredibly broad range of operating characteristics for nonroad equipment. Similar to the issue of emissions thresholds, certain aspects of the proposed highway OBD requirements carry with them serious concerns given the range of use for heavy-duty highway trucks (line-haul trucks versus garbage trucks versus urban delivery trucks, etc.). As discussed in various places in section II of this preamble, this broad range of uses makes it difficult for manufacturers to design a single approach that would, for example, ensure frequent monitoring events on all possible applications. This difficulty could be even more pronounced in the nonroad industry given the greater number of possible applications.

[3] Note that, while the WWH–OBD GTR is consistent with many of the specific requirements we are proposing, it is not currently as comprehensive as our proposal (e.g., it does not contain the same level of detail with respect to certification requirements and enforcement provisions). For that reason, at this time, we do not believe that the GTR would fully replace what we are proposing today.

[4] ''Revised Proposal for New Draft Global Technical Regulation (gtr): Technical Requirements for On-Board Diagnostic Systems (OBD) for Road Vehicles;'' ECE/TRANS/WP.29/GRPE/2006/8/Rev.1; March 27, 2006, Docket ID# EPA–HQ–OAR–2005–0047–0004.

We request comment regarding what any potential nonroad OBD monitoring requirements should look like. More specifically, we request comment regarding the inclusion of emissions thresholds versus relying solely on comprehensive component monitoring. From commenters in favor of emissions thresholds, we request details regarding the appropriate level of emissions thresholds including data and strong engineering analyses for/against the suggested level. We request comment regarding the comprehensiveness of monitoring (i.e., the entire emissions control system, aftertreatement devices only, feedback control systems only, etc.).

3. What Should the OBD Standardization Features Be?

Should nonroad OBD include a requirement for a dedicated, OBD-only malfunction indicator light? Should nonroad OBD require specific communication protocols for communication of onboard information to offboard devices and scan tools? What should those protocols be? What are the needs of the nonroad service industry with respect to standardization of onboard to offboard communications?

4. What Are the Prospects and/or Desires for International Harmonization of Nonroad OBD?

Nonroad equipment is perhaps the most international of all mobile source equipment. Land based nonroad equipment, while not as much so as marine equipment, tends to be designed, produced, marketed, and sold to a world market to a greater extent than is highway equipment. Given that, is there a sense within the nonroad industry that international harmonization is important? Imperative? Is the proper avenue for putting into place nonroad OBD regulations the WWH–OBD process discussed above? If so, is industry prepared to play a role in developing a nonroad OBD element to the WWH–OBD document? Are other government representatives prepared to do so?

II. What Are the Proposed OBD Requirements and When Would They Be Implemented?

The following subsections describe our proposed OBD monitoring requirements and the timelines for their implementation. The requirements are indicative of our goal for the program which is a set of OBD monitors that provide robust diagnosis of the emission control system. Our intention is to provide industry sufficient time and experience with satisfying the demands of the proposed OBD program. While their engines already incorporate OBD systems, those systems are generally less comprehensive and do not monitor the emission control system in the ways we are proposing. Additionally, the proposed OBD requirements represent a new set of technological requirements and a new set of certification requirements for the industry in addition to the 2007HD highway program and its challenging emission standards for PM and NO_X and other pollutants. As a result, we believe the monitoring requirements and timelines outlined in this section appropriately weigh the need for OBD monitors on the emission control system and the need to gain experience with not only those monitors but also the newly or recently added emission control hardware.

We request comment on all aspects of the requirements laid out in this section and throughout this preamble. As discussed in Section IX, we are also interested in comments concerning state run HDOBD-based inspection and maintenance (I/M) programs, the level of interest in such programs, and comments concerning the suitability of today's proposed OBD requirements toward facilitating potential HDOBD I/M programs in the future.

A. General OBD System Requirements

1. The OBD System

We are proposing that the OBD system be designed to operate for the actual life of the engine in which it is installed. Further, the OBD system cannot be programmed or otherwise designed to deactivate based on age and/or mileage of the vehicle during the actual life of the engine. This requirement is not intended to alter existing law and enforcement practice regarding a manufacturer's liability for an engine beyond its regulatory useful life, except where an engine has been programmed or otherwise designed so that an OBD system deactivates based on age and/or mileage of the engine.

We are also proposing that computer coded engine operating parameters not be changeable without the use of specialized tools and procedures (e.g. soldered or potted computer components or sealed (or soldered) computer enclosures). Upon Administrator approval, certain product lines may be exempted from this requirement if those product lines can be shown to not need such protections. In making the approval decision, the Administrator will consider such things as the current availability of performance chips, performance capability of the engine, and sales volume.

2. Malfunction Indicator Light (MIL) and Diagnostic Trouble Codes (DTC)

Upon detecting a malfunction within the emission control system,[5] the OBD system must make some indication to the driver so that the driver can take action to get the problem repaired. The proposal would require that a dashboard malfunction indicator light (MIL) be illuminated to inform the driver that a problem exists that needs attention. Upon illumination of the MIL, the proposal would require that a diagnostic trouble code (DTC) be stored in the engine's computer that identifies the detected malfunction. This DTC would then be read by a service technician to assist in making the necessary repair.

Because the MIL is meant to inform the driver of a detected malfunction, we are proposing that the MIL be located on the driver's side instrument panel and be of sufficient illumination and location to be readily visible under all lighting conditions. We are proposing that the MIL be amber (yellow) in color when illuminated because yellow is synonymous with the notion of a ''cautionary warning''; the use of red for the MIL would be strictly prohibited because red signifies ''danger'' which is not the proper message for malfunctions detected according to today's proposal. Further, we are proposing that, when illuminated, the MIL display the International Standards Organization (ISO) engine symbol because this symbol has become accepted after 10 years of light-duty OBD as a communicator of engine and emissions system related problems. We are also proposing that there be only one MIL used to indicate all malfunctions detected by the OBD system on a single vehicle. We believe this is important to avoid confusion over multiple lights and, potentially, multiple interpretations of those lights. Nonetheless, we seek comment on this limitation to one dedicated MIL to communicate emissions-related malfunctions. We also seek comment on the requirement that the MIL be amber in color since some trucks may use liquid crystal display (LCD) panels to display dashboard information and some such panels are monochromic and unable to display color.

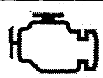
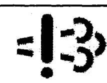
We are also interested in comments regarding the malfunction indicator light and the symbol displayed to

[5] What constitutes a ''malfunction'' for over 14,000 pound applications under today's proposal is covered in section II.B for diesel engines, section II.C for gasoline engines, and section II.D for all engines.

communicate that there is an engine and/or emission-related malfunction. As noted, we are proposing use of the ISO engine symbol as shown in Table II.A–1. The U.S. Department of Transportation has proposed use of an alternative ISO symbol to denote, specifically, an emission-related malfunction. (68 FR 55217) That symbol is also shown in Table II.A–1. While we are not proposing that this alternative symbol be used, comments are solicited regarding whether this alternative symbol provides a clearer message to the driver.

Generally, a manufacturer would be allowed sufficient time to be certain that a malfunction truly exists before illuminating the MIL. No one benefits if the MIL illuminates spuriously when a real malfunction does not exist. Thus, for most OBD monitoring strategies, manufacturers would not be required to illuminate the MIL until a malfunction clearly exists which will be considered to be the case when the same problem has occurred on two sequential driving cycles.[6]

Table II.A-1. ISO Warning Light Symbols

ISO Designation	Displayed Symbol	Comments
F01		Proposed for >14K OBD
F22		Proposed by U.S. DOT; Comments requested as possible MIL display for >14K OBD

To keep this clear in the onboard computer, we are proposing that the OBD system make certain distinctions between the problems it has detected, and that the system maintain a strict logic for diagnostic trouble code (DTC) storage/erasure and for MIL illumination/extinguishment. Whenever the enable criteria for a given monitor are met, we would expect that monitor to run. For continuous monitors, this would be during essentially all engine operation.[7] For non-continuous monitors, it would be during only a subset of engine operation.[8] In general, we are proposing that monitors make a diagnostic decision just once per drive cycle that contains operation satisfying the enable criteria for the given monitor.

When a problem is first detected, we are proposing that a ''pending'' DTC be stored. If, during the subsequent drive cycle that contains operation satisfying the enable criteria for the given monitor, a problem in the components/system is not again detected, the OBD system would declare that a malfunction does not exist and would, therefore, erase the pending DTC. However, if, during the subsequent drive cycle that contains operation satisfying the enable criteria for the given monitor, a problem in the component/system is again detected, a malfunction has been confirmed and, hence, a ''confirmed'' or ''MIL-on'' DTC would be stored.[9] Section II.F presents the requirements for standardization of OBD information and communications. Upon storage of a MIL-on DTC and, depending on the communication protocol used—ISO 15765–4 or SAE J1939—the pending DTC would either remain stored or be erased, respectively. Today's proposal neither stipulates which communication protocol nor which pending DTC logic be used. We are proposing to allow the use of either of the existing protocols as is discussed in more detail in section II.F. Upon storage of the MIL-on DTC, the MIL must be illuminated.[10] Also at this time, a ''permanent'' DTC would be stored (see section II.F.4 for more details regarding permanent DTCs and our rationale for proposing them).[11]

We are also proposing that, after three subsequent drive cycles that contain operation satisfying the enable criteria for the given monitor without any recurrence of the previously detected malfunction, the MIL should be extinguished (unless there are other MIL-on DTCs stored for which the MIL must also be illuminated), the permanent DTC should be erased, but a ''previous-MIL-on'' DTC should remain stored.[12] We are proposing that the previous MIL-on DTC remain stored for 40 engine warmup cycles after which time, provided the identified malfunction has not been detected again and the MIL is presently not illuminated for that malfunction, the previous-MIL-on DTC can be erased.[13] However, if an illuminated MIL is not extinguished, or if a MIL-on DTC is not erased, by the OBD system itself but is instead erased via scan tool or battery disconnect (which would erase all non-permanent, volatile memory), the permanent DTC must remain stored. This way, permanent DTCs can only be erased by the OBD system itself and cannot be erased through human interaction with the system.

We are proposing that the manufacturer be allowed, upon

6 Generally, a ''driving cycle'' or ''drive cycle'' consists of engine startup and engine shutoff or consists of four hours of continuous engine operation.

7 A ''continuous'' monitor—if used in the context of monitoring conditions for circuit continuity, lack of circuit continuity, circuit faults, and out-of-range values—means sampling at a rate no less than two samples per second. If a computer input component is sampled less frequently for engine control purposes, the signal of the component may instead be evaluated each time sampling occurs.

8 A ''non-continuous'' monitor being a monitor that runs only when a limited set of operating conditions occurs.

9 Different industry standards organizations—the Society of Automotive Engineers (SAE) and the International Standards Organization (ISO)—use different terminology to refer to a ''MIL-on'' DTC. For clarity, we use the term ''MIL-on'' DTC throughout this preamble to convey the concept and not any requirement that standard making bodies use the term in their standards.

10 Throughout this proposal, we refer to MIL illumination to mean a steady, continuous illumination during engine operation unless stated otherwise. This contrasts with the MIL illumination logic used by many engine manufacturers today by which the MIL would illuminate upon detection of a malfunction but would remain illuminated only while the malfunction was actually occurring. Under this latter logic, an intermittent malfunction or one that occurs under only limited operating conditions may result in a MIL that illuminates, extinguishes, illuminates, etc., as operating conditions change.

11 A permanent DTC must be stored in a manner such that electrical disconnections do not result in their erasure (i.e., they must be stored in non-volatile random access memory (NVRAM)).

12 This general ''three trip'' condition for extinguishing the MIL is true for all but two diesel systems/monitors—the misfire monitor and the SCR system—and three gasoline systems/monitors—the fuel system, the misfire monitor, and the evaporative system—which have further conditions on extinguishing the MIL This is discussed in more detail in sections II.B and II.C.

13 For simplicity, the discussion here refers to ''previous-MIL-on'' DTCs only. The ISO 15765 standard and the SAE J1939 standard use different terms to refer to the concept of a previous-MIL-on DTC. Our intent is to present the concept of our proposal in this preamble and not to specify the terminology used by these standard making bodies.

Administrator approval, to use alternative statistical MIL illumination and DTC storage protocols to those described above (i.e., alternatives to the ''first trip—pending DTC, second strip—MIL-on DTC logic). The Administrator would consider whether the manufacturer provided data and/or engineering evaluation adequately demonstrates that the alternative protocols can evaluate system performance and detect malfunctions in a manner that is equally effective and timely. Alternative strategies requiring, on average, more than six driving cycles for MIL illumination would probably not be accepted.

Upon storage of either a pending DTC and/or a MIL-on DTC, we are proposing that the computer store a set of ''freeze frame'' data. This freeze frame data would provide a snap shot of engine operating conditions present at the time the malfunction occurred and was detected. This information serves the repair technician in diagnosing the problem and conducting the proper repair. The freeze frame data should be stored upon storage of a pending DTC. If the pending DTC matures to a MIL-on DTC, the manufacturer can choose to update the freeze frame data or retain the freeze frame stored in conjunction with the pending DTC. Likewise, any freeze frame stored in conjunction with any pending or MIL-on DTC should be erased upon erasure of the DTC. Further information concerning the freeze frame requirement and the data required in the freeze frame is presented in section II.F.4, below.

We are also proposing that the OBD system illuminate the MIL and store a MIL-on DTC to inform the vehicle operator whenever the engine enters a mode of operation that can affect the performance of the OBD system. If such a mode of operation is recoverable (i.e., operation automatically returns to normal at the beginning of the following ignition cycle [14]), then in lieu of illuminating the MIL when the mode of operation is entered, the OBD system may wait to illuminate the MIL and store the MIL-on DTC if the mode of operation is again entered before the end of the next ignition cycle. We are proposing this because many operating strategies are designed such that they continue automatically through to the next key-off. Regardless, upon the next key-on, the engine control would start off in ''normal'' operating mode and would return to the ''abnormal'' operating mode only if the condition causing the abnormal mode was again encountered. In such cases, we are proposing to allow that the MIL be illuminated during the second consecutive drive cycle during which such an ''abnormal'' mode is engaged.[15]

Whether or not the ''abnormal'' mode of operation is recoverable, in this context, has nothing to do with whether the detected malfunction goes away or stays. Instead, it depends solely on whether or not the engine, by design, will stay in abnormal operating mode on the next key-on. We are proposing this MIL logic because often the diagnostic (i.e., monitor) that caused the engine to enter abnormal mode cannot run again once the engine is in the abnormal mode. So, if the MIL logic associated with abnormal mode activation was always a two-trip diagnostic, abnormal mode activation would set a pending DTC on the first trip and, since the system would then be stuck in that abnormal operating mode and would never be able to run the diagnostic again, the pending DTC could never mature to a MIL-on DTC nor illuminate the MIL. Hence, the MIL must illuminate upon the first entry into such an abnormal operating mode. If such a mode is recoverable, the engine will start at the next key-on in ''normal'' mode allowing the monitor to run again and, assuming another detection of the condition, the system would set a MIL-on DTC and illuminate the MIL.

The OBD system would not need to store a DTC nor illuminate the MIL upon abnormal mode operation if other telltale conditions would result in immediate action by the driver. Such telltale conditions would be, for example, an overt indication like a red engine shut-down warning light. The OBD system also need not store a DTC nor illuminate the MIL upon abnormal mode operation if the mode is indeed an auxiliary emission control device (AECD) approved by the Administrator.

There may be malfunctions of the MIL itself that would prevent it from illuminating. A repair technician—or possibly an I/M inspector—would still be able to determine the status of the MIL (i.e., commanded ''on'' or ''off'') by reading electronic information available through a scan tool, but there would be no indication to the driver of an emissions-related malfunction should one occur. Unidentified malfunctions may cause excess emissions to be emitted from the vehicle and may even cause subsequent deterioration or failure of other components or systems without the driver's knowledge. In order to prevent this, the manufacturer must ensure that the MIL is functioning properly. For this reason, we are proposing two requirements to check the functionality of the MIL itself. First, the MIL would be required to illuminate for a minimum of five seconds when the vehicle is in the key-on, engine-off position. This allows an interested party to check the MIL's functionality simply by turning the key to the key-on position. While the MIL would be physically illuminated during this functional check, the data stream value for the MIL command status would be required to indicate ''off'' during this check unless, of course, the MIL was currently being commanded ''on'' for a detected malfunction. This functional check of the MIL would not be required during vehicle operation in the key-on, engine-off position subsequent to the initial engine cranking of an ignition cycle (e.g., due to an engine stall or other non-commanded engine shutoff).

The second functional check requirement we are proposing requires the OBD system to perform a circuit continuity check of the electrical circuit that is used to illuminate the MIL to verify that the circuit is not shorted or open (e.g., a burned out bulb). While there would not be an ability to illuminate the MIL when such a malfunction is detected, the electronically readable MIL command status in the onboard computer would be changed from commanded ''off'' to ''on''. This would allow the truck owner or fleet maintenance staff to quickly determine whether an extinguished MIL means ''no malfunctions'' or ''broken MIL.'' It would also serve, should it become of interest in the future, complete automation of the I/M process by eliminating the need for inspectors to input manually the results of their visual inspections. Feedback from passenger car I/M programs indicates that the current visual bulb check performed by inspectors is subject to error and results in numerous vehicles being falsely failed or passed. By requiring monitoring of the circuit itself, the entire pass/fail criteria of an I/M program could be determined by the electronic information available through a scan tool, thus better facilitating quick

[14] ''Ignition Cycle'' means a drive cycle that begins with engine start and includes an engine speed that exceeds 50 to 150 rotations per minute (rpm) below the normal, warmed-up idle speed (as determined in the drive position for vehicles equipped with an automatic transmission) for at least two seconds plus or minus one second.

[15] Note that we use the term ''abnormal'' to refer to an operating mode that the engine is designed to enter upon determining that ''normal'' operation cannot be maintained. Therefore, the term ''abnormal'' is somewhat of a misnomer since the engine is doing what it has been designed to do. Nonetheless, the abnormal operating mode is clearly not the operating mode the manufacturer has intended for optimal operation. Such operating modes are sometimes referred to as ''default'' operating modes or ''limp-home'' operating modes.

and effective inspections and minimizing the chance for manually-entered errors.

At the manufacturer's option, the MIL may be used to indicate readiness status in a standardized format (see Section II.F) in the key-on, engine-off position. Readiness status is a term used in light-duty OBD that refers to a vehicle's readiness for I/M inspection. For a subset of monitors—those that are non-continuous monitors for which an emissions threshold exists (see sections II.B and II.C for more on emissions thresholds)—a readiness status indicator must be stored in memory to indicate whether or not that particular monitor has run enough times to make a diagnostic decision. Until the monitor has run sufficient times, the readiness status would indicate ''not ready''. Upon running sufficient times, the readiness status would indicate ''ready.'' This serves to protect against drivers disconnecting their battery just prior to the I/M inspection so as to erase any MIL-on DTCs. Such an action would simultaneously set all readiness status indicators to ''not ready'' resulting in a notice to return to the inspection site at a future date. Readiness indicators also help repair technicians because, after completing a repair, they can operate the vehicle until the readiness status indicates ''ready'' and, provided no DTCs are stored, know that the repair has been successful. We are proposing that HDOBD systems follow this same readiness status logic as used for years in light-duty OBD both to assist repair technicians and to facilitate potential future HDOBD I/M programs.

We are also proposing that the manufacturer, upon Administrator approval, be allowed to use the MIL to indicate which, if any, DTCs are currently stored (e.g., to ''blink'' the stored codes). The Administrator would approve the request if the manufacturer can demonstrate that the method used to indicate the DTCs will not be unintentionally activated during any inspection test or during routine driver operation.

3. Monitoring Conditions

a. Background

Given that the intent of the proposed OBD requirements is to monitor the emission control system for proper operation, it is logical that the OBD monitors be designed such that they monitor the emission control system during typical driving conditions. While many OBD monitors would be designed such that they are continuously making decisions about the operational status of the engine, many—and arguably the most critical—monitors are not so designed. For example, an OBD monitor whose function is to monitor the active fuel injection system of a NO_X adsorber or a DPF cannot be continuously monitoring that function since that function occurs on an infrequent basis. This OBD monitor presumably would be expected to ''run,'' or evaluate the active injection system, during an actual fuel injection event.

For this reason, manufacturers are allowed to determine the most appropriate times to run their non-continuous OBD monitors. This way, they are able to make an OBD evaluation either at the operating condition when an emission control system is active and its operational status can best be evaluated, and/or at the operating condition when the most accurate evaluation can be made (e.g., highly transient conditions or extreme conditions can make evaluation difficult). Importantly, manufacturers are prohibited from using a monitoring strategy that is so restrictive such that it rarely or never runs. To help protect against monitors that rarely run, we are proposing an ''in-use monitor performance ratio'' requirement which is detailed in section II.E.

The set of operating conditions that must be met so that an OBD monitor can run are called the ''enable criteria'' for that given monitor. These enable criteria are often different for different monitors and may well be different for different types of engines. A large diesel engine intended for use in a Class 8 truck would be expected to see long periods of relatively steady-state operation while a smaller engine intended for use in an urban delivery truck would be expected to see a lot of transient operation. Manufacturers will need to balance between a rather loose set of enable criteria for their engines and vehicles given the very broad range of operation HD highway engines see and a tight set of enable criteria given the desire for greater monitor accuracy.

b. General Monitoring Conditions

i. Monitoring Conditions for All Engines

As guidance to manufacturers, we are proposing the following criteria to assist manufacturers in developing their OBD enable criteria. These criteria would be used by the Agency during our OBD certification approval process to ensure that monitors run on a frequent basis during real world driving conditions. These criteria would be:

- The monitors should run during conditions that are technically necessary to ensure robust detection of malfunctions (e.g., to avoid false passes and false indications of malfunctions);
- The monitor enable criteria should ensure monitoring will occur during normal vehicle operation; and,
- Monitoring should occur during at least one test used by EPA for emissions verification '' either the HD Federal Test Procedure (FTP) transient cycle, or the Supplementary Emissions Test (SET).[16]

As discussed in more detail in sections II.B through II.D, we are proposing that manufacturers define the monitoring conditions, subject to Administrator approval, for detecting the malfunctions required by this proposal. The Administrator would determine if the monitoring conditions proposed by the manufacturer for each monitor abide by the above criteria.

In general, except as noted in sections II.B through II.D, the proposed regulation would require each monitor to run at least once per driving cycle in which the applicable monitoring conditions are met. The proposal would also require certain monitors to run continuously throughout the driving cycle. These include a few threshold monitors (e.g., fuel system monitor) and most circuit continuity monitors. While a basic definition of a driving cycle (e.g., from ignition key-on and engine startup to engine shutoff) has been sufficient for passenger cars, the driving habits of many types of vehicles in the heavy-duty industry dictate an alternate definition. Specifically, many heavy-duty operators will start the engine and leave it running for an entire day or, in some cases, even longer. As such, we are proposing that any period of continuous engine-on operation of four hours be considered a complete driving cycle. A new driving cycle would begin following such a four hour period, regardless of whether or not the engine had been shut down. Thus, the ''clock'' for monitors that are required to run once per driving cycle would be reset to run again (in the same key-on engine start or trip) once the engine has been operated beyond four hours continuously. This would avoid an unnecessary delay in detection of malfunctions simply because the heavy-duty vehicle operator has elected to leave the vehicle running continuously for an entire day or days at a time.

Manufacturers may request Administrator approval to define monitoring conditions that are not encountered during the FTP cycle. In evaluating the manufacturer's request, the Administrator will consider the degree to which the requirement to run

[16] See 40 CFR part 86, subpart N for details of EPA's test procedures.

during the FTP cycle restricts in-use monitoring, the technical necessity for defining monitoring conditions that are not encountered during the FTP cycle, data and/or an engineering evaluation submitted by the manufacturer which demonstrate that the component/system does not normally function, or monitoring is otherwise not feasible, during the FTP cycle, and, where applicable, the ability of the manufacturer to demonstrate that the monitoring conditions will satisfy the minimum acceptable in-use monitor performance ratio requirement as defined below.

ii. In-Use Performance Tracking Monitoring Conditions

In addition to the general monitoring conditions above, we are proposing that manufacturers be required to implement software algorithms in the OBD system to individually track and report in-use performance of the following monitors in the standardized format specified in section II.E:

- Diesel NMHC converting catalyst(s)
- Diesel NO_X converting catalyst(s)
- Gasoline catalyst(s)
- Exhaust gas sensor(s)
- Gasoline evaporative system
- Exhaust gas recirculation (EGR) system
- Variable valve timing (VVT) system
- Gasoline secondary air system
- Diesel particulate filter system
- Diesel boost pressure control system
- Diesel NO_X adsorber(s)

The OBD system is not required to track and report in-use performance for monitors other than those specifically identified above.

iii. In-Use Performance Ratio Requirement

We are also proposing that, for all 2013 and subsequent model year engines, manufacturers be required to define monitoring conditions that, in addition to meeting the general monitoring conditions, ensure that certain monitors yield an in-use performance ratio (which monitors and the details that define the performance ratio are defined in section II.E) that meets or exceeds the minimum acceptable in-use monitor performance ratio for in-use vehicles. We are proposing a minimum acceptable in-use monitor performance ratio of 0.100 for all monitors specifically required to track in-use performance. This means that the monitors listed in section II.A.3.ii above must run and make valid diagnostic decisions during 10 percent of the vehicle's trips. We intend to work with industry during the initial years of implementation to gather data on in-use performance ratios and may revise this ratio lower as appropriate depending on what we learn.

Note that manufacturers may not use the calculated ratio (or any element thereof), or any other indication of monitor frequency, as a monitoring condition for a monitor. For example, the manufacturer would not be allowed to use a low ratio to enable more frequent monitoring through diagnostic executive priority or modification of other monitoring conditions, or to use a high ratio to enable less frequent monitoring.

4. Determining the Proper OBD Malfunction Criteria

For determining the malfunction criteria for diesel engine monitors associated with an emissions threshold (see sections II.B and II.C for more on emissions thresholds), we are proposing that manufacturers be required to determine the appropriate emissions test cycle such that the most stringent monitor would result. In general, we believe that manufacturers can make this determination based on engineering judgement, but there may be situations where testing would be required to make the determination. We do not necessarily anticipate challenging a manufacturer's determination of which test cycle to use. Nonetheless, the manufacturer should be prepared, perhaps with test data, to justify their determination.

We are also proposing that, for engines equipped with emission controls that experience infrequent regeneration events (e.g., a DPF and/or a NO_X adsorber), a manufacturer must adjust the emission test results for monitors that are required to indicate a malfunction before emissions exceed a certain emission threshold.[17] For each such monitor, the manufacturer would have to adjust the emission result as done in accordance with the provisions of section 86.004–28(i) with the component for which the malfunction criteria are being established having been deteriorated to the malfunction threshold. As proposed, the adjusted emission value must be used for purposes of determining whether or not the applicable emission threshold is exceeded.

While we believe that this adjustment process for monitors of systems that experience infrequent regeneration events makes sense and would result in robust monitors, we also believe that it could prove to be overly burdensome for manufacturers. For example, a NO_X adsorber threshold being evaluated by running an FTP using a ''threshold'' part (i.e., a NO_X adsorber deteriorated such that tailpipe emissions are at the applicable thresholds) may be considered acceptable provided the NO_X adsorber does not regenerate during the test, but it may be considered unacceptable if the NO_X adsorber does happen to regenerate during the test. This could happen because emissions would be expected to increase slightly during the regeneration event thereby causing emissions to be slightly above the applicable threshold. This would require the manufacturer to recalibrate the NO_X adsorber monitor to detect at a lower level of deterioration to ensure that a regeneration event would not cause an exceedance of the threshold during an emissions test. After such a recalibration, the emissions occurring during the regeneration event would be lower than before because the new ''threshold'' NO_X adsorber would have a slightly higher conversion efficiency. We are concerned that manufacturers may find themselves in a difficult iterative process calibrating such monitors that, in the end, will not be correspondingly more effective.

For this reason, we request comment regarding the burden associated with the need to consider regeneration events in determining compliance with emissions thresholds. We also request comment on how to address any environmental concern versus the burden. Would it perhaps be best to simply use the emissions adjustments that are determined in accordance with section 86.004–28(i)? Is it necessary to even consider regeneration emissions when determining emission threshold compliance or is it perhaps best to ignore regeneration events in determining threshold calibrations?

B. Monitoring Requirements and Timelines for Diesel-Fueled/ Compression-Ignition Engines

Table II.B–1 summarizes the proposed diesel fueled compression ignition emissions thresholds at which point a component or system has failed to the point of requiring an illuminated MIL and a stored DTC. More detail regarding the specific monitoring requirements, implementation schedules, and liabilities can be found in the sections that follow.

[17] See proposed § 86.010–18(f).

TABLE II.B–1.—PROPOSED EMISSIONS THRESHOLDS FOR DIESEL FUELED CI ENGINES OVER 14,000 POUNDS

Component/monitor	MY	NMHC	CO	NO_X	PM
NMHC catalyst system	2010–2012	2.5x	....	....	....
	2013+	2x	....	....	....
NO_X catalyst system	2010+	....	....	+0.3	....
DPF system	2010–2012	2.5x	....	....	0.05/+0.04
	2013+	2x	....	....	0.05/+0.04
Air-fuel ratio sensors upstream	2010–2012	2.5x	2.5x	+0.3	0.03/+0.02
	2013+	2x	2x	+0.3	0.03/+0.02
Air-fuel ratio sensors downstream	2010–2012	2.5x	....	+0.3	0.05/+0.04
	2013+	2x	....	+0.3	0.05/+0.04
NO_X sensors	2010+	....	....	+0.3	0.05/+0.04
"Other monitors" with emissions thresholds (see section II.B)	2010–2012	2.5x	2.5x	+0.3	0.03/+0.02
	2013+	2x	2x	+0.3	0.03/+0.02

Notes: MY=Model Year; 2.5x means a multiple of 2.5 times the applicable emissions standard or family emissions limit (FEL); +0.3 means the standard or FEL plus 0.3; 0.05/+0.04 means an absolute level of 0.05 or an additive level of the standard or FEL plus 0.04, whichever level is higher; not all proposed monitors have emissions thresholds but instead rely on functionality and rationality checks as described in section II.D.4.

There are exceptions to the emissions thresholds shown in Table II.B–1 whereby a manufacturer can demonstrate that emissions do not exceed the threshold even when the component or system is non-functional at which point a functional check would be allowed.

Note that, in general, the monitoring strategies designed to meet the requirements discussed below should not involve the alteration of the engine control system or the emissions control system such that tailpipe emissions would increase. We do not want emissions to increase, even for short durations, for the sole purpose of monitoring the systems intended to control emissions. The Administrator would consider such monitoring strategies on a case-by-case basis taking into consideration the emissions impact and duration of the monitoring event. However, much effort has been expended in recent years to minimize engine operation that results in increased emissions and we encourage manufacturers to develop monitoring strategies that do not require alteration of the basic control system.

1. Fuel System Monitoring

a. Background

The fuel system of a diesel engine is an essential component of the engine's emissions control system. Proper delivery of fuel—quantity, pressure, and timing—can play a crucial role in maintaining low engine-out emissions. The performance of the fuel system is also critical for aftertreatment device control strategies. As such, thorough monitoring of the fuel system is an essential element in an OBD system. 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 undergone relatively minor hardware changes (but substantial fine-tuning in the control strategy and feedback inputs), diesel engines have more recently undergone substantial changes to the fuel system hardware and now incorporate more refined control strategies and feedback inputs.

For diesel engines, a substantial change has occurred in recent years as manufacturers have transitioned to new high-pressure fuel systems. One of the most widely used is a high-pressure common-rail fuel injection system, which is generally comprised of a high-pressure fuel pump, a fuel rail pressure sensor, a common fuel rail that feeds all injectors, individual fuel injectors that directly control fuel injection quantity and timing for each cylinder, and a closed-loop feedback system that uses the fuel rail pressure sensor to achieve the commanded fuel rail pressure. Unlike older style fuel systems where fuel pressure was mechanically linked to engine speed (and thus, varied from low to high as engine speed increased), common-rail systems are capable of controlling fuel pressure independent of engine speed. This increase in fuel pressure control allows greater flexibility in optimizing the performance and emission characteristics of the engine. The ability of the system to generate high pressure independent of engine speed also improves fuel delivery at low engine speeds.

Precise control of the fuel injection timing is crucial for optimal engine and emission performance. As injection timing is advanced (i.e., fuel injection occurs earlier), hydrocarbon (HC) emissions and fuel consumption are decreased but oxides of nitrogen (NO_X) emissions are increased. As injection timing is retarded (i.e., fuel injection occurs later), NO_X emissions can be reduced but HC emissions, particulate matter (PM) emissions, and fuel consumption increase. Most modern diesel fuel systems even provide engine manufacturers with the ability to separate a single fuel injection event into discrete events such as pilot (or pre) injection, main injection, and post injection.

Given the important role that modern diesel fuel systems play in emissions control, malfunctions or deterioration that would affect the fuel pressure control, injection timing, pilot/main/post injection timing or quantity, or ability to accurately perform rate-shaping could lead to substantial increases in emissions (primarily NO_X or PM), often times with an associated change in fuel consumption.

b. Fuel System Monitoring Requirements

We are proposing that the OBD system monitor the fuel delivery system to verify that it is functioning properly. The fuel system monitor would be required to monitor for malfunctions in the injection pressure control, injection quantity, injection timing, and feedback control (if equipped). The individual electronic components (e.g., actuators, valves, sensors, pumps) that are used in the fuel system and not specifically addressed in this section shall be monitored in accordance with the comprehensive component requirements in section II.D.4.

i. Fuel System Pressure Control

We are proposing that the OBD system continuously monitor the fuel system's ability to control to the desired fuel pressure. The OBD system would have to detect a malfunction of the fuel system's pressure control system when the pressure control system is unable to maintain an engine's emissions at or below the emissions thresholds for ''other monitors'' as shown in Table II.B–1. For engines in which no failure or deterioration of the fuel system pressure control could result in an engine's emissions exceeding the applicable emissions thresholds, the OBD system would be required to detect a malfunction when the system has reached its control limits such that the commanded fuel system pressure cannot be delivered.

ii. Fuel System Injection Quantity

We are proposing that the OBD system detect a malfunction of the fuel injection system when the system is unable to deliver the commanded quantity of fuel necessary to maintain an engine's emissions at or below the emissions thresholds for ''other monitors'' as shown in Table II.B–1. For engines in which no failure or deterioration of the fuel injection quantity could result in an engine's emissions exceeding the applicable emissions thresholds, the OBD system would be required to detect a malfunction when the system has reached its control limits such that the commanded fuel quantity cannot be delivered.

iii. Fuel System Injection Timing

We are proposing that the OBD system detect a malfunction of the fuel injection system when the system is unable to deliver fuel at the proper crank angle/timing (e.g., injection timing too advanced or too retarded) necessary to maintain an engine's emissions at or below the emissions thresholds for ''other monitors'' as shown in Table II.B–1. For engines in which no failure or deterioration of the fuel injection timing could result in an engine's emissions exceeding the applicable emissions thresholds, the OBD system would be required to detect a malfunction when the system has reached its control limits such that the commanded fuel injection timing cannot be achieved.

iv. Fuel System Feedback Control

If the engine is equipped with feedback control of the fuel system (e.g., feedback control of pressure or pilot injection quantity), we are proposing that the OBD system detect a malfunction when and if:

- The system fails to begin feedback control within a manufacturer specified time interval;
- A failure or deterioration causes open loop or default operation; or
- Feedback control has used up all of the adjustment allowed by the manufacturer.

A manufacturer may temporarily disable monitoring for malfunctions where the feedback control has used up all of the adjustment allowed by the manufacturer during conditions that the monitor cannot distinguish robustly between a malfunctioning system and a properly operating system. To do so, the manufacturer would be required to submit data and/or engineering analyses demonstrating that the control system, when operating as designed on an engine with all emission controls working properly, routinely operates during these conditions with all of the adjustment allowed by the manufacturer used up. In lieu of detecting, with a fuel system specific monitor, when the system fails to begin feedback control within a manufacturer specified time interval and/or when a failure or deterioration causes open loop or default operation, the OBD system may monitor the individual parameters or components that are used as inputs for fuel system feedback control provided that the monitors detect all malfunctions related to feedback control.

c. Fuel System Monitoring Conditions

The OBD system would be required to monitor continuously for malfunctions of the fuel pressure control and feedback control. Manufacturers would be required to define the monitoring conditions for malfunctions of the injection quantity and injection timing such that the minimum performance ratio requirements discussed in section II.E would be met.

d. Fuel System MIL Illumination and DTC Storage

We are proposing the general MIL illumination and DTC storage requirements as discussed in section II.A.2.

2. Engine Misfire Monitoring

a. Background

Misfire, the lack of combustion in the cylinder, causes increased engine-out hydrocarbon emissions. On gasoline engines, misfire results from the absence of spark, poor fuel metering, and poor compression. Further, misfire can be intermittent on gasoline engines (e.g., the misfire only occurs under certain engine speeds or loads). Consequently, our existing under 14,000 pound OBD regulation requires continuous monitoring for misfire malfunctions on gasoline engines.

In contrast, manufacturers have historically maintained that a diesel engine with traditional diesel technology misfires only due to poor compression (e.g., worn valves or piston rings, improper injector or glow plug seating). They have also maintained that, when poor compression results in a misfiring cylinder, the cylinder will misfire under all operating conditions rather than only some operating conditions. For that reason, our existing under 14,000 pound OBD regulation has not required continuous monitoring for misfire malfunctions on diesel engines.

However, with the increased use of EGR and its use to varying degrees at different speeds and load, and with emerging technologies such as homogeneous charge compression ignition (HCCI), we believe that the conventional wisdom regarding diesel engines and misfires no longer holds true. These newer technologies may indeed result in misfires that are intermittent, spread out among various cylinders, and that only happen at certain speeds and loads.

b. Misfire Monitoring Requirements

We are proposing that the OBD system monitor the engine for misfire causing excess emissions. The OBD system must be capable of detecting misfire occurring in one or more cylinders. To the extent possible without adding hardware for this specific purpose, the OBD system must also identify the specific misfiring cylinder. If more than one cylinder is continuously misfiring, a separate DTC must be stored indicating that multiple cylinders are misfiring. When identifying multiple cylinder misfire, the OBD system is not required to also identify each of the continuously misfiring cylinders individually through separate DTCs.

For 2013 and subsequent model year engines, we are proposing a more stringent requirement that the OBD system detect a misfire malfunction causing emissions to exceed the emissions thresholds for ''other monitors'' as shown in Table II.B–1. This requirement to detect engine misfire prior to exceeding an emissions threshold would apply only to those engines equipped with sensors capable of detecting combustion or combustion quality (e.g., cylinder pressure sensors used in homogeneous charge compression ignition (HCCI) control systems). Engines without such sensors would have to detect only when one or more cylinders are continually misfiring.

To determine what level of misfire would cause emissions to exceed the applicable emissions thresholds, we are proposing that manufacturers determine the percentage of misfire evaluated in 1000 revolution increments that would cause emissions from an emission durability demonstration engine to exceed the emissions thresholds if the percentage of misfire were present from the beginning of the test. To establish this percentage of misfire, the manufacturer would utilize misfire events occurring at equally spaced, complete engine cycle intervals, across randomly selected cylinders throughout each 1000-revolution increment. If this percentage of misfire is determined to be lower than one percent, the manufacturer may set the malfunction criteria at one percent. Any malfunction should be detected if the percentage of misfire established via this testing is exceeded regardless of the pattern of misfire events (e.g., random, equally spaced, continuous).

The manufacturer may employ other revolution increments besides the 1000 revolution increment being proposed. To do so, the manufacturer would need to demonstrate that the strategy would be equally effective and timely in detecting misfire.

c. Engine Misfire Monitoring Conditions

For engines without combustion sensors, we are proposing that the OBD system monitor for misfire during engine idle conditions at least once per drive cycle in which the monitoring conditions for misfire are met. The manufacturer would be required to define monitoring conditions, supported by manufacturer-submitted data and/or engineering analyses, that demonstrate that the monitoring conditions: are technically necessary to ensure robust detection of malfunctions (e.g., avoid false passes and false detection of malfunctions); require no more than 1000 cumulative engine revolutions; and, do not require any single continuous idle operation of more than 15 seconds to make a determination that a malfunction is present (e.g., a decision can be made with data gathered during several idle operations of 15 seconds or less).

For 2013 and subsequent model year engines with combustion sensors, we are proposing that the OBD system continuously monitor for misfire under all positive torque engine speeds and load conditions. If a monitoring system cannot detect all misfire patterns under all positive torque engine speeds and load conditions, the manufacturer may request that the Administrator approve the monitoring system nonetheless. In evaluating the manufacturer's request, the Administrator would consider the following factors: the magnitude of the region(s) in which misfire detection is limited; the degree to which misfire detection is limited in the region(s) (i.e., the probability of detection of misfire events); the frequency with which said region(s) are expected to be encountered in-use; the type of misfire patterns for which misfire detection is troublesome; and demonstration that the monitoring technology employed is not inherently incapable of detecting misfire under required conditions (i.e., compliance can be achieved on other engines). The evaluation would be based on the following misfire patterns: equally spaced misfire occurring on randomly selected cylinders; single cylinder continuous misfire; and, paired cylinder (cylinders firing at the same crank angle) continuous misfire.

d. Engine Misfire MIL Illumination and DTC Storage

For engines without combustion sensors, we are proposing the general MIL illumination and DTC storage requirements as discussed in section II.A.2.

For 2013 and subsequent model year engines with combustion sensors, we are proposing that, after four detections of the percentage of misfire that would cause emissions to exceed the applicable emissions thresholds during a single driving cycle, a pending DTC would be stored. If a pending DTC is stored, the OBD system would be required to illuminate the MIL and store a MIL—on DTC if the percentage of misfire is again exceeded four times during either: the driving cycle immediately following the storage of the pending DTC, regardless of the conditions encountered during the driving cycle; or, the next driving cycle in which similar conditions are encountered to the engine conditions that occurred when the pending DTC was stored.[18] For erasure of the pending DTC, we are proposing if, by the end of the next driving cycle in which similar conditions have been encountered to the engine conditions that occurred when the pending DTC was stored without an exceedance of the specified percentage of misfire, the pending DTC may be erased. The pending DTC may also be erased if similar conditions are not encountered during the next 80 driving cycles immediately following initial detection of the malfunction.

[18] "Similar conditions," as used in conjunction with misfire and fuel system monitoring, means engine conditions having an engine speed within 375 rpm, load conditions within 20 percent, and the same warm up status (i.e., cold or hot) as existing during the applicable previous problem detection. The Administrator may approve other definitions of similar conditions based on comparable timeliness and reliability in detecting similar engine operation.

We are proposing some specific items with respect to freeze frame storage associated with engine misfire. The OBD system shall store and erase freeze frame conditions either in conjunction with storing and erasing a pending DTC or in conjunction with storing a MIL—on DTC and erasing a MIL—on DTC. In addition to those proposed requirements discussed in section II.A.2, we are proposing that, if freeze frame conditions are stored for a malfunction other than a misfire malfunction when a DTC is stored, the previously stored freeze frame information shall be replaced with freeze frame information regarding the misfire malfunction (i.e., the misfire's freeze frame information should take precedence over freeze frames for other malfunctions). Further, we are proposing that, upon detection of misfire, the OBD system store the following engine conditions: engine speed, load, and warm up status of the first misfire event that resulted in the storage of the pending DTC.

Lastly, we are proposing that the MIL may be extinguished after three sequential driving cycles in which similar conditions have been encountered without an exceedance of the specified percentage of misfire.

3. Exhaust Gas Recirculation (EGR) System Monitoring

a. Background

Exhaust gas recirculation (EGR) systems are currently being used by many heavy-duty engine manufacturers to meet the 2.5 g/bhp-hr NO_X+NMHC standard for 2004 and later model year engines. (65 FR 59896) EGR reduces NO_X emissions in several ways. First, the recirculated exhaust gases dilute the intake air—i.e., oxygen in the fresh air is displaced with relatively non-reactive exhaust gases—which, in turn, results in less oxygen to form NO_X. Second, EGR absorbs heat from the combustion process which reduces combustion chamber temperatures which, in turn, reduces NO_X formation. The amount of heat absorbed from the combustion process is a function of EGR flow rate and recirculated gas temperature, both of which are controlled to minimize NO_X emissions. An EGR cooler can be added to the EGR system to lower the recirculated gas temperature which further enhances NO_X control. We fully expect that 2007 and later model year engines will continue to make use of cooled EGR systems.

While in theory the EGR system simply routes some exhaust gas back to the intake, production systems can be complex and involve many components to ensure accurate control of EGR flow to maintain acceptable PM and NO_X emissions while minimizing effects on fuel economy. To control EGR flow rates, EGR systems normally use the following components: an EGR valve, valve position sensor, boost pressure sensor, intake temperature sensor, intake (fresh) airflow sensor, and tubing or piping to connect the various components of the system. EGR temperature sensors and exhaust backpressure sensors can also be used. 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 (turbocharging and intake cooling) to control NO_X while not adversely affecting PM emissions and fuel economy.

b. EGR System Monitoring Requirements

We are proposing that the OBD system monitor the EGR system on engines so equipped for low EGR flow rate, high EGR flow rate, and slow EGR flow response malfunctions. For engines so equipped, we are proposing that the EGR feedback control be monitored. Also, for engines equipped with EGR coolers (e.g., heat exchangers), the OBD system would have to monitor the cooler for malfunctions associated with insufficient EGR cooling. The individual electronic components (e.g., actuators, valves, sensors) that are used in the EGR system would be monitored in accordance with the comprehensive component requirements presented in section II.D.4.

i. EGR Low Flow Malfunctions

We are proposing that the OBD system detect a malfunction prior to a decrease from the manufacturer's specified EGR flow rate that would cause an engine's emissions to exceed the emissions thresholds for ''other monitors'' as shown in Table II.B–1. For engines in which no failure or deterioration of the EGR system that causes a decrease in flow could result in an engine's emissions exceeding the applicable emissions thresholds, the OBD system would have to detect a malfunction when the system has reached its control limits such that it cannot increase EGR flow to achieve the commanded flow rate.

ii. EGR High Flow Malfunctions

We are proposing that the OBD system detect a malfunction of the EGR system, including a leaking EGR valve—i.e., exhaust gas flowing through the valve when the valve is commanded closed—prior to an increase from the manufacturer's specified EGR flow rate that would cause an engine's emissions to exceed the emissions thresholds for ''other monitors'' as shown in Table II.B–1. For engines in which no failure or deterioration of the EGR system that causes an increase in flow could result in an engine's emissions exceeding the applicable emissions thresholds, the OBD system would have to detect a malfunction when the system has reached its control limits such that it cannot reduce EGR flow to achieve the commanded flow rate.

iii. EGR Slow Response Malfunctions

We are proposing that the OBD system detect a malfunction of the EGR system prior to any failure or deterioration in the capability of the EGR system to achieve the commanded flow rate within a manufacturer-specified time that would cause an engine's emissions to exceed the emissions thresholds for ''other monitors'' as shown in Table II.B–1. The OBD system would have to monitor both the capability of the EGR system to respond to a commanded increase in flow and the capability of the EGR system to respond to a commanded decrease in flow.

iv. EGR Feedback Control

We are proposing that the OBD system on any engine equipped with feedback control of the EGR system (e.g., feedback control of flow, valve position, pressure differential across the valve via intake throttle or exhaust backpressure), detect a malfunction when and if:

• The system fails to begin feedback control within a manufacturer specified time interval;
• A failure or deterioration causes open loop or default operation; or
• Feedback control has used up all of the adjustment allowed by the manufacturer.

v. EGR Cooler Performance

We are proposing that the OBD system detect a malfunction of the EGR cooler prior to a reduction from the manufacturer's specified cooling performance that would cause an engine's emissions to exceed the emissions thresholds for ''other monitors'' as shown in Table II.B–1. For engines in which no failure or deterioration of the EGR cooler could result in an engine's emissions exceeding the applicable emissions thresholds, the OBD system would have to detect a malfunction when the system has no detectable amount of EGR cooling.

c. EGR System Monitoring Conditions

We are proposing that the OBD system monitor continuously for low EGR flow, high EGR flow, and feedback control malfunctions. Manufacturers would be required to define the monitoring conditions for EGR slow response malfunctions such that the minimum performance ratio requirements discussed in section II.E would be met with the exception that monitoring must occur every time the monitoring conditions are met during the driving cycle in lieu of once per driving cycle as required for most monitors. For purposes of tracking and reporting as required in section II.E, all monitors used to detect EGR slow response malfunctions must be tracked separately but reported as a single set of values as specified in section II.E.[19]

Manufacturersmay temporarily disable the EGR system check under specific conditions (e.g., when freezing may affect performance of the system). To do so, the manufacturer would be required to submit data and/or engineering analyses that demonstrate that a reliable check cannot be made when these specific conditions exist.

d. EGR System MIL Illumination and DTC Storage

We are proposing the general requirements for MIL illumination and DTC storage as discussed in section II.A.2.

4. Turbo Boost Control System Monitoring

a. Background

Turbochargers are used on internal combustion engines to enhance performance by increasing the density of the intake air. Some of the benefits of turbocharging include increased horsepower, improved fuel economy, and decreased exhaust smoke. Most modern diesel engines take advantage of these benefits and are equipped with turbocharging systems. Moreover, smaller turbocharged diesel engines can be used in place of larger non-turbocharged engines to achieve the desired engine performance characteristics.

[19] For specific components or systems that have multiple monitors that are required to be reported (e.g., exhaust gas sensor bank 1 may have multiple monitors for sensor response or other sensor characteristics), the OBD system must separately track numerators and denominators for each of the specific monitors and report only the corresponding numerator and denominator for the specific monitor that has the lowest numerical ratio. If two or more specific monitors have identical ratios, the corresponding numerator and denominator for the specific monitor that has the highest denominator shall be reported for the specific component.

Exhaust gases passing through the turbine cause it to spin which, in turn, causes an adjacent centrifugal pump on the same rotating shaft to spin. The spinning pump serves to compress the intake air thereby increasing its density. Typically, a boost pressure sensor is located in the intake manifold to provide a feedback signal of the current intake manifold pressure. As turbo speed (boost) increases, the pressure in the intake manifold also increases.

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. Another critical emission control system, EGR, is very dependent on these two pressures and generally uses the differential between them to force exhaust gas into the intake manifold. If the boost control system is not operating correctly, the exhaust or intake pressures may not be as expected and the EGR system may not function as designed. In high-pressure EGR systems, higher exhaust pressures will generate more EGR flow and, conversely, lower pressures will reduce EGR flow. A malfunction that causes excessive exhaust pressures (e.g., wastegate stuck closed at high engine speed) can produce higher EGR flowrates at high load conditions and have a negative impact on emissions.

Manufacturers commonly use charge air coolers to maximize the benefits of turbocharging and to control NO_X emissions. As the turbocharger compresses the intake air, the temperature of that intake air increases. This increasing air temperature causes the air to expand, which conflicts with one of the goals of turbocharging which is to increase charge air density. Charge air coolers are used to exchange heat between the compressed air and ambient air (or coolant) and cool the compressed air. Accordingly, a decrease in charge air cooler performance can affect emissions by causing higher intake air temperatures that can lead to higher combustion temperatures and higher NO_X 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 exists from the driver demand for more boost until the exhaust flow can physically speed up the turbocharger enough to deliver that boost. In addition to a negative effect on driveability and performance, improper fueling (e.g., over-fueling) during this lag can cause emission increases (typically PM).

To decrease the effects of turbo lag, manufacturers design turbos that spool up quickly at low engine speeds and low exhaust flowrates. However, designing a turbo that will accelerate quickly from a low engine speed but will not result in an over-speed/over-boost condition at higher engine speeds is challenging. That is, as the engine speed and exhaust flowrates near their maximum, the turbo speed increases to levels that cause excessive boost pressures and heat that could lead to engine or turbo damage. To prevent excessive turbine speeds and boost pressures at higher engine speeds, a wastegate is often used to bypass part of the exhaust stream around the turbocharger. The wastegate 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 wastegate is then opened at higher engine speeds to prevent engine or turbo damage from an over-speed condition.

An alternative to a wastegate is the variable geometry turborcharger (VGT). To prevent over-boost conditions and to decrease turbo lag, VGTs are designed such that the geometry of the turbocharger changes with engine speed. While various physical mechanisms are used 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 such 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-speed condition. The advantage that VGTs offer compared to a waste-gated turbocharger is that all exhaust flow is directed through the turbocharger under all operating conditions. This can be viewed as maximizing the use of the available exhaust energy.

b. Turbo Boost Control System Monitoring Requirements

We are proposing that the OBD system monitor the boost pressure control system on engines so equipped for under and over boost malfunctions. For engines equipped with variable geometry turbochargers (VGT), the OBD system would have to monitor the VGT system for slow response malfunctions. For engines equipped with charge air cooler systems, the OBD system would have to monitor the charge air cooler system for cooling system performance malfunctions. The individual electronic components (e.g., actuators, valves, sensors) that are used in the boost pressure control system shall be monitored in accordance with the comprehensive component requirements in section II.D.4.

i. Turbo Underboost Malfunctions

We are proposing that the OBD system detect a malfunction of the boost pressure control system prior to a decrease from the manufacturer's commanded boost pressure that would cause an engine's emissions to exceed the emissions thresholds for ''other monitors'' as shown in Table II.B–1. For engines in which no failure or deterioration of the boost pressure control system that causes a decrease in boost could result in an engine's emissions exceeding the applicable emissions thresholds, the OBD system must detect a malfunction when the system has reached its control limits such that it cannot increase boost to achieve the commanded boost pressure.

ii. Turbo Overboost Malfunctions

We are proposing that the OBD system detect a malfunction of the boost pressure control system prior to an increase from the manufacturer's commanded boost pressure that would cause an engine's emissions to exceed the emissions thresholds for ''other monitors'' as shown in Table II.B–1. For engines in which no failure or deterioration of the boost pressure control system that causes an increase in boost could result in an engine's emissions exceeding the applicable emissions thresholds, the OBD system must detect a malfunction when the system has reached its control limits such that it cannot decrease boost to achieve the commanded boost pressure.

iii. VGT Slow Response Malfunctions

We are proposing that the OBD system detect a malfunction prior to any failure or deterioration in the capability of the VGT system to achieve the commanded turbocharger geometry within a manufacturer-specified time that would cause an engine's emissions to exceed the emissions thresholds for ''other monitors'' as shown in Table II.B–1. For engines in which no failure or deterioration of the VGT system response could result in an engine's emissions exceeding the applicable emissions thresholds, the OBD system must detect a malfunction of the VGT system when proper functional response of the system to computer commands does not occur.

iv. Turbo Boost Feedback Control Malfunctions

We are proposing that, for engines equipped with feedback control of the boost pressure system—e.g., control of VGT position, turbine speed, manifold pressure—the OBD system shall detect a malfunction when and if:

- The system fails to begin feedback control within a manufacturer specified time interval;
- A failure or deterioration causes open loop or default operation; or
- Feedback control has used up all of the adjustment allowed by the manufacturer.

v. Charge Air Undercooling Malfunctions

We are proposing that the OBD system detect a malfunction of the charge air cooling system prior to a decrease from the manufacturer's specified cooling rate that would cause an engine's emissions to exceed the emissions thresholds for ''other monitors'' as shown in Table II.B–1. For engines in which no failure or deterioration of the charge air cooling system that causes a decrease in cooling performance could result in an engine's emissions exceeding the applicable emissions thresholds, the OBD system must detect a malfunction when the system has no detectable amount of charge air cooling.

c. Turbo Boost Control System Monitoring Conditions

We are proposing that the OBD system monitor continuously for underboost and overboost malfunctions and for boost feedback control malfunctions. Manufacturers would be required to define the monitoring conditions for VGT slow response malfunctions such that the minimum performance ratio requirements discussed in section II.E would be met with the exception that monitoring must occur every time the monitoring conditions are met during the driving cycle in lieu of once per driving cycle as required for most monitors. For purposes of tracking and reporting as required in section II.E, all monitors used to detect VGT slow response malfunctions malfunctions must be tracked separately but reported as a single set of values as discussed in section II.E.[20]

d. Turbo Boost MIL Illumination and DTC Storage

We are proposing the general MIL illumination and DTC storage requirements as discussed in section II.A.2.

5. Non-Methane Hydrocarbon (NMHC) Converting Catalyst Monitoring

a. Background

Diesel oxidation catalysts (DOCs) have been used on some nonroad diesel engines since the 1960s and on some diesel trucks and buses in the U.S. since the early 1990s. DOCs are generally used for converting HC and carbon monoxide (CO) emissions to water and CO_2 via an oxidation process. Current DOCs can also be used to convert PM emissions. DOCs may also be used in conjunction with other aftertreatment emission controls—such as NO_X adsorber systems, selective catalytic reduction (SCR) systems, and PM filters—to improve their performance and/or clean up certain reducing agents that might slip through the system (e.g., the urea used in urea SCR systems).

b. NMHC Converting Catalyst Monitoring Requirements

We are proposing that the OBD system monitor the NMHC converting catalyst(s) for proper NMHC conversion capability. We are also proposing that each catalyst that converts NMHC be monitored either individually or in combination with others. For engines equipped with catalyzed diesel particulate filters (CDPFs) that convert NMHC emissions, the catalyst function of the CDPF must be monitored in accordance with the CDPF monitoring requirements in section II.B.8.

i. NMHC Converting Catalyst Conversion Efficiency

We are proposing that the OBD system detect an NMHC catalyst malfunction when the catalyst conversion capability decreases to the point that NMHC emissions exceed the emissions thresholds for ''NMHC catalysts'' as shown in Table II.B–1. If no failure or deterioration of the catalyst NMHC conversion capability could result in an engine's NMHC emissions exceeding the applicable emissions thresholds, the OBD system would have to detect a malfunction when the catalyst has no detectable amount of NMHC conversion capability.

ii. Other Aftertreatment Assistance Functions

For catalysts used to generate an exotherm to assist CDPF regeneration, we are proposing that the OBD system detect a malfunction when the catalyst is unable to generate a sufficient exotherm to achieve that regeneration. For catalysts used to generate a feedgas constituency to assist SCR systems (e.g., to increase NO_2 concentration upstream of an SCR system), the OBD system would have to detect a malfunction when the catalyst is unable to generate the necessary feedgas constituents for proper SCR system operation. For catalysts located downstream of a CDPF and used to convert NMHC emissions during a CDPF regeneration event, the OBD system would be required to detect a malfunction when the catalyst has no detectable amount of NMHC conversion capability.

c. NMHC Converting Catalyst Monitoring Conditions

Manufacturers would be required to define the monitoring conditions for NMHC converting catalyst malfunctions such that the minimum performance ratio requirements discussed in section II.E would be met. For purposes of tracking and reporting as discussed in section II.E, all monitors used to detect NMHC converting catalyst malfunctions must be tracked separately but reported as a single set of values as discussed in section II.E.[21]

d. NMHC Converting Catalyst MIL Illumination and DTC Storage

We are proposing the general requirements for MIL illumination and DTC storage discussed in section II.A.2. Note that the monitoring method for the catalyst(s) must be capable of detecting all instances, except diagnostic self-clearing, when a catalyst DTC has been cleared but the catalyst has not been replaced (e.g., catalyst over temperature histogram approaches are not acceptable).[22]

[20] For specific components or systems that have multiple monitors that are required to be reported (e.g., exhaust gas sensor bank 1 may have multiple monitors for sensor response or other sensor characteristics), the OBD system must separately track numerators and denominators for each of the specific monitors and report only the corresponding numerator and denominator for the specific monitor that has the lowest numerical ratio. If two or more specific monitors have identical ratios, the corresponding numerator and denominator for the specific monitor that has the highest denominator shall be reported for the specific component.

[21] For specific components or systems that have multiple monitors that are required to be reported (e.g., exhaust gas sensor bank 1 may have multiple monitors for sensor response or other sensor characteristics), the OBD system must separately track numerators and denominators for each of the specific monitors and report only the corresponding numerator and denominator for the specific monitor that has the lowest numerical ratio. If two or more specific monitors have identical ratios, the corresponding numerator and denominator for the specific monitor that has the highest denominator shall be reported for the specific component.

[22] For gasoline catalyst monitoring, manufacturers generally use what is called an exponentially

Continued

6. Selective Catalytic Reduction (SCR) and Lean NO_X Catalyst Monitoring

a. Background

Selective Catalytic Reduction (SCR) catalysts that use ammonia as a NO_X reductant have been used for stationary source NO_X control for a number of years. Frequently, urea is used as the source of ammonia for SCR catalysts, and such systems are commonly referred to as Urea SCR systems. In recent years, considerable effort has been invested in developing urea SCR systems that could be applied to heavy-duty diesel vehicles with low sulfur diesel fuel. We now expect that urea SCR systems will be introduced in Europe to comply with the EURO IV heavy-duty diesel emission standards. Such systems have been introduced in the past year by some heavy-duty diesel engine manufacturers both in Europe and in Japan.

SCR catalyst systems require an accurate urea control system to inject precise amounts of reductant. An injection rate that is too low may result in lower NO_X conversions while an injection that is too high may release unwanted ammonia emissions—referred to as ammonia slip—to the atmosphere. In general, ammonia to NO_X ratios of around 1:1 are used to provide the highest NO_X conversion rates with minimal ammonia slip. Therefore, injecting just the right amount of ammonia appropriate for the amount of NO_X in the exhaust is very important. This can be challenging in a highway application because on-road diesel engines operate over a variety of speeds and loads. This makes the use of closed-loop feedback systems for reductant metering very attractive. This can be achieved, for example, with a dedicated NO_X sensor in the exhaust so that the NO_X concentration can be accurately known. With an accurate fast response NO_X sensor, closed-loop control of the ammonia injection can be used to achieve and maintain the desired ammonia/NO_X ratios in the SCR catalyst for the high NO_X conversion efficiencies necessary to achieve the 2010 emission standards under various engine operating conditions.

Some have estimated that achieving the 2010 NO_X emission standards with SCR systems will require NO_X sensors that can measure NO_X levels accurately in the 20 to 40 ppm range with little cross sensitivity to ammonia. Some in industry have even stated a desire for accuracy in the two to three ppm range. Suppliers have been developing NO_X sensors capable of measuring NO_X in the 0 to 100 ppm range with +/−5 ppm accuracy which we believe will be available by 2010.[23] Regarding cross-sensitivity to ammonia, work has been done that indicates ammonia and NO_X measurements can be independently measured by conditioning the output signal.[24] This signal conditioning method resulted in a linear output for both ammonia and NO_X from the NO_X sensor downstream of the catalyst.

For SCR systems, closed-loop control of the reductant injection may require the use of two NO_X sensors. The first NO_X sensor would be located upstream of the catalyst and the reductant injection point would be used for measuring the engine-out NO_X emissions and determining the amount of reductant injection needed to reduce emissions. The second NO_X sensor located downstream of the catalyst would be used for measuring the amount of ammonia and NO_X emissions exiting the catalyst and providing feedback to the reductant injection control system. If the downstream NO_X sensor detects too much NO_X emissions exiting the catalyst, the control system can inject higher quantities of reductant. Conversely, if the downstream NO_X sensor detects too much ammonia slip exiting the catalyst, the control system can decrease the amount of reductant injection.

In addition to exhaust NO_X levels, another important parameter for achieving high NO_X conversion rates with minimum ammonia slip is catalyst temperature. SCR catalysts have a defined temperature range where they are most effective. For example, platinum catalysts are effective between 175 and 250 degrees Celsius, vanadium catalysts are effective between 300 and 450 degrees Celsius, and zeolite catalysts are most effective between 350 and 600 degrees Celsius. To determine exhaust catalyst temperature for reductant control purposes, manufacturers are likely to use temperature sensors placed in the exhaust system. We project that only one temperature sensor positioned just downstream of the SCR system will be utilized for reductant injection control purposes.

Production SCR catalyst systems may also contain auxiliary catalysts to improve the overall emissions control capability of the system. An oxidation catalyst is often positioned downstream of the SCR catalyst to help control ammonia slip on systems without closed-loop control of ammonia injection. The use of a ‘‘guard’’ catalyst could allow higher ammonia injection levels, thereby increasing the NO_X conversion efficiency without releasing un-reacted ammonia into the exhaust. The guard catalyst can also reduce HC and CO emission levels and diesel odors. However, increased N2O emissions may occur and NO_X emission levels may actually increase if too much ammonia is oxidized in the catalyst. Some SCR systems may also include an oxidation catalyst upstream of the SCR catalyst and urea injection point to generate NO2 for lowering the effective operating temperature and/or volume of the SCR catalyst. Studies have indicated that increasing the NO2 content in the exhaust stream can reduce the SCR temperature requirements by about 100 degrees Celsius.[25] This ‘‘pre-oxidation’’ catalyst also has the added benefit of reducing HC emissions.

b. SCR and Lean NO_X Catalyst Monitoring Requirements

We are proposing that the OBD system monitor SCR catalysts and lean NO_X catalysts for proper conversion capability. We are also proposing that each catalyst that converts NO_X be monitored either individually or in combination with others. For engines equipped with SCR systems or other catalyst systems that utilize an active/intrusive reductant injection (e.g., active lean NO_X catalysts utilizing diesel fuel

weighted moving average (EWMA) approach to making decisions about the catalyst's pass/fail status. This approach monitors the catalyst and ‘‘saves’’ that information. The next time it monitors the catalyst, it saves that information along with the previous information, placing a higher weighting on the most recent information. This is done every time the OBD system monitors the catalyst and the EWMA saves six or seven monitoring events before making a decision. Importantly, once there exists six or seven pieces of information, every monitoring event can result in a decision because the EWMA is always using the previous six or seven events. Unfortunately, if a service technician clears the data with a scan tool, it is going to take six or seven monitoring events before the catalyst monitor can make a decision on the pass/fail status of the catalyst. So, we want to be sure that, in addition to the EWMA aspect of the catalyst monitor, there exists a way of determining quickly that someone has cleared the data but perhaps did not actually repair the catalyst. This is required to help prevent against DTC clearing without fixing a failed catalyst as a means of passing an inspection & maintenance test.

[23] Draft Technical Support Document, HDOBD NPRM, EPA420–D–06–006, Docket ID# EPA–HQ–OAR–2005–0047–0008.

[24] Schaer, C. M., Onder, C. H., Geering, H. P., and Elsener, M., ‘‘Control of a Urea SCR Catalytic Converter System for a Mobile Heavy-Duty Diesel Engine,’’ SAE Paper 2003–01–0776 which may be obtained from Society of Automotive Engineers International, 400 Commonwealth Dr., Warrendale, PA, 15096–0001.

[25] Walker, A. P., Chandler, G. R., Cooper, B. J., et al., ‘‘An Integrated SCR and Continuously Regenerating Trap System to Meet Future NO_X and PM Legislation,’’ SAE Paper 2000–01–0188 which may be obtained from Society of Automotive Engineers International, 400 Commonwealth Dr., Warrendale, PA, 15096–0001.

injection), the OBD system would be required to monitor the active/intrusive reductant injection system for proper performance. The individual electronic components (e.g., actuators, valves, sensors, heaters, pumps) in the active/intrusive reductant injection system must be monitored in accordance with the comprehensive component requirements in section II.D.4.

i. Catalyst Conversion Efficiency Malfunctions

We are proposing that the OBD system detect a catalyst malfunction when the catalyst conversion capability decreases to the point that would cause an engine's NO_X emissions to exceed any of the applicable emissions thresholds for ''NO_X Catalyst Systems'' as shown in Table II.B–1. If no failure or deterioration of the catalyst NO_X conversion capability could result in an engine's NO_X emissions exceeding any of the applicable emissions thresholds, the OBD system would have to detect a malfunction when the catalyst has no detectable amount of NO_X conversion capability.

ii. Active/Intrusive Reductant Injection System Malfunctions

Specific to SCR and other active/intrusive reductant injection system performance, we are proposing that the OBD system detect a malfunction prior to any failure or deterioration of the system to regulate reductant delivery properly (e.g., urea injection, separate injector fuel injection, post injection of fuel, air assisted injection/mixing) that would cause an engine's NO_X emissions to exceed any of the applicable emissions thresholds for ''NO_X Catalyst Systems'' as shown in Table II.B–1. As above, if no failure or deterioration of the reductant delivery system could result in an engine's NO_X emissions exceeding the applicable emissions thresholds, the OBD system would have to detect a malfunction when the system has reached its control limits such that it is no longer able to deliver the desired quantity of reductant.

If the system uses a reductant other than the fuel used for the engine or uses a reservoir/tank for the reductant that is separate from the fuel tank used for the engine, the OBD system must detect a malfunction when there is no longer sufficient reductant available (e.g., the reductant tank is empty). If the system uses a reservoir/tank for the reductant that is separate from the fuel tank used for the engine, the OBD system must detect a malfunction when an improper reductant is used in the reductant reservoir/tank (e.g., the reductant tank is filled with something other than the proper reductant).

iii. SCR and Lean NO_X Catalyst Feedback Control System Malfunctions

If the engine is equipped with feedback control of the reductant injection, we are proposing that the OBD system detect a malfunction when and if:

- The system fails to begin feedback control within a manufacturer specified time interval;
- A failure or deterioration causes open loop or default operation; or
- Feedback control has used up all of the adjustment allowed by the manufacturer.

c. SCR and Lean NO_X Catalyst Monitoring Conditions

Manufacturers would be required to define the monitoring conditions for catalyst conversion efficiency malfunctions such that the minimum performance ratio requirements discussed in section II.E would be met. For purposes of tracking and reporting as required in section II.E, all monitors used to detect catalyst conversion efficiency malfunctions must be tracked separately but reported as a single set of values as specified in section II.E.[26] We are also proposing that the OBD system monitor continuously for active/intrusive reductant injection system malfunctions. Manufacturers would be required to monitor continuously the active/intrusive reductant delivery system.

d. SCR and Lean NO_X Catalyst MIL Illumination and DTC Storage

We are proposing the general MIL illumination and DTC storage requirements presented in section II.A.2 with the exception of active/intrusive reductant injection related malfunctions. If the OBD system is capable of discerning that a system malfunction is being caused by an empty reductant tank, the manufacturer may delay illumination of the MIL if the vehicle is equipped with an alternative indicator for notifying the vehicle operator of the malfunction. The manufacturer would be required to demonstrate that: The alternative indicator is of sufficient illumination and location to be readily visible to the operator under all lighting conditions; and the alternative indicator provides equivalent assurance that a vehicle operator will be promptly notified; and, that corrective action would be undertaken. If the vehicle is not equipped with an alternative indicator and the MIL illuminates, the MIL may be immediately extinguished and the corresponding DTC erased once the OBD system has verified that the reductant tank has been properly refilled and the MIL has not been illuminated for any other type of malfunction. The Administrator may approve other strategies that provide equivalent assurance that a vehicle operator will be promptly notified and that corrective action will be undertaken.

The monitoring method for the catalyst(s) would have to be capable of detecting all instances, except diagnostic self-clearing, when a catalyst DTC has been cleared but the catalyst has not been replaced (e.g., catalyst over temperature histogram approaches are not acceptable).

7. NO_X Adsorber System Monitoring

a. Background

NO_X adsorbers, or lean NO_X traps (LNT), work to control NO_X emissions by storing NO_X on the surface of the catalyst during the lean engine operation typical of diesel engines and then by undergoing subsequent brief rich regeneration events where the NO_X is released and reduced across a precious metal catalyst.

NO_X adsorber systems generally consist of a conventional three-way catalyst function (e.g., platinum) with NO_X storage components (i.e., adsorbents) incorporated into the washcoat. Three-way catalysts convert NO_X emissions as well as HC and CO emissions (hence the name three-way) by promoting oxidation of HC and CO to H_2O and CO_2 using the oxidation potential of the NO_X pollutant and, in the process, reducing the NO_X emissions to nitrogen, N_2. Said another way, three-way catalysts work with exhaust conditions where the net oxidizing and reducing chemistry of the exhaust is approximately equal, allowing the catalyst to promote complete oxidation/reduction reactions to the desired exhaust components of CO_2, H_2O, and N_2. The oxidizing potential in the exhaust comes from NO_X emissions and any feedgas oxygen (O_2) not consumed during combustion. The reducing potential in the exhaust

[26] For specific components or systems that have multiple monitors that are required to be reported (e.g., exhaust gas sensor bank 1 may have multiple monitors for sensor response or other sensor characteristics), the OBD system must separately track numerators and denominators for each of the specific monitors and report only the corresponding numerator and denominator for the specific monitor that has the lowest numerical ratio. If two or more specific monitors have identical ratios, the corresponding numerator and denominator for the specific monitor that has the highest denominator shall be reported for the specific component.

comes from HC and CO emissions, which represent products of incomplete combustion. Operation of the engine to ensure that the oxidizing and reducing potential of the combustion and exhaust conditions is precisely balanced is referred to as stoichiometric engine operation.

Because diesel engines run lean of stoichiometric operation, the NO_X emissions are stored, or absorbed—via chemical reaction with alkaline earth metals such as barium nitrate in the washcoat—and then released during rich operation for conversion to N_2. This NO_X release during rich operation is referred to as a regeneration event. The rich operating conditions required for NO_X regeneration, which generally last for several seconds, are typically achieved using a combination of intake air throttling (to reduce the amount of intake air), exhaust gas recirculation, and post-combustion fuel injection.

NO_X adsorber systems have demonstrated NO_X reduction efficiencies from 50 percent to in excess of 90 percent. This efficiency has been found to be highly dependent on the fuel sulfur content because NO_X adsorbers are extremely sensitive to sulfur. The NO_X adsorption material has an even greater affinity for sulfur compounds than NO_X. Thus, sulfur compounds can saturate the adsorber and limit the number of active sites for NO_X adsorption, thereby lowering the NO_X reduction efficiency. Accordingly, low sulfur fuel is required to achieve the greatest NO_X reduction efficiencies. Although new adsorber washcoat materials are being developed with a higher resistance to sulfur poisoning and ultra-low sulfur fuel will be the norm by 2010, NO_X adsorber systems will still need to purge the stored sulfur from the storage bed by a process referred to as desulfation. Because the desulfation process takes longer (e.g., several minutes) and requires more fuel and heat than the NO_X regeneration step, permanent thermal degradation of the NO_X adsorber and fuel economy penalties may result from desulfation events happening with excessive frequency. However, if desulfation is not done frequently enough, NO_X storage capacity would be compromised and fuel economy penalties would be incurred from excessive attempts at NO_X regeneration.

In order to achieve and maintain high NO_X conversion efficiencies while limiting negative impacts on fuel economy and driveability, vehicles with NO_X adsorber systems will require precise air/fuel control in the engine and in the exhaust stream. Diesel manufacturers are expected to utilize NO_X sensors and temperature sensors to provide the most precise closed-loop control for the NO_X adsorber system. If NO_X sensors are not used to control the NO_X adsorber system, manufacturers could use wide-range air-fuel (A/F) sensors located upstream and downstream of the adsorber as a substitute. However, A/F sensors cannot provide an instantaneous indication of tailpipe NO_X levels, which would allow the control system to precisely determine when the adsorber system is filled to capacity and regeneration should be initiated. If A/F sensors are used in lieu of NO_X sensors, an estimation of engine-out NO_X emissions and their subsequent storage in the NO_X adsorber can be achieved indirectly through modeling.

b. NO_X Adsorber System Monitoring Requirements

We are proposing that the OBD system monitor the NO_X adsorber on engines so equipped for proper performance. For engines equipped with active/intrusive injection (e.g., in-exhaust fuel and/or air injection) to achieve NO_X regeneration, the OBD system would have to monitor the active/intrusive injection system for proper performance. The individual electronic components (e.g., injectors, valves, sensors) that are used in the active/intrusive injection system would have to be monitored in accordance with the comprehensive component requirements in section II.D.4.

i. NO_X Adsorber Capability Malfunctions

We are proposing that the OBD system detect a NO_X adsorber malfunction when its capability—i.e., its combined adsorption and conversion capability—decreases to the point that would cause an engine's NO_X emissions to exceed the applicable emissions thresholds for ''NO_X Catalyst Systems'' as shown in Table II.B–1. If no failure or deterioration of the NO_X adsorber capability could result in an engine's NO_X emissions exceeding the applicable emissions thresholds, the OBD system would have to detect a malfunction when the system has no detectable amount of NO_X adsorber capability.

ii. Active/Intrusive Reductant Injection System Malfunctions

For NO_X adsorber systems that use active/intrusive injection (e.g., in-cylinder post fuel injection, in-exhaust air-assisted fuel injection) to achieve desorption of the NO_X adsorber, the OBD system would have to detect a malfunction if any failure or deterioration of the injection system's ability to properly regulate injection causes the system to be unable to achieve desorption of the NO_X adsorber.

iii. NO_X Adsorber Feedback Control System Malfunctions

If the engine is equipped with feedback control of the reductant injection (e.g., feedback control of injection quantity, time), we are proposing that the OBD system detect a malfunction when and if:

- The system fails to begin feedback control within a manufacturer specified time interval;
- A failure or deterioration causes open loop or default operation; or
- Feedback control has used up all of the adjustment allowed by the manufacturer.

c. NO_X Adsorber System Monitoring Conditions

We are proposing that manufacturers define the monitoring conditions for NO_X adsorber capability malfunctions such that the minimum performance ratio requirements discussed in section II.E would be met. For purposes of tracking and reporting as required in section II.E, all monitors used to detect NO_X adsorber capability malfunctions must be tracked separately but reported as a single set of values as specified in section II.E.[27] We are also proposing that the OBD system monitor continuously for active/intrusive reductant injection and feedback control system malfunctions.

d. NO_X Adsorber System MIL Illumination and DTC Storage

We are proposing the general requirements for MIL illumination and DTC storage discussed in section II.A.2.

8. Diesel Particulate Filter (DPF) System Monitoring

a. Background

Diesel particulate filters control diesel PM by capturing the soot (solid carbon) portion of PM in a filter media, typically a ceramic wall flow substrate, and then by oxidizing (burning) it in the oxygen-rich atmosphere of diesel exhaust.[28] In aggregate over a driving cycle, the PM must be burned at a rate equal to or

[27] For specific components or systems that have multiple monitors that are required to be reported (e.g., exhaust gas sensor bank 1 may have multiple monitors for sensor response or other sensor characteristics), the OBD system must separately track numerators and denominators for each of the specific monitors and report only the corresponding numerator and denominator for the specific monitor that has the lowest numerical ratio. If two or more specific monitors have identical ratios, the corresponding numerator and denominator for the specific monitor that has the highest denominator shall be reported for the specific component.

greater than its accumulation rate, or the DPF will clog. Given low sulfur diesel fuel (diesel fuel with a sulfur content of 15 ppm or lower), highly active catalytic metals (e.g., platinum) can be used to promote soot oxidation. This method of PM filter regeneration, called passive regeneration, is the primary means of soot oxidation that we project industry will use in 2007/2010.

The DPF technology has proven itself in tens of thousands of retrofit applications where low sulfur diesel fuel is already available. More than a million light-duty passenger cars in Europe now have diesel particulate filters. DPFs 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 order to maintain the performance of the DPF and the engine, the trapped PM must be periodically removed before too much particulate is accumulated and exhaust backpressure reaches unacceptable levels. The process of periodically removing accumulated PM from the DPF is known as ''regeneration'' and is very important for maintaining low PM emission levels. DPF regeneration can be passive (i.e., occur continuously during regular operation of the filter), active (i.e., occur on a controlled, periodic basis after a predetermined quantity of particulates have been accumulated), or a combination of the two. With passive regeneration, the oxidizing catalyst material on the DPF substrate serves to lower the temperature for oxidizing PM. This allows the DPF to continuously oxidize trapped PM material during normal driving. In contrast, active systems utilize an external heat source—such as an electric heater or fuel burner—to facilitate DPF regeneration. We are projecting that virtually all DPF systems will have some sort of active regeneration mechanism as a backup mechanism should operating conditions not be conducive for passive regeneration.

One of the key considerations for a DPF regeneration control system is the amount of soot quantity that is stored in the DPF (often called soot loading). If too much soot is stored when regeneration is activated, the soot can burn uncontrollably and DPF substrate could be damaged via melting or cracking. Conversely, activating regeneration when there is too little trapped soot will not ensure good combustion propagation which would effectively waste the energy (fuel) used to initiate the regeneration. Another important consideration in the control system design is the fuel economy penalty involved with DPF regeneration. Prolonged operation with high backpressures in the exhaust and regenerations occurring too frequently are both detrimental to fuel economy and DPF durability. Therefore, DPF system designers will need to carefully balance the regeneration frequency with various conflicting factors. To optimize the trap regeneration for these design factors, the DPF regeneration control system is projected to incorporate both pressure sensors and temperature sensors to model soot loading and other phenomena.[29] Through the information provided by these sensors, designers can optimize the DPF for high effectiveness and maximum durability while minimizing fuel economy and performance penalties.

b. DPF System Monitoring Requirements

We are proposing that the OBD system monitor the DPF on engines so-equipped for proper performance.[30] For engines equipped with active regeneration systems that utilize an active/intrusive injection (e.g., in-exhaust fuel injection, in-exhaust fuel/air burner), the OBD system would have to monitor the active/intrusive injection system for proper performance. The individual electronic components (e.g., injectors, valves, sensors) that are used in the active/intrusive injection system must be monitored in accordance with the comprehensive component requirements in section II.D.4.

i. PM Filtering Performance

We are proposing that the OBD system detect a malfunction prior to a decrease in the filtering capability of the DPF (e.g., cracking, melting, etc.) that would cause an engine's PM emissions to exceed the applicable emissions thresholds for ''DPF Systems'' as shown in Table II.B–1. If no failure or deterioration of the PM filtering performance could result in an engine's PM emissions exceeding the applicable emissions thresholds, the OBD system would have to detect a malfunction when no detectable amount of PM filtering occurs.

ii. DPF Regeneration Frequency Malfunctions—Too Frequent

We are proposing that the OBD system detect a malfunction when the DPF regeneration frequency increases from—i.e., occurs more often than—the manufacturer's specified regeneration frequency to a level such that it would cause an engine's NMHC emissions to exceed the applicable emissions threshold for ''DPF Systems'' as shown in Table II.B–1. If no such regeneration frequency exists that could cause NMHC emissions to exceed the applicable emission threshold, the OBD system would have to detect a malfunction when the PM filter regeneration frequency exceeds the manufacturer's specified design limits for allowable regeneration frequency.

iii. DPF Incomplete Regeneration Malfunctions

We are proposing that the OBD system detect a regeneration malfunction when the DPF does not properly regenerate under manufacturer-defined conditions where regeneration is designed to occur.

iv. DPF NMHC Conversion Efficiency Malfunctions

We are proposing that, for any DPF that serves to convert NMHC emissions, the OBD system must monitor the NMHC converting function of the DPF and detect a malfunction when the NMHC conversion capability decreases to the point that NMHC emissions exceed the NMHC threshold for ''DPF Systems'' as shown in Table II.B–1. If no failure or deterioration of the NMHC conversion capability could result in NMHC emissions exceeding the applicable NMHC threshold, the OBD system would have to detect a malfunction when the system has no detectable amount of NMHC conversion capability.

v. DPF Missing Substrate Malfunctions

We are proposing that the OBD system detect a malfunction if either the DPF substrate is completely destroyed, removed, or missing, or if the DPF assembly has been replaced with a muffler or straight pipe.

vi. DPF Active/Intrusive Injection System Malfunctions

We are proposing that, for systems that utilize active/intrusive injection (e.g., in-cylinder post fuel injection, in-exhaust air-assisted fuel injection) to achieve DPF regeneration, the OBD system detect a malfunction if any

[28] See ''Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements;'' EPA420–R–00–026; December 2000 at Chapter III for a more complete description of DPFs.

[29] 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 which may be obtained from Society of Automotive Engineers International, 400 Commonwealth Dr., Warrendale, PA, 15096–0001.

[30] Note that these requirements would also apply to a catalyzed diesel particulate filter (CDPF). We use the more common term DPF throughout this discussion.

failure or deterioration of the injection system's ability to properly regulate injection causes the system to be unable to achieve DPF regeneration.

vii. DPF Regeneration Feedback Control System Malfunctions

We are proposing that, if the engine is equipped with feedback control of the DPF regeneration (e.g., feedback control of oxidation catalyst inlet temperature, PM filter inlet or outlet temperature, in-cylinder or in-exhaust fuel injection), the OBD system must detect a malfunction when and if:

- The system fails to begin feedback control within a manufacturer specified time interval;
- A failure or deterioration causes open loop or default operation; or
- Feedback control has used up all of the adjustment allowed by the manufacturer.

c. DPF System Monitoring Conditions

We are proposing that manufacturers define the monitoring conditions for all DPF related malfunctions such that the minimum performance ratio requirements discussed in section II.E would be met with the exception that monitoring must occur every time the monitoring conditions are met during the driving cycle rather than once per driving cycle as required for most monitors. For purposes of tracking and reporting as required in section II.E, all monitors used to detect all DPF related malfunctions would have to be tracked separately but reported as a single set of values as specified in section II.E.[31]

d. DPF System MIL Illumination and DTC Storage

We are proposing the general requirements for MIL illumination and DTC storage as discussed in section II.A.2.

9. Exhaust Gas Sensor Monitoring

a. Background

Exhaust gas sensors (e.g., oxygen sensors, wide-range air-fuel (A/F) sensors, NO_X sensors) are important to the emission control system of vehicles. These sensors are used for enhancing the performance of several emission control technologies (e.g., catalysts, EGR systems). We expect that both oxygen sensors and wide range A/F sensors may be used by heavy-duty manufacturers to optimize their emission control technologies. We would expect that, in addition to their emissions control functions, these sensors will also be used to satisfy many of the proposed HDOBD monitoring requirements, such as fuel system monitoring, catalyst monitoring, and EGR system monitoring. NO_X sensors may also be used for optimization of several diesel emission control technologies, such as NO_X adsorbers and selective catalytic reduction (SCR) systems. 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 to maintain low emissions. The reliance on these sensors for emissions control and OBD monitoring makes it important that any malfunction that adversely affects the performance of any of these sensors be detected by the OBD system.

b. Exhaust Gas Sensor Monitoring Requirements

We are proposing that the OBD system monitor all exhaust gas sensors (e.g., oxygen, air-fuel ratio, NO_X) used either for emission control system feedback (e.g., EGR control/feedback, SCR control/feedback, NO_X adsorber control/feedback), or as a monitoring device, for proper output signal, activity, response rate, and any other parameter that can affect emissions. For engines equipped with heated exhaust gas sensors, the OBD system would have to monitor the heater for proper performance.

i. Air/Fuel Ratio Sensor Malfunctions

For all air/fuel ratio sensors, we are proposing the following:

- Circuit malfunctions: The OBD system must detect malfunctions of the sensor caused by either a lack of circuit continuity or out-of-range values.
- Feedback malfunctions: The OBD system must detect a malfunction of the sensor when a sensor failure or deterioration causes an emissions control system—e.g., the EGR, SCR, or NO_X adsorber systems—to stop using that sensor as a feedback input (e.g., causes default or open-loop operation).
- Monitoring capability: To the extent feasible, the OBD system must detect a malfunction of the sensor when the sensor output voltage, resistance, impedance, current, amplitude, activity, offset, or other characteristics are no longer sufficient for use as an OBD system monitoring device (e.g., for catalyst, EGR, SCR, or NO_X adsorber monitoring).

Specifically for sensors located upstream of an aftertreatment device, we are proposing the following:

- Sensor performance malfunctions: The OBD system must detect a malfunction prior to any failure or deterioration of the sensor voltage, resistance, impedance, current, response rate, amplitude, offset, or other characteristic(s) that would cause an engine's emissions to exceed the applicable emissions thresholds for ''Other Monitors'' as shown in Table II.B–1.

Specifically for sensors located downstream of an aftertreatment device, we are proposing the following:

- Sensor performance malfunctions: The OBD system must detect a malfunction prior to any failure or deterioration of the sensor voltage, resistance, impedance, current, response rate, amplitude, offset, or other characteristic(s) that would cause an engine's emissions to exceed the applicable emissions thresholds for ''Air-fuel ratio sensors downstream of aftertreatment devices'' as shown in Table II.B–1.

ii. NO_X Sensor Malfunctions

For NO_X sensors, we are proposing the following:

- Sensor performance malfunctions: The OBD system must detect a malfunction prior to any failure or deterioration of the sensor voltage, resistance, impedance, current, response rate, amplitude, offset, or other characteristic(s) that would cause an engine's emissions to exceed the applicable emissions thresholds for ''NO_X sensors'' as shown in Table II.B–1.
- Circuit malfunctions: The OBD system must detect malfunctions of the sensor caused by either a lack of circuit continuity or out-of-range values.
- Feedback malfunctions: The OBD system shall detect a malfunction of the sensor when a sensor failure or deterioration causes an emission control—e.g., the EGR, SCR, or NO_X adsorber systems—to stop using that sensor as a feedback input (e.g., causes default or open-loop operation).
- Monitoring capability: To the extent feasible, the OBD system must detect a malfunction of the sensor when the sensor output voltage, resistance, impedance, current, amplitude, activity, offset, or other characteristics are no longer sufficient for use as an OBD system monitoring device (e.g., for catalyst, EGR, SCR, or NO_X adsorber monitoring).

[31] For specific components or systems that have multiple monitors that are required to be reported (e.g., exhaust gas sensor bank 1 may have multiple monitors for sensor response or other sensor characteristics), the OBD system must separately track numerators and denominators for each of the specific monitors and report only the corresponding numerator and denominator for the specific monitor that has the lowest numerical ratio. If two or more specific monitors have identical ratios, the corresponding numerator and denominator for the specific monitor that has the highest denominator shall be reported for the specific component.

iii. Other Exhaust Gas Sensor Malfunctions

For other exhaust gas sensors, we are proposing that the manufacturer submit a monitoring plan to the Administrator for approval. The Administrator would approve the request upon determining that the manufacturer has submitted data and an engineering evaluation that demonstrate that the monitoring plan is as reliable and effective as the monitoring plan required for air/fuel ratio sensors and NO_X sensors.

iv. Exhaust Gas Sensor Heater Malfunctions

We are proposing that the OBD system detect a malfunction of the heater performance 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 required to be met by the component vendor for heater circuit performance at high mileage). The manufacturer may use other malfunction criteria for heater performance malfunctions. To do so, the manufacturer would be required to submit data and/or engineering analyses that demonstrate that the monitoring reliability and timeliness would be equivalent to the criteria stated here. Further, the OBD system would be required to detect malfunctions of the heater circuit including open or short circuits that conflict with the commanded state of the heater (e.g., shorted to 12 Volts when commanded to 0 Volts (ground)).

c. Exhaust Gas Sensor Monitoring Conditions

For exhaust gas sensor performance malfunctions, we are proposing that manufacturers define the monitoring conditions such that the minimum performance ratio requirements discussed in section II.E would be met. For purposes of tracking and reporting as required in section II.E, all monitors used to detect sensor performance malfunctions would have to be tracked separately but reported as a single set of values as specified in section II.E.[32]

For exhaust gas sensor monitoring capability malfunctions, manufacturers would have to define the monitoring conditions such that the minimum performance ratio requirements discussed in section II.E would be met with the exception that monitoring must occur every time the monitoring conditions are met during the driving cycle rather than once per driving cycle as required for most monitors.

For exhaust gas sensor circuit malfunctions and feedback malfunctions, monitoring must be conducted continuously.

The manufacturer may disable continuous exhaust gas sensor monitoring when an exhaust gas sensor malfunction cannot be distinguished from other effects (e.g., disable ''out-of-range low'' monitoring during fuel cut conditions). To do so, the manufacturer would be required to submit test data and/or engineering analyses that demonstrate that a properly functioning sensor cannot be distinguished from a malfunctioning sensor and that the disablement interval is limited only to that necessary for avoiding a false detection.

For exhaust gas sensor heater malfunctions, manufacturers must define monitoring conditions such that the minimum performance ratio requirements discussed in section II.E would be met. Monitoring for sensor heater circuit malfunctions must be conducted continuously.

d. Exhaust Gas Sensor MIL Illumination and DTC Storage

We are proposing the general requirements for MIL illumination and DTC storage as discussed in section II.A.2.

C. Monitoring Requirements and Timelines for Gasoline/Spark-Ignition Engines

Table II.C–1 summarizes the proposed gasoline fueled spark ignition emissions thresholds at which point a component or system has failed to the point of requiring an illuminated MIL and a stored DTC. Table II.C–2 summarizes the proposed implementation schedule for these thresholds—i.e., the proposed certification requirements and in-use liabilities. More detail regarding the specific monitoring requirements, implementation schedules, and liabilities can be found in the sections that follow.

TABLE II.C–1.—PROPOSED EMISSIONS THRESHOLDS FOR GASOLINE FUELED SI ENGINES OVER 14,000 POUNDS

Component/Monitor	MY	NMHC	CO	NO_X
Catalytic converter system	2010+	1.75x		1.75x
''Other monitors'' with emissions thresholds (see section II.C)	2010+	1.5x	1.5x	1.5x
Evaporative emissions control system	2010+	0.150 inch leak.		

Notes: MY=Model Year; 1.75x means a multiple of 1.75 times the applicable emissions standard; not all proposed monitors have emissions thresholds but instead rely on functionality and rationality checks as described in section II.D.4. The evaporative emissions control system threshold is not, technically, an emissions threshold but rather a leak size that must be detected; nonetheless, for ease we refer to this as the threshold.

There are exceptions to the emissions thresholds shown in Table II.C–1 whereby a manufacturer can demonstrate that emissions do not exceed the threshold even when the component or system is non-functional at which point a functional check would be allowed.

The monitoring requirements described below for gasoline engines mirror those that are already in place for gasoline engines used in vehicles under 14,000 pounds. The HD gasoline industry—General Motors and Ford, as of today [33]—have told us that their preference is to use essentially the same OBD system on their engines used in both under and over 14,000 pound vehicles.[34] In general, we agree with the

[32] For specific components or systems that have multiple monitors that are required to be reported (e.g., exhaust gas sensor bank 1 may have multiple monitors for sensor response or other sensor characteristics), the OBD system must separately track numerators and denominators for each of the specific monitors and report only the corresponding numerator and denominator for the specific monitor that has the lowest numerical ratio. If two or more specific monitors have identical ratios, the corresponding numerator and denominator for the specific monitor that has the highest denominator shall be reported for the specific component.

[33] This is true according to our certification database for both he 2004 and 2005 model years. Other manufacturers certify engines that use the Otto cycle, but those engines do not burn gasoline and instead burn various alternative fuels.

[34] ''EMA Comments on Proposed HDOBD Requirements for HDGE,'' bullet items 3 and 4; April 28, 2005, Docket ID# EPA–HQ–OAR–2005–0047–0003.

HD gasoline industry on this issue for three reasons:

• The engines used in vehicles above and below 14,000 pounds are the same which makes it easy for industry to use the same OBD monitors.

• The existing OBD requirements for engines used in vehicles below 14,000 pounds have proven effective; and,

• The industry members have more than 10 years experience complying with the OBD requirements for engines used in vehicles below 14,000 pounds.

As a result, we are proposing requirements that should allow for OBD system consistency in vehicles under and over 14,000 pounds rather than proposing requirements that mirror the proposed HD diesel requirements discussed in section II.B. Nonetheless, the requirements proposed below are for engine-based OBD monitors only rather than monitors for the entire powertrain (which would include the transmission). We are doing this for the same reasons as done for the proposed diesel OBD requirements in that certification of gasoline applications over 14,000 pounds, like their diesel counterparts, is done on an engine basis and not a vehicle basis.

1. Fuel System Monitoring

a. Background

As with diesel engines, the fuel system of a gasoline engine is an essential component of the engine's emissions control system. 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 using oxygen sensor(s) or air-fuel ratio (A/F) sensor(s). The feedback sensors are located in the exhaust system and are used to regulate the fuel injection quantity to achieve a stoichiometric mixture in the exhaust. If the sensor indicates a rich (or lean) mixture, the system reduces (or increases) the amount of fuel being injected by applying a short term correction to the fuel injection quantity calculated for the current engine operating condition. To account for aging or deterioration in the system such as reduced injector flow, more permanent long term corrections are also learned and applied to the fuel injection quantity for more precise fueling.

For gasoline engines, fuel system monitoring has been implemented on light-duty vehicles since the 1996 model year and on heavy-duty vehicles less than 14,000 pounds and the engines used in those vehicles since the 2004/2005 model year. For heavy-duty gasoline engines used in vehicles over 14,000 pounds (many of which are the same engine as is used in vehicles less than 14,000 pounds), the system components and control strategies are identical to those used in the light-duty and under 14,000 pound categories. As such, the monitoring requirements established for engines used in vehicles less than 14,000 pounds can be directly applied to engines used in vehicles over 14,000 pounds.

b. Fuel System Monitoring Requirements

We are proposing that the fuel system be continuously monitored for its ability to maintain engine emissions below the applicable emissions thresholds. Manufacturers would also be required to verify that the fuel system is in closed-loop operation—e.g., that it is using the oxygen sensor for feedback control. The individual components of the fuel system would also be covered by separate monitoring requirements for oxygen sensors, misfire (for the fuel injectors), and comprehensive components (in systems such as those with electronically-controlled variable speed fuel pumps or electronically-controlled fuel pressure regulators).

i. Fuel System Performance

We are proposing that the OBD system be required to detect a malfunction of the fuel delivery system (including feedback control based on a secondary oxygen sensor) when the fuel delivery system is unable to maintain the engine's emissions at or below the applicable emissions thresholds for ''Other monitors'' as shown in Table II.C–1.

ii. Fuel System Feedback Control

If the engine is equipped with adaptive feedback control, we are proposing that the OBD system be required to detect a malfunction when the adaptive feedback control has used up all of the adjustment allowed by the manufacturer. However, if the engine is equipped with feedback control that is based on a secondary oxygen (or equivalent) sensor, the OBD system would not be required to detect a malfunction of the fuel system solely when the feedback control based on that secondary oxygen sensor has used up all of the adjustment allowed by the manufacturer. For such systems, the OBD system would be required to meet the fuel system performance requirements presented above.

Additionally, we are proposing that the OBD system be required to detect a malfunction whenever the fuel control system fails to enter closed loop operation within a time interval after engine startup. The manufacturer would be required to submit data and/or engineering analyses that support their chosen time interval.

Lastly, manufacturers would be allowed to adjust the malfunction criteria and/or monitoring conditions to compensate for changes in altitude, temporary introduction of large amounts of purge vapor, or for other similar identifiable operating conditions when they occur.

c. Fuel System Monitoring Conditions

We are proposing that the OBD system monitor continuously for malfunctions of the fuel system.

d. Fuel System MIL Illumination and DTC Storage

We are proposing that a pending DTC be stored immediately upon detecting a malfunction according to the fuel system monitoring requirements presented in section II.C.1.b (i.e., rather than waiting until the end of the drive cycle to store the pending DTC). Once a pending DTC is stored, the OBD system would be required to illuminate the MIL immediately and store a MIL-on DTC if a malfunction is again detected during either of the following two events: (1) The drive cycle immediately following the drive cycle during which the pending DTC was stored, regardless of the conditions encountered during the drive cycle; or, (2) on the next drive cycle during which similar conditions are encountered to those that occurred when the pending DTC was stored.[35]

We are also proposing that the pending DTC may be erased at the end of the next drive cycle in which similar conditions have been encountered without detecting a malfunction according to the fuel system monitoring requirements. The pending DTC may also be erased if similar conditions are not encountered during the 80 drive cycles immediately after the initial

[35] ''Similar conditions,'' as used in conjunction with misfire and fuel system monitoring, means engine conditions having an engine speed within 375 rpm, load conditions within 20 percent, and the same warm up status (i.e., cold or hot) as existing during the applicable previous problem detection. The Administrator may approve other definitions of similar conditions based on comparable timeliness and reliability in detecting similar engine operation.

detection of a malfunction for which the pending DTC was set.

We are proposing some specific requirements with respect to storage of freeze frame information associated with fuel system malfunctions. First, the OBD system must store and erase freeze frame information either in conjunction with storing and erasing a pending DTC or in conjunction with storing and erasing a MIL-on DTC. Second, if freeze frame information is already stored for a malfunction other than an engine misfire or fuel system malfunction at the time that a fuel system DTC is stored, the preexisting freeze frame information must be replaced with freeze frame information regarding the fuel system malfunction.

The OBD system would also be required to store the engine speed, load, and warm up status present when the first fuel system malfunction is detected that resulted in the storage of the pending DTC. The MIL may be extinguished after three sequential drive cycles in which similar conditions have been encountered without detecting a malfunction of the fuel system.

2. Engine Misfire Monitoring

a. Background

Detecting engine misfire on a gasoline spark ignition engine is important for two reasons: Its impact on the emissions performance of the engine and its impact on the durability of the catalytic converter. Engine misfire has two primary causes: Lack of spark and poor fuel metering (delivery). When misfire occurs, unburned fuel and air are pumped out of the engine and into the exhaust system and into the catalyst. This can increase dramatically the operating temperature of the catalyst where temperatures can soar to above 900 degrees Celsius. This problem is usually most severe under high load/ high speed engine operating conditions and can cause irreversible damage to the catalyst. Though the durability of catalysts has been improving, most are unable to sustain continuous operation at such high temperatures. Engine misfire also contributes to poor emissions performance, especially when the misfire occurs during engine warm-up and the catalyst itself has not yet reached its operating temperature.

b. Engine Misfire Monitoring Requirements

We are proposing that the OBD system detect both engine misfire capable of causing catalyst damage and engine misfire capable of causing poor emissions performance. Additionally, the OBD system would be required to identify the specific cylinder in which misfire is occurring and/or if there exists a condition in which more than one cylinder is misfiring; when identifying a multiple cylinder misfire condition, the OBD system would not be required to identify individually each of the misfiring cylinders. We are proposing an exception to this whereby if more than 90 percent of the detected misfires are occurring in a single cylinder, the manufacturer may elect to consider it a single cylinder misfire condition rather than a multiple cylinder misfire condition. However, we are proposing that, if two or more cylinders individually have more than 10 percent of the total number of detected misfires, the manufacturer must consider it a multiple cylinder misfire condition.

i. Engine Misfire Capable of Causing Catalyst Damage

We are proposing that the manufacturer be required to detect the percentage of misfire—evaluated in 200 revolution increments—for each engine speed and load condition that would result in a temperature capable of damaging the catalyst. For every engine speed and load condition at which this percentage is determined to be less than five percent, the manufacturer may set the malfunction criteria at five percent. The manufacturer may use a longer interval than a 200 revolution increment but only for determining, on a given drive cycle, the first misfire exceedance; upon detecting the first such exceedance, the 200 revolution increment must be used. The manufacturer may use a longer initial interval by submitting data and/or engineering analyses that demonstrate that catalyst damage would not occur due to unacceptably high catalyst temperatures before the interval has elapsed.

Further, we are proposing that, for the purpose of establishing the temperature at which catalyst damage would occur, manufacturers not be allowed to define the catalyst damaging temperature at a temperature more severe than what the catalyst system could be operated at for 10 consecutive hours and still meet the applicable standards.

ii. Engine Misfire Causing Poor Emissions Performance

We are proposing that the manufacturer be required to detect the percentage of misfire—evaluated in 1000 revolution increments—that would cause emissions to exceed the emissions thresholds for ''Other monitors'' as shown in Table II.C–1 if that percentage of misfire were present from the beginning of the test procedure. To establish this percentage of misfire, the manufacturer would be required to use misfire events occurring at equally spaced, complete engine cycle intervals, across randomly selected cylinders throughout each 1000 revolution increment. If this percentage of misfire is determined to be lower than one percent, the manufacturer may set the malfunction criteria at one percent. The manufacturer may use a different interval than a 1000 revolution increment. To do so, the manufacturer would be required to submit data and/ or engineering analyses demonstrating that the strategy would be equally effective and timely at detecting misfire. A malfunction must be detected if the percentage of misfire is exceeded regardless of the pattern of misfire events (e.g., random, equally spaced, continuous).

c. Engine Misfire Monitoring Conditions

We are proposing that the OBD system monitor continuously to detect engine misfire under all of the following conditions:

- From no later than the end of the second crankshaft revolution after engine start;
- During the rise time and settling time as the engine reaches the desired idle speed immediately following engine start-up (i.e., ''flare-up'' and ''flare-down''); and,
- Under all positive torque conditions except within the engine operating region bound by lines connecting the following three points: An engine speed of 3000 rpm with the engine load at the positive torque line (i.e., engine load with the transmission in neutral), an engine speed at the redline rpm with the engine load at the positive torque line, and an engine speed at the redline rpm with an engine load at which intake manifold vacuum is four inches of mercury lower than that at the positive torque line (this would be an engine load somewhat greater than the engine load at the positive torque line).[36]

If a monitoring system cannot detect all misfire patterns under the required engine speed and load conditions, the manufacturer may request approval of the system nonetheless. In evaluating the manufacturer's request, the Administrator would consider:

- The magnitude of the region(s) in which misfire detection is limited;
- The degree to which misfire detection is limited in those region(s)

[36] ''Redline engine speed'' is actually defined by the manufacturer as either the recommended maximum engine speed as normally displayed on instrument panel tachometers or the engine speed at which fuel shutoff occurs.

(i.e., the probability of detection of misfire events);

- The frequency with which said region(s) are expected to be encountered in-use;
- The type of misfire patterns for which misfire detection is troublesome; and,
- Demonstration that the monitoring technology being used is not inherently incapable of detecting misfire under the required conditions (i.e., compliance can be achieved by other manufacturers on their engines).

The Administrator's evaluation would be based on the following misfire patterns:

- Equally spaced misfire occurring on randomly selected cylinders;
- Single cylinder continuous misfire; and,
- Paired cylinder (cylinders firing at the same crank angle) continuous misfire.

Further, a manufacturer may use a monitoring system that has reduced misfire detection capability during the portion of the first 1000 revolutions after engine start during which a cold start emission reduction strategy is active that reduces engine torque (e.g., spark retard strategies). To do so, the manufacturer would be required to submit data and/or engineering analyses demonstrating that the probability of detection is greater than or equal to 75 percent during the worst case condition (i.e., lowest generated torque) for a vehicle operated continuously at idle (park/neutral idle) on a cold start between 50 and 86 degrees Fahrenheit and that the technology cannot reliably detect a higher percentage of the misfire events during these conditions.

A manufacturer may disable misfire monitoring or use an alternative malfunction criterion when misfire cannot be distinguished from other effects. To do so, the manufacturer would be required to submit data and/or engineering analyses demonstrating that the disablement interval or period of use of an alternative malfunction criterion is limited only to that necessary for avoiding a false detection (errors of commission). Such disablements would be allowed for conditions involving:

- Rough road;
- Fuel cut;
- Gear changes for manual transmission vehicles;
- Traction control or other vehicle stability control activation such as anti-lock braking or other engine torque modifications to enhance vehicle stability;
- Off-board control or intrusive activation of vehicle components or diagnostics during service or assembly plant testing;
- Portions of intrusive evaporative system or EGR diagnostics that can significantly affect engine stability (i.e., while the purge valve is open during the vacuum pull-down of a evaporative system leak check but not while the purge valve is closed and the evaporative system is sealed or while an EGR diagnostic causes the EGR valve to be intrusively cycled on and off during positive torque conditions); or,
- Engine speed, load, or torque transients due to throttle movements more rapid than occurs over the FTP cycle for the worst case engine within each engine family.

Additionally, the manufacturer may disable misfire monitoring when the fuel level is 15 percent or less of the nominal capacity of the fuel tank, when PTO units are active, or while engine coolant temperature is below 20 degrees Fahrenheit. For the latter case, the manufacturer may continue the misfire monitoring disablement until engine coolant temperature exceeds 70 degrees Fahrenheit provided the manufacturer can demonstrate that it is necessary.

In general, the Administrator would not approve misfire monitoring disablement for conditions involving normal air conditioning compressor cycling from on-to-off or off-to-on, automatic transmission gear shifts (except for shifts occurring during wide open throttle operation), transitions from idle to off-idle, normal engine speed or load changes that occur during the engine speed rise time and settling time (i.e., ''flare-up'' and ''flare-down'') immediately after engine starting without any vehicle operator-induced actions (e.g., throttle stabs), or excess acceleration (except for acceleration rates that exceed the maximum acceleration rate obtainable at wide open throttle while the vehicle is in gear due to abnormal conditions such as slipping of a clutch).

Further, the manufacturer may request approval of other misfire monitoring disablements or use of alternative malfunction criteria for any other condition. The Administrator would consider such requests on a case by case basis and will consider whether or not the manufacturer has demonstrated that the request is based on an unusual or unforeseen circumstance and that it is applying the best available computer and monitoring technology.

For engines with more than eight cylinders that cannot meet the continuous monitoring and detection requirements listed above, a manufacturer may use alternative misfire monitoring conditions. Any manufacturer wishing to use alternative misfire monitoring conditions must submit data and/or an engineering evaluation that demonstrate that misfire detection throughout the required operating region cannot be achieved when using proven monitoring technology (i.e., a technology that provides for compliance with these requirements on other engines) and provided misfire is detected to the fullest extent permitted by the technology. However, the misfire detection system would still be required to monitor during all positive torque operating conditions encountered during an FTP transient cycle.

d. Engine Misfire MIL Illumination and DTC Storage

Manufacturers may store a general misfire DTC instead of a cylinder specific DTC under certain operating conditions. Do so shall depend on the manufacturer submitting data and/or an engineering evaluation that demonstrate that the specific misfiring cylinder cannot be reliably identified when the certain operating conditions occur.

i. Engine Misfire Capable of Causing Catalyst Damage

We are proposing that a pending DTC shall be stored immediately if, during a single drive cycle, the percentage of misfire determined by the manufacturer as being capable of causing catalyst damage is exceeded three times when operating in the positive torque region encountered during an FTP transient cycle or is exceeded on a single occasion when operating at any other engine speed and load condition in the positive torque region defined above. Immediately after a pending DTC is stored, the MIL shall blink once per second at all times while misfire is occurring during the drive cycle (i.e., the MIL may be extinguished during those times when misfire is not occurring during the drive cycle). If, at the time such a catalyst damaging engine misfire is occurring, the MIL is already illuminated for a malfunction other than engine misfire, the MIL shall blink similarly while the engine misfire is occurring and, if the misfire ceases, the MIL shall stop blinking but shall remain illuminated as commanded by the other malfunction.

If a pending DTC is stored as described above, the OBD system shall immediately store a MIL-on DTC if the percentage of misfire determined by the manufacturer as being capable of causing catalyst damage is again exceeded one or more times during either: (a) the drive cycle immediately following the storage of the pending DTC, regardless of the conditions encountered during the drive cycle; or, (b) on the next drive cycle in which similar conditions are encountered to those that existed when the pending DTC was stored.

If, during a previous drive cycle, a pending DTC has been stored associated with detection of an engine misfire capable of causing poor emissions performance, the OBD system shall immediately store a MIL-on DTC if the percentage of misfire determined by the manufacturer as capable of causing catalyst damage is exceeded, regardless of the conditions encountered.

Upon storage of a MIL-on DTC associated with engine misfire capable of causing catalyst damage, the MIL shall blink as described above while the engine misfire is occurring and then shall remain continuously illuminated if the engine misfire ceases. This MIL illumination logic shall continue until the requirements for extinguishing the MIL are met, as described below.

If the engine misfire is not again detected by the end of the next drive cycle in which similar conditions are encountered to those that existed when the pending DTC was stored then the pending DTC shall be erased. The pending DTC may also be erased if similar conditions are not encountered during the 80 drive cycles subsequent to the initial malfunction detection.

We are also proposing that engines with fuel shutoff and default fuel control—that are used to prevent catalyst damage should engine misfire capable of causing catalyst damage be detected—shall have some exemptions from these MIL illumination requirements. Most notably, the MIL is not required to blink while the catalyst damaging misfire is occurring. Instead, the MIL may simply illuminate in a steady fashion while the misfire is occurring provided that the fuel shutoff and default fuel control are activated as soon as the misfire is detected. Fuel shutoff and default fuel control may be deactivated only to permit fueling outside of the misfire range. Manufacturers may also periodically, but not more than once every 30 seconds, deactivate fuel shutoff and default fuel control to determine if the catalyst damaging misfire is still occurring. Normal fueling and fuel control may be resumed if the catalyst damaging misfire is no longer being detected.

Manufacturers may also use a MIL illumination strategy that continuously illuminates the MIL in lieu of blinking the MIL during extreme misfire conditions capable of causing catalyst damage (i.e., misfire capable of causing catalyst damage that is occurring at all engine speeds and loads). Manufacturers would be allowed to use such a strategy only when catalyst damaging misfire levels cannot be avoided during reasonable driving conditions and the manufacturer can demonstrate that the strategy will encourage operation of the vehicle in conditions that will minimize catalyst damage (e.g., at low engine speeds and loads).

ii. Engine Misfire Causing Poor Emissions Performance

We are proposing that, for a misfire detected within the first 1000 revolutions after engine start during which misfire detection is active, a pending DTC shall be stored after the first exceedance of the percentage of misfire determined by the manufacturer as capable of causing poor emissions performance. If a pending DTC is stored, the OBD system shall illuminate the MIL and store a MIL-on DTC within 10 seconds if an exceedance of the percentage of misfire is again detected in the first 1000 revolutions during any subsequent drive cycle, regardless of the conditions encountered during the driving cycle. The pending DTC shall be erased at the end of the next drive cycle in which similar conditions are encountered to those that existed when the pending DTC was stored provided the specified percentage of misfire is not again detected. The pending DTC may also be erased if similar conditions are not encountered during the 80 drive cycles subsequent to the initial malfunction detection.

For a misfire detected after the first 1000 revolutions following engine start, a pending DTC shall be stored no later than after the fourth exceedance—during a single drive cycle—of the percentage of misfire determined by the manufacturer as being capable of causing poor emissions performance. If a pending DTC is stored, the OBD system shall illuminate the MIL and store a MIL-on DTC within 10 seconds if an exceedance of the percentage of misfire is again detected four times during: (a) the drive cycle immediately following the storage of the pending DTC, regardless of the conditions encountered during the drive cycle; or, (b) on the next drive cycle in which similar conditions are encountered to those that existed when the pending DTC was stored. The pending DTC shall be erased at the end of the next drive cycle in which similar conditions are encountered to those that existed when the pending DTC was stored provided the specified percentage of misfire is not again detected. The pending DTC may also be erased if similar conditions are not encountered during the 80 drive cycles subsequent to the initial malfunction detection.

We are proposing some specific items with respect to freeze frame storage associated with engine misfire. The OBD system shall store and erase freeze frame conditions either in conjunction with storing and erasing a pending DTC or in conjunction with storing a MIL-on DTC and erasing a MIL-on DTC. In addition to those proposed requirements discussed in section II.A.2, we are proposing that, if freeze frame conditions are stored for a malfunction other than a misfire malfunction when a DTC is stored, the previously stored freeze frame information shall be replaced with freeze frame information regarding the misfire malfunction (i.e., the misfire's freeze frame information should take precedence over freeze frames for other malfunctions). Further, we are proposing that, upon detection of misfire, the OBD system store the following engine conditions: engine speed, load, and warm up status of the first misfire event that resulted in the storage of the pending DTC.

Lastly, we are proposing that the MIL may be extinguished after three sequential driving cycles in which similar conditions have been encountered without an exceedance of the specified percentage of misfire.

3. Exhaust Gas Recirculation (EGR) Monitoring

a. Background

EGR works to reduce NO_X emissions the same way in gasoline engines as described earlier for diesel engines. First, the recirculated exhaust gases dilute the intake air—i.e., oxygen in the fresh air is displaced with relatively non-reactive exhaust gases—which, in turn, results in less oxygen to form NO_X. Second, EGR absorbs heat from the combustion process which reduces combustion chamber temperatures which, in turn, reduces NO_X formation. The amount of heat absorbed from the combustion process is a function of EGR flow rate and recirculated gas temperature, both of which are controlled to minimize NO_X emissions. EGR systems can involve many components to ensure accurate control of EGR flow, including valves, valve position sensors, and actuators.

b. EGR System Monitoring Requirements

We are proposing that the OBD system monitor the EGR system on engines so equipped for low and high flow rate malfunctions. The individual electronic components (e.g., actuators, valves, sensors) that are used in the EGR system must be monitored in accordance with the comprehensive component requirements in section II.D.4.

i. EGR Low Flow Malfunctions

We are proposing that the OBD system detect a malfunction prior to a decrease from the manufacturer's specified EGR flow rate that would cause an engine's emissions to exceed the emissions thresholds for ''other monitors'' as shown in Table II.C–1. For engines in which no failure or deterioration of the EGR system that causes a decrease in flow could result in an engine's emissions exceeding the applicable emissions thresholds, the OBD system would have to detect a malfunction when the system has reached its control limits such that it cannot increase EGR flow to achieve the commanded flow rate.

ii. EGR High Flow Malfunctions

We are proposing that the OBD system detect a malfunction of the EGR system, including a leaking EGR valve—i.e., exhaust gas flowing through the valve when the valve is commanded closed—prior to an increase from the manufacturer's specified EGR flow rate that would cause an engine's emissions to exceed the emissions thresholds for ''other monitors'' as shown in Table II.C–1. For engines in which no failure or deterioration of the EGR system that causes an increase in flow could result in an engine's emissions exceeding the applicable emissions thresholds, the OBD system would have to detect a malfunction when the system has reached its control limits such that it cannot reduce EGR flow to achieve the commanded flow rate.

c. EGR System Monitoring Conditions

We are proposing that manufacturers define the monitoring conditions for EGR system malfunctions such that the minimum performance ratio requirements discussed in section II.E would be met. For purposes of tracking and reporting as required in section II.E, all monitors used to detect EGR low flow and high flow malfunctions must be tracked separately but reported as a single set of values as specified in section II.E.[37]

Manufacturers may temporarily disable the EGR system monitor under conditions when monitoring may not be reliable (e.g., when freezing may affect performance of the system). Such temporary disablement would be allowed provided the manufacturer has submitted data and/or an engineering evaluation that demonstrate that the EGR monitor cannot be done reliably when these specific conditions exist.

d. EGR System MIL Illumination and DTC Storage

We are proposing the general requirements for MIL illumination and DTC storage as discussed in section II.A.2.

4. Cold Start Emission Reduction Strategy Monitoring

a. Background

The largest portion of exhaust emissions from gasoline engines is generated during the brief period following startup before the engine and catalyst have warmed up to their normal operating temperatures. To meet increasingly stringent emissions standards, manufacturers are developing hardware and associated control strategies to reduce these ''cold start'' emissions. Most efforts center on reducing catalyst warm-up time.

A cold catalyst is heated mainly by two mechanisms: heat transferred from the exhaust gases to the catalyst; and, heat generated in the catalyst as a result of the exothermic catalytic reactions. Most manufacturers use substantial spark retard and/or increased idle speed following a cold engine start, both of which maximize the heat available in the exhaust gases which, in turn, increases the heat transfer to the catalyst. Vehicle drivability and engine idle quality concerns tend to limit the amount of spark retard and/or increased idle speed that a manufacturer can use to accelerate catalyst warm up. These strategies or, more correctly, the systems used to employ these strategies—the ignition system for spark retard and the idle control system for control of engine speed—are normally monitored only after engine warm-up. Therefore, any malfunctions that might occur during the cold start event may not be detected by the OBD system. This could have significant emissions consequences due to the unknown loss of emissions control during the time following engine startup.

This concern is exacerbated by the high cost of precious metals—the platinum group metals (PGM) platinum, palladium, and rhodium—which motivates industry to minimize their use in catalysts. To compensate for the resultant reduction in overall catalyst performance, manufacturers will likely use increasingly more aggressive cold start emission reduction strategies in an attempt to further reduce cold start emissions. These strategies must be successful—and be properly monitored—to meet the more stringent 2008 emissions standards and to maintain low emissions in-use.

b. Cold Start Emission Reduction Strategy Monitoring Requirements

We are proposing that, if an engine incorporates an engine control strategy specifically to reduce cold start emissions, the OBD system must monitor the key components (e.g., idle air control valve), other than the secondary air system, while the control strategy is active to ensure that the control strategy is operating properly. Secondary air systems would have to be monitored separately as discussed in section II.C.5.

The OBD system would be required to detect a malfunction prior to any failure or deterioration of the individual components associated with the cold start emissions reduction control strategy that would cause an engine's emissions to exceed the emissions thresholds for ''other monitors'' as shown in Table II.C–1. For components where no failure or deterioration of the component used by the cold start emission reduction strategy could result in an engine's emissions exceeding the applicable emissions thresholds, the individual components would have to be monitored for proper functional response as described in section II.D.4 while the control strategy is active.

Manufacturers would be required to establish the appropriate malfunction criteria based on data from one or more representative engine(s). Further, manufacturers would be required to provide an engineering evaluation for establishing the malfunction criteria for the remainder of the manufacturer's product line. An annual evaluation of these criteria by the Administrator may not be necessary provided the manufacturer can demonstrate that any technological changes from one year to the next do not affect the previously approved malfunction criteria.

c. Cold Start Emission Reduction Strategy Monitoring Conditions

We are proposing that manufacturers define the monitoring conditions for

[37] For specific components or systems that have multiple monitors that are required to be reported (e.g., exhaust gas sensor bank 1 may have multiple monitors for sensor response or other sensor characteristics), the OBD system must separately track numerators and denominators for each of the specific monitors and report only the corresponding numerator and denominator for the specific monitor that has the lowest numerical ratio. If two or more specific monitors have identical ratios, the corresponding numerator and denominator for the specific monitor that has the highest denominator shall be reported for the specific component.

malfunctions of the cold start emissions reduction strategy such that the minimum performance ratio requirements discussed in section II.E would be met.

d. Cold Start Emission Reduction Strategy MIL Illumination and DTC Storage

We are proposing the general requirements for MIL illumination and DTC storage as discussed in section II.A.2.

5. Secondary Air System Monitoring

a. Background

Secondary air systems—expected to be used on gasoline engines only—are used to reduce cold start emissions of hydrocarbons and carbon monoxide. Many of today's engines operate near stoichiometry after a cold engine start. However, the future more stringent emission standards may require the addition of a secondary air system in combination with a richer than stoichiometric cold start mixture. Such an approach could quickly warm up the catalyst for improved cold start emissions 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 converter(s). This system usually operates only after a cold engine start and usually for only a brief period of time. When the electric air pump is operating, fresh air is delivered into the exhaust where it mixes with and ignites any unburned fuel. This serves to warm up the catalyst far more rapidly than would otherwise occur. Any problems that might occur in the field—corroded check valves, damaged tubing and hoses, malfunctioning air switching valves—could cause cold start emissions performance to suffer. Therefore, monitoring is needed given the importance of a properly functioning secondary air system to emissions performance.

b. Secondary Air System Monitoring Requirements

We are proposing that the OBD system on engines equipped with any form of secondary air delivery system be required to monitor the proper functioning of the secondary air delivery system, including all air switching valve(s). The individual electronic components (e.g., actuators, valves, sensors) in the secondary air system would have to be monitored in accordance with the comprehensive component requirements discussed in section II.D.4.

i. Secondary Air System Low Flow Malfunctions

We are proposing that the OBD system detect a secondary air system malfunction prior to a decrease from the manufacturer's specified air flow during normal operation that would cause an engine's emissions to exceed the emissions thresholds for ''other monitors'' as shown in Table II.C–1.[38] For engines in which no deterioration or failure of the secondary air system would result in an engine's emissions exceeding any of the applicable emissions thresholds, the OBD system would have to detect a malfunction when no detectable amount of air flow is delivered during normal operation of the secondary air system.

ii. Secondary Air System High Flow Malfunctions

We are proposing that the OBD system detect a secondary air system malfunction prior to an increase from the manufacturer's specified air flow during normal operation that would cause an engine's emissions to exceed the emissions thresholds for ''other monitors'' as shown in Table II.C–1.[39] For engines in which no deterioration or failure of the secondary air system would result in an engine's emissions exceeding any of the applicable emissions thresholds, the OBD system would have to detect a malfunction when no detectable amount of air flow is delivered during normal operation of the secondary air system.

c. Secondary Air System Monitoring Conditions

We are proposing that manufacturers define the monitoring conditions for malfunctions of the secondary air system such that the minimum performance ratio requirements discussed in section II.E would be met. For purposes of tracking and reporting as required in section II.E, all monitors used to detect malfunctions of the secondary air system during its normal operation must be tracked separately but reported as a single set of values as specified in section II.E

d. Secondary Air System MIL Illumination and DTC Storage

We are proposing the general requirements for MIL illumination and DTC storage as discussed in section II.A.2.

6. Catalytic Converter Monitoring

a. Background

Three-way catalysts are one of the most important emission-control components on gasoline engines. They consist of ceramic or metal substrates coated with the one or more of the platinum group metals (PGM) platinum, palladium, and rhodium. These PGMs are dispersed within an alumina washcoat containing ceria, and the substrates are mounted in a stainless steel container in the vehicle exhaust system. Three-way catalysts are capable of oxidizing HC emissions, oxidizing CO emissions, and reducing NO_X emissions, hence the term three-way.

While continuous improvements to catalysts have increased their durability, their performance still deteriorates, especially when subjected to very high temperatures. Such high temperatures can be caused by, among other factors, engine misfire which results in unburned fuel and air entering and igniting in the catalyst. Exposure to such high temperatures will result in reduced catalyst conversion efficiency. Catalyst efficiency can also deteriorate via poisoning if exposed to lead, phosphorus, or high sulfur levels. Catalysts can also fail by mechanical means such as excessive vibration. Given its importance to emissions control and the many factors that can reduce its effectiveness, the catalyst is one of the most important components to be monitored.

b. Catalytic Converter Monitoring Requirements

We are proposing that the OBD system monitor the catalyst system for proper conversion capability. Specifically, the OBD system would be required to detect a catalyst system malfunction when the catalyst system's conversion capability decreases to the point that any of the following occurs:

- NMHC and/or NO_X emissions exceed the emissions thresholds for the ''catalytic converter system'' as shown in Table II.C–1.

For purposes of determining the catalyst system malfunction criteria the manufacturer would be required to use a catalyst system deteriorated to the malfunction criteria using methods established by the manufacturer to

[38] For purposes of secondary air system malfunctions, ''air flow'' is defined as the air flow delivered by the secondary air system to the exhaust system. For engines using secondary air systems with multiple air flow paths/distribution points, the air flow to each bank (i.e., a group of cylinders that share a common exhaust manifold, catalyst, and control sensor) must be monitored in accordance with these malfunction criteria. Also, ''normal operation'' is defined as the condition where the secondary air system is activated during catalyst and/or engine warm-up following engine start. ''Normal operation'' does not include the condition where the secondary air system is intrusively turned on solely for the purpose of monitoring.

[39] *Ibid.*

represent real world catalyst deterioration under normal and malfunctioning operating conditions. The malfunction criteria must be established by using a catalyst system with all monitored and unmonitored catalysts simultaneously deteriorated to the malfunction criteria.[40] For engines using fuel shutoff to prevent over-fueling during misfire conditions (see section II.C.2), the malfunction criteria could be established using a catalyst system with all monitored catalysts simultaneously deteriorated to the malfunction criteria and all unmonitored catalysts deteriorated to the end of the engine's useful life.

c. Catalytic Converter Monitoring Conditions

We are proposing that manufacturers define the monitoring conditions for malfunctions of the catalytic converter system such that the minimum performance ratio requirements discussed in section II.E would be met. For purposes of tracking and reporting as required in section II.E, all monitors used to detect malfunctions of the catalytic converter system during its normal operation must be tracked separately but reported as a single set of values as specified in section II.E.

d. Catalytic Converter MIL Illumination and DTC Storage

We are proposing the general requirements for MIL illumination and DTC storage as discussed in section II.A.2. Note that the monitoring method for the catalyst(s) would have to be capable of detecting all instances, except diagnostic self-clearing, when a catalyst DTC has been cleared but the catalyst has not been replaced (e.g., catalyst over temperature histogram approaches are not acceptable).

7. Evaporative Emission Control System Monitoring

a. Background

The evaporative emission control system controls HC emissions that would otherwise evaporate from the vehicle's fuel tank and fuel lines. Should any leak develop in the evaporative emission control system—e.g., a disconnected hose—the HC emissions can be quite high and well over the evaporative emissions standards. Additionally, evaporative purge system defects—e.g., deteriorated vacuum lines, damaged canisters, non-functioning purge control valves—may occur which could also result in very high evaporative emissions.

b. Evaporative System Monitoring Requirements

We are proposing that the OBD system verify purge flow from the evaporative system and detect any vapor leaks from the complete evaporative system, excluding the tubing and connections between the purge valve and the intake manifold. Individual components of the evaporative system (e.g. valves, sensors) must be monitored in accordance with the comprehensive components requirements discussed in section II.D.4.

The OBD system would be required to detect an evaporative system malfunction when any of the following conditions exist:

- No purge flow from the evaporative system to the engine can be detected by the OBD system (i.e., the "purge flow" requirement); or
- For the 2010 and later model years, the complete evaporative system contains a leak or leaks that cumulatively are greater than or equal to a leak caused by a 0.150 inch diameter orifice (i.e., the "system leak" requirement).[41]

If the most reliable monitoring method available cannot reliably detect a system leak as specified above, a manufacturer may design their system to detect a larger leak. The manufacturer would be required to provide data and/or engineering analyses that demonstrate the inability of the monitor to reliably detect the required leak and their justification for detecting at their proposed orifice size. Further, if the manufacturer can demonstrate that leaks of the required size cannot cause evaporative or running loss emissions to exceed 1.5 times the applicable evaporative emissions standards, the Administrator would revise upward the required leak size to the size demonstrated by the manufacturer that would result in emissions exceeding 1.5 times the standards.

c. Evaporative System Monitoring Conditions

We are proposing that manufacturers define the monitoring conditions for both purge flow and system leak malfunctions such that the minimum performance ratio requirements discussed in section II.E would be met. For purposes of tracking and reporting as required in section II.E, all monitors used to detect system leak malfunctions must be tracked separately but reported as a single set of values as specified in section II.E.

Manufacturers may disable or abort an evaporative emission control system monitor when the fuel tank level is over 85 percent of nominal tank capacity or during a refueling event. Manufacturers may design their evaporative emission control system monitor such that it executes only during drive cycles determined by the manufacturer to be cold starts if such a condition is needed to ensure reliable monitoring. The manufacturer would have to provide data and/or an engineering evaluation demonstrating that a reliable check can only be made on drive cycles when the cold start criteria are satisfied. However, the manufacturer may not determine a cold start solely on the basis that ambient temperature is higher than engine coolant temperature at engine start. Lastly, manufacturers would be allowed to disable temporarily the evaporative purge system to perform an evaporative system leak check.

d. Evaporative System MIL Illumination and DTC Storage

We are proposing the general requirements for MIL illumination and DTC storage as discussed in section II.A.2, with an exception for leaks associated with the fuel filler cap. If the OBD system is capable of discerning that a system leak is being caused by a missing or improperly secured fuel filler cap, the manufacturer is not required to illuminate the MIL or store a DTC provided the vehicle is equipped with an alternative indicator for notifying the vehicle operator of the fuel filler cap "malfunction." The alternative indicator would have to be of sufficient illumination and location to be readily visible to the vehicle operator under all lighting conditions. However, if the vehicle is not equipped with an alternative indicator and, instead, the MIL is illuminated to inform the operator of the "malfunction," the MIL may be extinguished and the corresponding DTC(s) erased once the OBD system has verified that the fuel filler cap has been securely fastened and the MIL has not been commanded ON for any other type of malfunction. The Administrator may approve other strategies provided the manufacturer was able to demonstrate that the vehicle operator would be promptly notified of the missing or improperly secured fuel filler cap and that the notification would reasonably result in corrective action being undertaken.

[40] The unmonitored portion of the catalyst system would be that portion downstream of the sensor(s) used for catalyst monitoring.

[41] In their HDOBD regulation, 13 CCR 1971.1, CARB defines "orifice" as an O'Keefe Controls Co. precision metal "Type B" orifice with NPT connections with a diameter of the specified dimension (e.g., part number B–31–SS for a stainless steel 0.031 inch diameter orifice).

8. Exhaust Gas Sensor Monitoring

a. Background

Exhaust gas sensors (e.g., oxygen sensors, air-fuel ratio (A/F) sensors) are a critical element of the emissions control system on gasoline engines. In addition to maintaining a stoichiometric air-fuel mixture and, thus, helping to achieve the lowest possible emissions, these sensors are also used for enhancing the performance of several emission control technologies—e.g., catalysts, EGR systems). Many modern vehicles control the fuel supply with an oxygen sensor feedback system to maintain stoichiometry. Oxygen sensors are located typically in the exhaust system upstream and downstream of the catalytic converters. The front, or upstream, oxygen sensor is used generally for fuel control. The rear, or downstream, oxygen sensor is used generally for adjusting the front oxygen sensor signal as it drifts slightly with age related deterioration—often referred to as fuel trimming—and for onboard monitoring the catalyst system. Many vehicles use A/F sensors in lieu of the more conventional oxygen sensors since A/F sensors provide a precise reading of the actual air-fuel ratio.

We expect that heavy-duty gasoline manufacturers will use both of these types of sensors to optimize their emissions control strategies and to satisfy many of the proposed heavy-duty OBD monitoring requirements—fuel system monitoring, catalyst monitoring, EGR system monitoring. Since exhaust gas sensors can be a critical component of an engine's fuel and emissions control system, their proper performance needs to be assured to maintain low emissions. Thus, any malfunction that adversely affects the performance of any of these exhaust gas sensors should be detected by the OBD system.

b. Exhaust Gas Sensor Monitoring Requirements

We are proposing that the OBD system monitor the output signal, response rate, and any other parameter that could affect emissions of all primary (i.e., fuel control) exhaust gas sensors for malfunction. Both the lean to rich and rich to lean response rates must be monitored. In addition, we are proposing that the OBD system monitor all secondary exhaust gas sensors (i.e., those used for fuel trimming or as a monitoring device for another system) for proper output signal, activity, and response rate. For engines equipped with heated exhaust gas sensors, the OBD system would be required to monitor the sensor heater for proper performance.

i. Primary Exhaust Gas Sensors

We are proposing that the OBD system detect a malfunction prior to any failure or deterioration of the exhaust gas sensor output voltage, resistance, impedance, current, response rate, amplitude, offset, or other characteristic(s) (including drift or bias corrected for by secondary sensors) that would cause an engine's emissions to exceed the emissions thresholds for ''other monitors'' as shown in Table II.C–1. The OBD system would also be required to detect the following exhaust gas sensor malfunctions:

- Those caused by either a lack of circuit continuity or out-of-range values.
- Those where a sensor failure or deterioration causes the fuel system to stop using that sensor as a feedback input (e.g., causes default or open-loop operation).
- Those where the sensor output voltage, resistance, impedance, current, amplitude, activity, or other characteristics are no longer sufficient for use as an OBD system monitoring device (e.g., for catalyst monitoring).

ii. Secondary Exhaust Gas Sensors

We are proposing that the OBD system detect a malfunction prior to any failure or deterioration of the exhaust gas sensor voltage, resistance, impedance, current, response rate, amplitude, offset, or other characteristic(s) that would cause an engine's emissions to exceed the emissions thresholds for ''other monitors'' as shown in Table II.C–1. The OBD system would also be required to detect the following exhaust gas sensor malfunctions:

- Those caused by either a lack of circuit continuity or out-of-range values.
- Those where a sensor failure or deterioration causes the fuel system to stop using that sensor as a feedback input (e.g., causes default or open-loop operation).
- Those where the sensor output voltage, resistance, impedance, current, amplitude, activity, or other characteristics are no longer sufficient for use as an OBD system monitoring device (e.g., for catalyst monitoring).

iii. Exhaust Gas Sensor Heaters

We are proposing that the OBD system detect a malfunction of the sensor heater performance 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 required by the component vendor for heater circuit performance at high mileage). The manufacturer may use other malfunction criteria for heater performance malfunctions. To do so, the manufacturer would be required to submit data and/or engineering analyses that demonstrate that the monitoring reliability and timeliness would be equivalent to the criteria stated here.

In addition, the OBD system would be required to detect malfunctions of the heater circuit including open or short circuits that conflict with the commanded state of the heater (e.g., shorted to 12 Volts when commanded to 0 Volts (ground)).

c. Exhaust Gas Sensor Monitoring Conditions

i. Primary Exhaust Gas Sensors

We are proposing that manufacturers define the monitoring conditions for primary exhaust gas sensor malfunctions causing exceedance of the applicable thresholds and/or inability to perform as an OBD monitoring device such that the minimum performance ratio requirements discussed in section II.E would be met. For purposes of tracking and reporting as required in section II.E, all such monitors must be tracked separately but reported as a single set of values as specified in section II.E.

Monitoring for primary exhaust gas sensor malfunctions related to circuit continuity, out-of-range, and open-loop operation must be done continuously with the exception that manufacturers may disable continuous exhaust gas sensor monitoring when an exhaust gas sensor malfunction cannot be distinguished from other effects. As an example, a manufacturer may disable monitoring for out-of-range on the low side during conditions where fuel has been cut (i.e., shut off temporarily). To do so, the manufacturer would have to submit data and/or engineering analyses that demonstrate that a properly functioning sensor cannot be distinguished from a malfunctioning sensor and that the disablement interval is limited only to that necessary for avoiding a false detection.

ii. Secondary Exhaust Gas Sensors

We are proposing that manufacturers define the monitoring conditions for secondary exhaust gas sensor malfunctions causing exceedance of the applicable emissions thresholds, lack of circuit continuity, and/or inability to perform as an OBD monitoring device such that the minimum performance ratio requirements discussed in section II.E would be met.

Monitoring for secondary exhaust gas sensor malfunctions related to out-of-range and open loop operation must be done continuously with the exception that manufacturers may disable continuous exhaust gas sensor monitoring when an exhaust gas sensor malfunction cannot be distinguished from other effects. As an example, a manufacturer may disable monitoring for out-of-range on the low side during conditions where fuel has been cut (i.e., shut off temporarily). To do so, the manufacturer would have to submit data and/or engineering analyses that demonstrate that a properly functioning sensor cannot be distinguished from a malfunctioning sensor and that the disablement interval is limited only to that necessary for avoiding a false detection.

iii. Sensor Heaters

We are proposing that manufacturers define monitoring conditions for sensor heater performance malfunctions such that the minimum performance ratio requirements discussed in section II.E would be met. Monitoring for sensor heater circuit malfunctions must be done continuously.

d. Exhaust Gas Sensor MIL Illumination and DTC Storage

We are proposing the general requirements for MIL illumination and DTC storage as discussed in section II.A.2.

D. Monitoring Requirements and Timelines for Other Diesel and Gasoline Systems

1. Variable Valve Timing and/or Control (VVT) System Monitoring

a. Background

Variable valve timing (VVT) and/or control 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 and at fixed times, VVT controls can vary the timing of valve opening/closing and vary the effective size of the valve opening itself (in some systems) depending on the driving conditions (e.g., high engine speed and load). This feature permits a better compromise between performance, driveability, and emissions than conventional systems. With more stringent NO_X emission standards being phased in, more vehicles are anticipated to use VVT. By doing so, some exhaust gas can be retained in the combustion chamber thereby reducing peak combustion temperatures and, hence, NO_X emissions (known as ''internal EGR'').

b. VVT and/or Control System Monitoring Requirements

We are proposing that the OBD system monitor the VVT system on engines so equipped for target error and slow response malfunctions. The individual electronic components (e.g., actuators, valves, sensors) that are used in the VVT system must be monitored in accordance with the comprehensive components requirements in section II.D.4.

i. VVT Target Error Malfunctions

We are proposing that the OBD system detect a malfunction prior to any failure or deterioration in the capability of the VVT system to achieve the commanded valve timing and/or control within a crank angle and/or lift tolerance that would cause an engine's emissions to exceed the emissions thresholds for ''other monitors'' as shown in Table II.B–1 for diesel engines or Table II.C–1 for gasoline engines. For engines in which no failure or deterioration of the VVT system could result in an engine's emissions exceeding the applicable emissions thresholds, the OBD system would have to detect a malfunction of the VVT system when proper functional response of the system to computer commands does not occur.

ii. VVT Slow Response Malfunctions

We are proposing that the OBD system detect a malfunction prior to any failure or deterioration in the capability of the VVT system to achieve the commanded valve timing and/or control within a manufacturer-specified time that would cause an engine's emissions to exceed the emissions thresholds for ''other monitors'' as shown in Table II.B–1 for diesel engines or Table II.C–1 for gasoline engines. For engines in which no failure or deterioration of the VVT system could result in an engine's emissions exceeding the applicable emissions thresholds, the OBD system would have to detect a malfunction of the VVT system when proper functional response of the system to computer commands does not occur.

c. VVT and/or Control System Monitoring Conditions

We are proposing that manufacturers define the monitoring conditions for VVT target error or slow response malfunctions such that the minimum performance ratio requirements discussed in section II.E would be met with the exception that monitoring shall occur every time the monitoring conditions are met during the driving cycle rather than once per driving cycle as required for most monitors. For purposes of tracking and reporting as required in section II.E, all monitors used to detect all VVT related malfunctions would have to be tracked separately but reported as a single set of values as specified in section II.E.[42]

d. VVT and/or Control System MIL Illumination and DTC Storage

We are proposing the general requirements for MIL illumination and DTC storage as discussed in section II.A.2.

2. Engine Cooling System Monitoring

a. Background

We are concerned about two elements of the engine cooling system. These elements are the thermostat and the engine coolant temperature sensor. Manufacturers typically use a thermostat to control the flow of coolant through the radiator and around the engine. During a cold engine start, the thermostat is closed typically which prevents the flow of coolant and serves to promote more rapid warm-up of the engine. As the coolant approaches a specific temperature, the thermostat begins to open allowing circulation of coolant through the radiator and around the engine. 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 due to prolonged operation of the vehicle at temperatures below the stabilized, warmed-up value. This is particularly true at lower ambient temperatures—50 degrees Fahrenheit and below—but not so low that they are rare in the U.S. Equally important is that the engine coolant temperature is often used as an enable criterion for many OBD monitors. If the engine's coolant temperature does not reach the

[42] For specific components or systems that have multiple monitors that are required to be reported (e.g., exhaust gas sensor bank 1 may have multiple monitors for sensor response or other sensor characteristics), the OBD system must separately track numerators and denominators for each of the specific monitors and report only the corresponding numerator and denominator for the specific monitor that has the lowest numerical ratio. If two or more specific monitors have identical ratios, the corresponding numerator and denominator for the specific monitor that has the highest denominator shall be reported for the specific component.

manufacturer-specified warmed-up value, such monitors would be effectively disabled, perhaps indefinitely, and would, therefore, never detect malfunctions.

Closely linked with the thermostat is the engine coolant temperature (ECT) sensor. Manufacturers typically use an ECT sensor as an input for many of the emission-related engine control systems. For gasoline engines, the ECT sensor is often one of the most important factors in determining when to begin closed-loop fuel control. If the engine coolant does not warm-up sufficiently, closed-loop fuel control is usually not engaged and the vehicle remains in open-loop fuel control. Since open-loop fuel control does not provide the precision of closed-loop control, the result is increased emissions levels. For diesel engines, the ECT sensor is often used to engage closed-loop control of the EGR system. Similar to closed-loop fuel control on gasoline engines, if the coolant temperature does not warm up, closed-loop control of the EGR system would not engage which would result in increased emissions levels. In addition, for both gasoline and diesel engines, the ECT sensor may be used to enable many of the monitors that are being proposed. Such monitors would be effectively disabled and incapable of detecting malfunctions should the ECT sensor itself malfunction.

b. Engine Cooling System Monitoring Requirements

We are proposing that the OBD system monitor the thermostat on engines so equipped for proper operation. We are also proposing that the OBD system monitor the ECT sensor for circuit continuity, out-of-range values, and rationality faults. For engines that use an approach other than the cooling system and ECT sensor—e.g., oil temperature, cylinder head temperature—for an indication of engine operating temperature for emission control purposes (e.g., to modify spark or fuel injection timing or quantity), the manufacturer may forego cooling system monitoring in favor of monitoring the components or systems used in their approach. To do so, the manufacturer would be required to submit data and/or engineering analyses that demonstrate that their monitoring plan is as reliable and effective as the monitoring required for the engine cooling system.

i. Thermostat Monitoring Requirements

We are proposing that the OBD system detect a thermostat malfunction if, within the manufacturer specified time interval following engine start, any of the following conditions occur:

- The coolant temperature does not reach the highest temperature required by the OBD system to enable other diagnostics;
- The coolant temperature does not reach a warmed-up temperature within 20 degrees Fahrenheit of the manufacturer's nominal thermostat regulating temperature. The manufacturer may use a lower temperature for this criterion provided the manufacturer can demonstrate that the fuel, spark timing, and/or other coolant temperature-based modification to the engine control strategies would not cause an emissions increase greater than or equal to 50 percent of any of the applicable emissions standards.

The time interval specified by the manufacturer would have to be supported by the manufacturer via data and/or engineering analyses demonstrating that it provides robust monitoring and minimizes the likelihood of other OBD monitors being disabled. The manufacturer may use alternative malfunction criteria that are a function of temperature at engine start on engines that do not reach the temperatures specified in the malfunction criteria when the thermostat is functioning properly. To do so, the manufacturer would be required to submit data and/or engineering analyses that demonstrate that a properly operating system does not reach the specified temperatures and that the possibility is minimized for cooling system malfunctions to go undetected and disable other OBD monitors. In some cases, a manufacturer may forgo thermostat monitoring if the manufacturer can demonstrate that a malfunctioning thermostat cannot cause a measurable increase in emissions during any reasonable driving condition nor cause any disablement of other OBD monitors.

ii. Engine Coolant Temperature Sensor Monitoring Requirements

We are proposing that the OBD system detect an ECT sensor malfunction when a lack of circuit continuity or an out-of-range value occurs. We are also proposing that the OBD system detect if, within the manufacturer specified time interval following engine start, the ECT sensor does not achieve the highest stabilized minimum temperature that is needed to initiate closed-loop/feedback control of all affected emission control systems (e.g., fuel system, EGR system). The manufacturer specified time interval would have to be a function of the engine coolant temperature and/or intake air temperature at startup. The manufacturer time interval would also have to be supported by the manufacturer via data and/or engineering analyses demonstrating that it provides robust monitoring and minimizes the likelihood of other OBD monitors being disabled. Manufacturers may forego the requirement to detect the ''time to closed loop/feedback enable temperature'' malfunction if the manufacturer does not use engine coolant temperature or the ECT sensor to enable closed-loop/feedback control of any emission control systems.

We are also proposing that, to the extent feasible when using all available information, the OBD system must detect a malfunction if the ECT sensor inappropriately indicates a temperature below the highest minimum enable temperature required by the OBD system to enable other monitors. For example, an OBD system that requires an engine coolant temperature greater than 140 degrees Fahrenheit prior to enabling an OBD monitor must detect malfunctions that cause the ECT sensor to indicate inappropriately a temperature below 140 degrees Fahrenheit. Manufacturers may forego such monitoring within temperature regions in which the thermostat monitor or the ECT sensor ''time to reach closed-loop/feedback enable temperature'' monitor would detect this ''stuck in a range below the highest minimum enable temperature'' ECT sensor malfunction.

Lastly, we are proposing that, to the extent feasible when using all available information, the OBD system must detect a malfunction if the ECT sensor inappropriately indicates a temperature above the lowest maximum enable temperature required by the OBD system to enable other monitors. For example, an OBD system that requires an engine coolant temperature less than 90 degrees Fahrenheit at startup prior to enabling an OBD monitor must detect malfunctions that cause the ECT sensor to indicate inappropriately a temperature above 90 degrees Fahrenheit. Manufacturers may forego such monitoring within temperature regions in which the thermostat monitor, the ECT sensor ''time to reach closed-loop/feedback enable temperature'' monitor, or the ECT sensor ''stuck in a range below the highest minimum enable temperature'' monitor would detect this ECT sensor ''stuck in a range above the lowest maximum enable temperature'' ECT sensor malfunction. The manufacturer may also forego such monitoring if the MIL would be illuminated for entering a ''limp home'' or default mode of operation—e.g., for an over temperature protection strategy—as discussed in section II.A.2. Manufacturers may also forego this monitoring within temperature regions where the temperature gauge indicates a temperature in the engine overheating ''red zone'' should the vehicle have a temperature gauge on the instrument panel that displays the same temperature information as used by the OBD system (note that a temperature gauge would be required, not a temperature warning light).

c. Engine Cooling System Monitoring Conditions

i. Thermostat Monitoring Conditions

We are proposing that manufacturers define the monitoring conditions for thermostat malfunctions in accordance with the general monitoring conditions for all engines described in section II.A.3. Additionally, monitoring for thermostat malfunctions would have to be done once per drive cycle on every drive cycle in which the ECT sensor indicates, at engine start, a temperature lower than the temperature established as the malfunction criteria in section II.D.2.b.i. Manufacturers would be allowed to disable thermostat monitoring at ambient engine start temperatures below 20 degrees Fahrenheit. Manufacturers may suspend or disable thermostat monitoring if the engine is subjected to conditions that could lead to false diagnosis (e.g., engine operation at idle for more than 50 percent of the warm-up time and/or hot restart conditions). To do so, the manufacturer must submit data and/or engineering analyses that demonstrate that the suspension or disablement is necessary. In general, the manufacturer would not be allowed to suspend or disable the thermostat monitor on engine starts where the engine coolant temperature at engine start is more than 35 degrees Fahrenheit lower than the thermostat malfunction threshold temperature.

ii. Engine Coolant Temperature Sensor Monitoring Conditions

We are proposing that monitoring for ECT sensor circuit continuity and out-of-range malfunctions be done continuously. Manufacturers would be allowed to disable continuous ECT sensor monitoring when an ECT sensor malfunction cannot be distinguished from other effects. To do so, the manufacturer would have to submit test data and/or engineering evaluation that demonstrate that a properly functioning sensor cannot be distinguished from a malfunctioning sensor and that the disablement interval is limited only to that necessary for avoiding false detection.

We are also proposing that manufacturers define the monitoring conditions for ''time to reach closed-loop/feedback enable temperature'' malfunctions in accordance with the general monitoring conditions for all engines described in section II.A.3. Additionally, monitoring for ''time to reach closed-loop/feedback enable temperature'' malfunctions would have to be conducted once per drive cycle on every drive cycle in which the ECT sensor at engine start indicates a temperature lower than the closed-loop enable temperature (i.e., all engine start temperatures greater than the ECT sensor out-of-range low temperature and less than the closed-loop enable temperature). Manufacturers would be allowed to suspend or delay the ''time to reach closed-loop/feedback enable temperature'' monitor if the engine is subjected to conditions that could lead to false diagnosis (e.g., vehicle operation at idle for more than 50 to 75 percent of the warm-up time).

We are also proposing that manufacturers define the monitoring conditions for ECT sensor ''stuck in a range below the highest minimum enable temperature'' and ''stuck in a range above the lowest maximum enable temperature'' malfunctions in accordance with the general monitoring conditions for all engines described in section II.A.3 and in accordance with the minimum performance ratio requirements discussed in section II.E.

d. Engine Cooling System MIL Illumination and DTC Storage

We are proposing the general requirements for MIL illumination and DTC storage as discussed in section II.A.2.

3. Crankcase Ventilation System Monitoring

a. Background

Crankcase emissions are the pollutants emitted in the gases that are vented from an engine's crankcase. These gases are also referred to as ''blowby gases'' because they result from engine exhaust from the combustion chamber ''blowing by'' the piston rings into the crankcase. These gases are vented to prevent high pressures from occurring in the crankcase. Our emission standards have historically prohibited crankcase emissions from all highway engines except turbocharged heavy-duty diesel engines. The most common way to eliminate crankcase emissions has been to vent the blowby gases into the engine air intake system, so that the gases can be recombusted. We made the exception for turbocharged heavy-duty diesel engines in the past because of concerns about fouling that could occur by routing the diesel particulates (including engine oil) into the turbocharger and aftercooler. Newly developed closed crankcase filtration systems specifically designed for turbocharged heavy-duty diesel engines now allow the crankcase gases to be captured.

In general, the crankcase ventilation system consists of a fresh air inlet hose, a crankcase vapor outlet hose, and a crankcase ventilation valve to control the flow through the system. Fresh air is introduced to the crankcase via the inlet (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 and then to the intake manifold. On gasoline engines, the intake manifold provides the vacuum that is needed to accomplish the circulation while the engine is running.

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, limiting air flow to a small amount. For most systems, a mechanical valve is all that is necessary to adequately regulate crankcase ventilation system air flow. The crankcase ventilation system on diesel engines, while slightly different than that for gasoline engines, has essentially the same purpose and function.

We do not believe that failures involving cracked or deteriorated hoses have a significant impact on crankcase emissions because vapors are drawn into the engine by intake manifold vacuum which suggests that fresh air would be drawn into the cracked hose rather than dirty exhaust being blown out of the cracked hose. The more likely cause of crankcase ventilation system malfunctions and excess emissions is improper service or tampering of the system. Such failures include misrouted or disconnected hoses and missing valves. Of these failures, hose disconnections on the vapor vent side of the system and/or missing valves can cause harmful crankcase emissions to be vented directly to the atmosphere.

b. Crankcase Ventilation System Monitoring Requirements

We are proposing that the OBD system monitor the crankcase ventilation system on engines so equipped for system integrity. Engines not equipped with crankcase ventilation systems would be exempt from monitoring the crankcase ventilation system.

Specifically for diesel engines, the manufacturer would be required to submit a plan for the monitoring strategy, malfunction criteria, and monitoring conditions prior to OBD certification. The plan would have to demonstrate the effectiveness of the strategy to monitor the performance of the crankcase ventilation system to the extent feasible with respect to the malfunction criteria below and the monitoring conditions required by the monitor.

We are proposing that the OBD system detect a malfunction of the crankcase ventilation system when a disconnection of the system occurs between either the crankcase and the crankcase ventilation valve, or between the crankcase ventilation valve and the intake manifold. Manufacturers may forego detecting a disconnection between the crankcase and the crankcase ventilation valve provided the manufacturer can demonstrate that the crankcase ventilation system is designed such that the crankcase ventilation valve is fastened directly to the crankcase in a manner that makes it significantly more difficult to remove the valve from the crankcase than to disconnect the line between the valve and the intake manifold (aging effects must be taken into consideration). Manufacturers may also forego detecting a disconnection between the crankcase and the crankcase ventilation valve for system designs that use tubing between the valve and the crankcase provided the manufacturer can demonstrate that the connections between the valve and the crankcase are: (1) Resistant to deterioration or accidental disconnection; (2) significantly more difficult to disconnect than the line between the valve and the intake manifold; and, (3) not subject to disconnection per the manufacturer's repair procedures for non-crankcase ventilation system repair work. Lastly, manufacturers may forego detecting a disconnection between the crankcase ventilation valve and the intake manifold upon determining that the disconnection: (1) Causes the vehicle to stall immediately during idle operation; or, (2) is unlikely to occur due to a crankcase ventilation system design that is integral to the induction system (e.g., machined passages rather than tubing or hoses).

c. Crankcase Ventilation System Monitoring Conditions

We are proposing that manufacturers define the monitoring conditions for crankcase ventilation system malfunctions in accordance with the general monitoring conditions for all engines described in section II.A.3, and the minimum performance ratio requirements discussed in section II.E.

d. Crankcase Ventilation System MIL Illumination and DTC Storage

We are proposing the general requirements for MIL illumination and DTC storage as discussed in section II.A.2. The stored DTC need not specifically identify the crankcase ventilation system (e.g., a DTC for idle speed control or fuel system monitoring can be stored) if the manufacturer can demonstrate that additional monitoring hardware would be necessary to make this identification, and provided the manufacturer's diagnostic and repair procedures for the detected malfunction include directions to check the integrity of the crankcase ventilation system.

4. Comprehensive Component Monitors

a. Background

Comprehensive components is a term meant to capture essentially every other emissions related component not discussed above. Specifically, it covers all other electronic engine components or systems not mentioned above that either can affect vehicle emissions or are used as part of the OBD diagnostic strategy for another monitored component or system. Comprehensive components are generally identified as input components—i.e., those that provide input directly or indirectly to the onboard computer—or as output components and/or systems—i.e., those that receive commands from the onboard computer. Typical examples of input components include temperature sensors and pressure sensors, while examples of output components and/or systems include the idle control system, glow plugs, and wait-to-start lamps.

While a malfunctioning comprehensive component may not have as much impact on emissions as a malfunctioning major emissions-related component, it still could result in a measurable increase in emissions. The proper performance of these components can be critical to both the proper functioning of major emissions-related components, and to the accurate monitoring of those components or systems. Malfunctions of comprehensive components that go undetected by the OBD system may disable or adversely affect the robustness of other OBD monitors without any awareness by the operator that a problem exists. Due to the vital role these components play, monitoring them properly is extremely important.

b. Comprehensive Component Monitoring Requirements

We are proposing that the OBD system monitor for malfunction any electronic engine components/systems not otherwise described in sections above that either provides input to (directly or indirectly) or receives commands from the onboard computer(s), and: (1) Can affect emissions during any reasonable in-use driving condition; or, (2) is used as part of the diagnostic strategy for any other monitored system or component.[43]

Input components required to be monitored may include the crank angle sensor, knock sensor, throttle position sensor, cam position sensor, intake air temperature sensor, boost pressure sensor, manifold pressure sensor, mass air flow sensor, exhaust temperature sensor, exhaust pressure sensor, fuel pressure sensor, and fuel composition sensor (e.g., flexible fuel vehicles). Output components/systems required to be monitored may include the idle speed control system, glow plug system, variable length intake manifold runner systems, supercharger or turbocharger electronic components, heated fuel preparation systems, the wait-to-start lamp on diesel applications, and the MIL. The manufacturer would be responsible for determining which input and output components/systems could affect emissions during any reasonable in-use driving condition. The manufacturer would be allowed to make this determination based on data or engineering judgment. However, if the Administrator reasonably believes that a manufacturer has incorrectly determined that a component/system cannot affect emissions, the manufacturer may be required to provide emissions data showing that the component/system, when malfunctioning and installed in a suitable test engine, does not have an emissions effect. Such emissions data may be requested for any reasonable driving condition.

[43] When referring to "comprehensive components" and their monitors, "electronic engine components/systems" is not meant to include components/systems that are driven by the engine yet are not related to the control of the fueling, air handling, or emissions of the engine (e.g., PTO components, air conditioning system components, and power steering components are not included).

i. Input Components

We are proposing that the OBD system detect malfunctions of input components caused by a lack of circuit continuity, out-of-range values, and, where feasible, improper rationality. To the extent feasible, the rationality diagnostics should verify that a sensor's input to the onboard computer is neither inappropriately high nor inappropriately low (i.e., ''two-sided'' diagnostics should be used). Also to the extent feasible, the OBD system should detect and store different DTCs that distinguish rationality malfunctions from lack of circuit continuity malfunctions and out-of-range values. For lack of circuit continuity malfunctions and out-of-range values, the OBD system should detect and store different DTCs for each distinct malfunction (e.g., out-of-range low, out-of-range high, open circuit). The OBD system is not required to store separate DTCs for lack of circuit continuity malfunctions that cannot be distinguished from malfunctions associated with out-of-range values.

For input components that are used to activate alternative strategies that can affect emissions (e.g., AECDs, engine shutdown systems), the OBD system would be required to detect rationality malfunctions that cause the system to erroneously activate or deactivate the alternative strategy. To the extent feasible when using all available information, the rationality diagnostics should detect a malfunction if the input component inappropriately indicates a value that activates or deactivates the alternative strategy. For example, if an alternative strategy requires an intake air temperature greater than 120 degrees Fahrenheit prior to activating, the OBD system should detect malfunctions that cause the intake air temperature sensor to inappropriately indicate a temperature above 120 degrees Fahrenheit.

For engines that require precise alignment between the camshaft and the crankshaft, the OBD system would be required to monitor the crankshaft position sensor(s) and camshaft position sensor(s) to verify proper alignment between the camshaft and crankshaft. The OBD system would also have to monitor the sensors for circuit continuity and rationality malfunctions. Such monitoring for proper alignment between a camshaft and a crankshaft would only be required in cases where both are equipped with position sensors.

For engines equipped with VVT systems and a timing belt or chain, the OBD system must detect a malfunction if the alignment between the camshaft and crankshaft is off by one or more cam/crank sprocket cogs (e.g., the timing belt/chain has slipped by one or more teeth/cogs). If a manufacturer demonstrates that a single tooth/cog misalignment cannot cause a measurable increase in emissions during any reasonable driving condition, the OBD system would be required to detect a malfunction when the minimum number of teeth/cogs misalignment needed to cause a measurable emission increase has occurred.

ii. Output Components/Systems

We are proposing that the OBD system detect a malfunction of an output component/system when proper functional response of the component/ system to computer commands does not occur. If a functional check is not feasible, the OBD system would be required to detect malfunctions caused by a lack of circuit continuity (e.g., short to ground or high voltage). For output component malfunctions associated with the lack of circuit continuity, the OBD system is not required to store different DTCs for each distinct malfunction (e.g., open circuit, shorted low). Further, manufacturers would not be required to activate an output component/system when it would not normally be active for the exclusive purpose of performing functional monitoring of output components/ systems.

Additionally, the idle control system would have to be monitored for proper functional response to computer commands. For gasoline engines that use monitoring strategies based on deviation from target idle speed, a malfunction would have to be detected when either of the following conditions occur: (a) The idle speed control system cannot achieve the target idle speed within 200 revolutions per minute (rpm) above the target speed or 100 rpm below the target speed—the OBD system could use larger engine speed tolerances provided the manufacturer is able to demonstrate via data and/or engineering analyses that the tolerances can be exceeded without a malfunction being present; or, (b) the idle speed control system cannot achieve the target idle speed within the smallest engine speed tolerance range required by the OBD system to enable any other OBD monitors. For diesel engines, a malfunction would have to be detected when either of the following conditions occur: (a) The idle fuel control system cannot achieve the target idle speed or fuel injection quantity within +/−50 percent of the manufacturer-specified fuel quantity and engine speed tolerances; or, (b) the idle fuel control system cannot achieve the target idle speed or fueling quantity within the smallest engine speed or fueling quantity tolerance range required by the OBD system to enable any other OBD monitors.

Glow plugs and intake air heater systems would also have to be monitored for proper functional response to computer commands and for malfunctions associated with circuit continuity. The glow plug and intake air heater circuit(s) would have to be monitored for proper current and voltage drop. The manufacturer may use other monitoring strategies by submitting data and/or engineering analyses that demonstrate that the strategy provides equally reliable and timely detection of malfunctions. In general, the OBD system would have to detect a malfunction when a single glow plug no longer operates within the manufacturer's specified limits for normal operation. If a manufacturer demonstrates that a single glow plug malfunction cannot cause a measurable increase in emissions during any reasonable driving condition, the OBD system must detect a malfunction for the minimum number of glow plugs needed to cause an emissions increase. Further, to the extent feasible without adding additional hardware for this purpose, the stored DTC must identify the specific malfunctioning glow plug(s).

Lastly, the wait-to-start lamp circuit and the MIL circuit would have to be monitored for malfunctions that cause either lamp to fail to illuminate when commanded on (e.g., burned out bulb).

c. Comprehensive Component Monitoring Conditions

i. Input Components

We are proposing that input components be monitored continuously for circuit continuity and for providing values within the proper range. For rationality monitoring, where applicable, manufacturers would define the monitoring conditions for detecting malfunctions in accordance with the general monitoring conditions for all engines described in section II.A.3 and the minimum performance ratio requirements described in section II.E except that rationality monitoring would have to occur every time the monitoring conditions are met during the drive cycle rather than once per drive cycle as required in section II.A.3.

A manufacturer may disable continuous monitoring for circuit continuity, and for providing values within the proper range, when a malfunction cannot be distinguished from other effects. To do so, the manufacturer would have to submit data and/or engineering analyses that demonstrate that a properly functioning input component cannot be distinguished from a malfunctioning input component and that the disablement interval is limited only to that necessary for avoiding false detection.

ii. Output Components/Systems

We are proposing that output components/systems be monitored continuously for circuit continuity. For functional monitoring, manufacturers would define the monitoring conditions for detecting malfunctions in accordance with the general monitoring conditions for all engines described in section II.A.3 and the minimum performance ratio requirements described in section II.E.

For the idle control system, we are proposing that manufacturers define the monitoring conditions for functional monitoring in accordance with the general monitoring conditions for all engines described in section II.A.3 and the minimum performance ratio requirements described in section II.E except that functional monitoring would have to occur every time the monitoring conditions are met during the drive cycle rather than once per drive cycle as required in section II.A.3.

A manufacturer may disable continuous monitoring for circuit continuity when a malfunction cannot be distinguished from other effects. To do so, the manufacturer would have to submit data and/or engineering analyses that demonstrate that a properly functioning output component cannot be distinguished from a malfunctioning output component and that the disablement interval is limited only to that necessary for avoiding false detection.

d. Comprehensive Component MIL Illumination and DTC Storage

With a couple of exceptions, we are proposing the general requirements for MIL illumination and DTC storage as discussed in section II.A.2. The exceptions to this being that MIL illumination would not be required in conjunction with storing a MIL-on DTC for any comprehensive component if: (a) The component or system, when malfunctioning, could not cause engine emissions to increase by 15 percent or more of the FTP standard during any reasonable driving condition; and, (b) the component or system is not used as part of the diagnostic strategy for any other monitored system or component. MIL illumination is also not required if a malfunction has been detected in the MIL circuit that prevents the MIL from illuminating (e.g., burned out bulb or light emitting diode (LED)). However, the electronic MIL status must be reported as ‘‘commanded on’’ and a MIL-on DTC would have to be stored.

5. Other Emissions Control System Monitoring

a. Background

As noted above, the primary purpose of OBD is to detect malfunctions in the engine and/or emissions control system. Therefore, we are proposing that manufacturers be required to submit to the Administrator a monitoring plan for any new engine and/or emissions control technology not otherwise described above. Such technology might include hydrocarbon traps or homogeneous charge compression ignition (HCCI) systems. This would allow manufacturers and EPA to evaluate the new technology and determine an appropriate level of monitoring that would be both technologically feasible and consistent with the monitoring requirements for the other emissions control devices described above.

As proposed, the Administrator would provide guidance as to what type of components would fall under the ‘‘other emissions control system’’ requirements and which would fall under the comprehensive component requirements. Specifically, we are concerned that uncertainty may arise for those emission control components or systems that also meet the definition of electronic engine components. As such, the proposal would delineate the two by requiring components/systems that fit both definitions but are not corrected or compensated for by the adaptive fuel control system to be monitored as ‘‘other emissions control devices’’ rather than as comprehensive components. A typical device that would fall under this category instead of the comprehensive components category because of this delineation would be a swirl control valve system. Such delineation is necessary because such emissions control components generally require more thorough monitoring than comprehensive components to ensure low emissions levels throughout an engine’s life. Further, emissions control components that are not compensated for by the fuel control system as they age or deteriorate can have a larger impact on tailpipe emissions than is typical of comprehensive components that are corrected for by the fuel control system as they deteriorate.

Note that the Administrator does not foresee any outcome where a promising new emissions control technology would be prohibited based solely on the lack of an OBD monitoring strategy for it. Instead, we want to instill in manufacturers the need to consider OBD monitoring when developing any new emissions control technology. Further, we want to instill in manufacturers the sense that an OBD monitoring strategy will, one day, be necessary so a plan for such should exist prior to introducing the technology on new products.

b. Other Emissions Control System Monitoring Requirements/Conditions

We are proposing that, for other emission control systems that are: (1) Not identified or addressed in sections II.B through II.D.4—e.g., hydrocarbon traps, HCCI control systems; or, (2) identified or addressed in section II.D.4 but not corrected or compensated for by an adaptive control system—e.g., swirl control valves, manufacturers would be required to submit a plan for Administrator approval of the monitoring strategy, the malfunction criteria, and the monitoring conditions prior to introduction on a production engine. Administrator approval of the plan would be based on the effectiveness of the monitoring strategy, the robustness of the malfunction criteria, and the frequency of meeting the necessary monitoring conditions.

We are also proposing that, for engines that use emissions control systems that alter intake air flow or cylinder charge characteristics by actuating valve(s), flap(s), etc., in the intake air delivery system (e.g., swirl control valve systems), the manufacturers, in addition to meeting the requirements above, may elect to have the OBD system monitor the shaft to which all valves in one intake bank are physically attached rather than monitoring the intake air flow, cylinder charge, or individual valve(s)/flap(s) for proper functional response. For non-metal shafts or segmented shafts, the monitor must verify all shaft segments for proper functional response (e.g., by verifying the segment or portion of the shaft furthest from the actuator functions properly). For systems that have more than one shaft to operate valves in multiple intake banks, manufacturers are not required to add more than one set of detection hardware (e.g., sensor, switch) per intake bank to meet this requirement.

6. Exceptions to Monitoring Requirements

a. Background

Under some conditions, the reliability of specific monitors may be diminished significantly. Therefore, we are proposing to allow manufacturers to disable the affected monitors when these conditions are encountered in-use. These include situations of extreme conditions (e.g., very low ambient temperatures, high altitudes) and of periods where default modes of operation are active (e.g., when a tire pressure problem is detected). In some of these cases, we may allow manufacturers to revise the emission malfunction threshold to ensure the most reliable monitoring performance.

b. Requirements for Exceptions to Monitoring

The Administrator may revise the emission threshold for any monitor, or revise the PM filtering performance malfunction criteria for DPFs to exclude detection of specific failure modes such as partially melted substrates, if the most reliable monitoring method developed requires a higher threshold or, in the case of PM filtering performance, the exclusion of specific failure modes, to prevent significant errors of commission in detecting a malfunction. The Administrator would notify the industry of any such revisions to ensure that all manufacturers would be able to implement OBD on an equal basis. In other words, we would not allow one manufacturer to revise a specific monitoring threshold upwards while insisting that another meet the proposed threshold.

Manufacturers may disable an OBD system monitor at ambient engine start temperatures below 20 degrees Fahrenheit (low ambient temperature conditions may be determined based on intake air or engine coolant temperature at engine start) or at elevations higher than 8000 feet above sea level. To do so, the manufacturer would have to submit data and/or engineering analyses that demonstrate that monitoring would be unreliable during the disable conditions. A manufacturer may request that an OBD system monitor be disabled at other ambient engine start temperatures by submitting data and/or engineering analyses demonstrating that misdiagnosis would occur at the given ambient temperatures due to their effect on the component itself (e.g., component freezing).

Manufacturers may disable an OBD system monitor when the fuel level is 15 percent or less of the nominal fuel tank capacity for those monitors that can be affected by low fuel level or running out of fuel (e.g., misfire detection). To do so, the manufacturer would have to submit data and/or engineering analyses that demonstrate that both monitoring at the given fuel levels would be unreliable, and the OBD system is still able to detect a malfunction if the component(s) used to determine fuel level indicates erroneously a fuel level that causes the disablement.

Manufacturers may disable OBD monitors that can be affected by vehicle battery or system voltage levels. For an OBD monitor affected by low vehicle battery or system voltages, manufacturers may disable monitoring when the battery or system voltage is below 11.0 Volts. Manufacturers may use a voltage threshold higher than 11.0 Volts to disable monitors but would have to submit data and/or engineering analyses that demonstrate that monitoring at those voltages would be unreliable and that either operation of a vehicle below the disablement criteria for extended periods of time is unlikely or the OBD system monitors the battery or system voltage and would detect a malfunction at the voltage used to disable other monitors.

For monitoring systems affected by high vehicle battery or system voltages, manufacturers may disable monitoring when the battery or system voltage exceeds a manufacturer-defined voltage. To do so, the manufacturer would have to submit data and/or engineering analyses that demonstrate that monitoring above the manufacturer-defined voltage would be unreliable and that either the electrical charging system/alternator warning light would be illuminated (or voltage gauge would be in the ''red zone'') or the OBD system monitors the battery or system voltage and would detect a malfunction at the voltage used to disable other monitors.

A manufacturer may also disable affected OBD monitors in vehicles designed to accommodate the installation of power take off (PTO) units provided disablement occurs only while the PTO unit is active and the OBD readiness status is cleared by the onboard computer (i.e., all monitors set to indicate ''not complete'') while the PTO unit is activated (see section II.F.4 below). If the disablement occurs, the readiness status may be restored, when the disablement ends, to its state prior to PTO activation.

E. A Standardized Method To Measure Real World Monitoring Performance

As was noted in section II.A.3, manufacturers determine the most appropriate times to run the non-continuous OBD monitors. This way, they are able to make their OBD evaluation either at the operating condition when an emissions control system is active and its operational status can best be evaluated, and/or at the operating condition when the most accurate evaluation can be made (e.g., highly transient conditions or extreme conditions can make evaluation difficult). Importantly, manufacturers are prohibited from using a monitoring strategy that is so restrictive such that it rarely or never runs. To help protect against monitors that rarely run, we are proposing an ''in-use monitor performance ratio'' requirement as described here.

The set of operating conditions that must be met so that an OBD monitor can run are called the ''enable criteria'' for that given monitor. These enable criteria are often different for different monitors and may well be different for different types of engines. A large diesel engine intended for use in a Class 8 truck would be expected to see long periods of relatively steady-state operation while a smaller engine intended for use in an urban delivery truck would be expected to see a lot of transient operation. Manufacturers will need to balance between a rather loose set of enable criteria for their engines and vehicles given the very broad range of operation HD highway engines see and a tight set of enable criteria given the desire for greater monitor accuracy. Manufacturers would be required to design these enable criteria so that the monitor:

- Is robust (i.e., accurate at making pass/fail decisions);
- Runs frequently in the real world; and,
- In general, also runs during the FTP heavy-duty transient cycle.

If designed incorrectly, these enable criteria may be either too broad and result in inaccurate monitors, or overly restrictive thereby preventing the monitor from executing frequently in the real world.

Since the primary purpose of an OBD system is to monitor for and detect emission-related malfunctions while the engine is operating in the real world, a standardized methodology for quantifying real world performance would be beneficial to both EPA and manufacturers. Generally, in determining whether a manufacturer's monitoring conditions are sufficient, a manufacturer would discuss the proposed monitoring conditions with EPA staff. The finalized conditions would be included in the certification applications and submitted to EPA staff who would review the conditions and make determinations on a case-by-case basis based on the engineering judgment of the staff. In cases where we are concerned that the documented conditions may not be met during reasonable in-use driving conditions, we would most likely ask the manufacturer for data or other engineering analyses used by the manufacturer to determine that the conditions would occur in-use. In proposing a standardized methodology for quantifying real world performance, we believe this review process can be done more efficiently than would occur otherwise. Furthermore, it would serve to ensure that all manufacturers are held to the same standard for real world performance. Lastly, we want review procedures that will ensure that monitors operate properly and frequently in the field.

Therefore, we are proposing that all manufacturers be required to use a standardized method for determining real world monitoring performance and to hold manufacturers liable if monitoring occurs less frequently than a minimum acceptable level, expressed as minimum acceptable in-use performance ratio. We are also proposing that manufacturers be required to implement software in the onboard computer to track how often several of the major monitors (e.g., catalyst, EGR, CDPF, other diesel aftertreatment devices) execute during real world driving. The onboard computer would keep track of how many times each of these monitors has executed and how much the engine has been operated. By measuring both of these values, the ratio of monitor operation relative to engine operation can be calculated to determine monitoring frequency.

The proposed minimum acceptable frequency requirement would apply to many but not all of the OBD monitors. We are proposing that monitors be required to operate either continuously, once per drive cycle, or, in a few cases, multiple times per drive cycle (i.e., whenever the proper monitoring conditions are present). For components or systems that are more likely to experience intermittent failures or failures that can routinely happen in distinct portions of an engine's operating range (e.g., only at high engine speed and load, only when the engine is cold or hot), monitors would be required to operate continuously. Examples of continuous monitors include the fuel system monitor and most electrical/circuit continuity monitors. For components or systems that are less likely to experience intermittent failures or failures that only occur in specific vehicle operating regions or for components or systems where accurate monitoring can only be performed under limited operating conditions, monitors would be required to run once per drive cycle. Examples of once per drive cycle monitors typically include gasoline catalyst monitors, evaporative system leak detection monitors, and output comprehensive component functional monitors. For components or systems that are routinely used to perform functions that are crucial to maintaining low emissions but may still require monitoring under fairly limited conditions, monitors would be required to run each and every time the manufacturer-defined enable conditions are present. Examples of multiple times per drive cycle monitors typically include input comprehensive component rationality monitors and some exhaust aftertreatment monitors.

Monitors required to run continuously, by definition, would always be running, thereby making a minimum frequency requirement moot. The new frequency requirement would essentially apply only to those monitors that are designated as once per drive cycle or multiple times per drive cycle monitors. For all of these monitors, manufacturers would be required to define monitoring conditions that ensure adequate frequency in-use. Specifically, the monitors would need to run often enough so that the measured monitor frequency on in-use engines would exceed the minimum acceptable frequency. However, even though the minimum frequency requirement would apply to nearly all once per drive cycle and multiple times per drive cycle monitors, manufacturers would only be required to implement software to track and report the in-use frequency for a few of the major monitors. These few monitors generally represent the major emissions control components and the ones with the most limited enable criteria.

We believe that OBD monitors should run frequently to ensure early detection of emissions-related malfunctions and, consequently, to maintain low emissions. Allowing malfunctions to continue undetected and unrepaired for long periods of time allows emissions to increase unnecessarily. Frequent monitoring can also help to ensure detection of intermittent emissions-related malfunctions (i.e., those that are not continuously present but occur sporadically for days and even weeks at a time). The nature of mechanical and electrical systems is that intermittent malfunctions can and do occur. The less frequent the monitoring, the less likely these malfunctions will be detected and repaired. Additionally, for both intermittent and continuous malfunctions, earlier detection is equivalent to preventative maintenance in that the original malfunction can be detected and repaired prior to it causing subsequent damage to other components. This can help vehicle operators avoid more costly repairs that could have resulted had the first malfunction gone undetected.

Infrequent monitoring can also have an impact on the service and repair industry. Specifically, monitors that have unreasonable or overly restrictive enable conditions could hinder vehicle repair services. In general, upon completing an OBD-related repair to an engine, a technician will attempt to verify that the repair has indeed fixed the problem. Ideally, a technician will operate the vehicle in a manner that will exercise the appropriate OBD monitor and allow the OBD system to confirm that the malfunction is no longer present. This affords a technician the highest level of assurance that the repair was indeed successful. However, OBD monitors that operate infrequently are difficult to exercise and, therefore, technicians may not be able (or may not be likely) to perform such post-repair evaluations. Despite the service information availability requirements we are proposing—requirements that manufacturers make all of their service and repair information available to all technicians, including the information necessary to exercise OBD monitors—technicians would still find it difficult to exercise monitors that require infrequently encountered engine operating conditions (e.g., abnormally steady constant speed operation for an extended period of time). Additionally, to execute OBD monitors in an expeditious manner or to execute monitors that would require unusual or infrequently encountered conditions, technicians may be required to operate the vehicle in an unsafe manner (e.g., at freeway speeds on residential streets or during heavy traffic). If unsuccessful in executing these monitors, technicians may even take shortcuts in attempting to validate the repair while maintaining a reasonable cost for customers. These shortcuts would likely not be as thorough in verifying repairs and could increase the chance that improperly repaired engines would be returned to the vehicle owner or additional repairs would be performed just to ensure the problem is fixed. In the end, monitors that operate less frequently can result in unnecessary costs and inconvenience to both vehicle owners and technicians.

1. Description of Software Counters to Track Real World Performance

As stated above, manufacturers would be required to track monitor peformance by comparing the number of monitoring events (i.e., how often each monitor has run) to the number of driving events (i.e., how often has the vehicle been operated). The ratio of these two numbers would give an indication of how often the monitor is operating relative to vehicle operation. In equation form, this can be stated as:

$$\text{In-Use Performance (Ratio)} = \frac{\text{Number of Monitoring Events (Numerator)}}{\text{Number of Driving Events (Denominator)}}$$

To ensure that all manufacturers are tracking in-use performance in the same manner, we are proposing very detailed requirements for defining and incrementing both the numerator and denominator of this ratio. Manufacturers would be required to keep track of separate numerators and denominators for each of the major monitors, and to ensure that the data are saved every time the engine is shut off. The numerators and denominators would be reset to zero only in extreme circumstances when the non-volatile memory has been cleared (e.g., when the onboard computer has been reprogrammed in the field or when the onboard computer memory has been corrupted). The values would not be reset to zero during normal occurrences such as clearing of stored DTCs or performing routine service or maintenance.

Further, the numerator and denominator would be structured such that their maximum values would be 65,535 which is the maximum number that can be stored in a 2-byte location. This would ensure that manufacturers allocate sufficient and consistent memory space in the onboard computer. If either the numerator or denominator for a particular monitor reaches the maximum value, both values for that particular monitor would be divided by two before counting resumes. In general, the numerator and denominator would only be allowed to increment a maximum of once per drive cycle because most of the major monitors are designed to operate only once per drive cycle. Additionally, incrementing of both the numerator and denominator for a particular monitor would be disabled (i.e., paused but the stored values would not be erased or reset) only when a problem has been detected (i.e., a pending or MIL-on DTC has been stored) that prevents the monitor from executing. Once the problem is no longer detected and any stored DTCs associated with the problem have been erased, either through the allowable self-clearing process or upon command by a technician via a scan tool, incrementing of both the numerator and denominator would resume.

SAE has developed standards for storing and reporting the data to a generic scan tool. This would help ensure that all manufacturers report the data in an identical manner which should ease data collection in the field.

a. Number of Monitoring Events (''Numerator'')

For the numerator, manufacturers would be required to keep a separate numeric count of how often each of the particular monitors has operated. More specifically, manufacturers would have to implement a software counter that increments by one every time the particular monitor meets all of the enable/monitoring conditions for a long enough period of time such that a malfunctioning component would have been detected. For example, if a manufacturer requires a vehicle to be warmed-up and at idle for 20 seconds continuously to detect a malfunctioning catalyst, the catalyst monitor numerator could only be incremented if the vehicle actually operates simultaneously in all of those conditions. If the vehicle is operated in some but not all of the conditions (e.g., at idle but not warmed-up), the numerator would not be allowed to increment because the monitor would not have been able to detect a malfunctioning catalyst since all of the conditions were not satisfied simultaneously.

Another complication is the difference between a monitor reaching a ''pass'' or ''fail'' decision. At first glance, it would appear that a manufacturer should simply increment the numerator anytime the particular monitor reaches a decision, be it ''pass'' or ''fail''. However, monitoring strategies may have a different set of criteria that must be met to reach a ''pass'' decision versus a ''fail'' decision. As a simple example, a manufacturer may appropriately require only 10 seconds of operation at idle to reach a ''pass'' decision but require 30 seconds of operation at idle to reach a ''fail'' decision. Manufacturers would not be allowed to increment the numerator if the vehicle had idled for 10 seconds and reached a ''pass'' decision since insufficient time had passed to allow for a possible ''fail'' decision. This is necessary because the primary function of OBD systems is to detect malfunctions (i.e., to correctly reach ''fail'' decisions, not ''pass'' decisions) and, thus, the real world ability of the monitors to detect malfunctions is the parameter we want most to measure. Therefore, monitors with different criteria to reach a ''pass'' decision versus a ''fail'' decision would not be allowed to increment the numerator solely upon satisfying the ''pass'' criteria.

The correct implementation of the numerator counters by manufacturers is imperative to ensure a reliable measure for determining real world performance. ''Overcounting'' would falsely indicate the monitor is executing more often than it really is, while ''undercounting'' would make it appear as if the monitor is not running as often as it really is. Manufacturers would be required to describe their numerator incrementing strategy in their certification documentation and to verify the proper performance of their strategy during production vehicle evaluation testing.

b. Number of Driving Events (''Denominator'')

We are also proposing that manufacturers separately track how often the engine is operated. Basically, the denominator would be a counter that increments by one each time the engine is operated. We are proposing that the denominator counter be incremented by one only if several criteria are satisfied during a single drive cycle. This allows very short trips or trips during extreme conditions such as very cold temperatures or very high altitude to be filtered out and excluded from the count. This is appropriate because these are also conditions where most OBD monitors are neither expected nor required to operate.

Specifically, the denominator would be incremented if, on a single key start, the following criteria were satisfied while ambient temperature remained above 20 degrees Fahrenheit and altitude remained below 8,000 feet:

- Minimum engine run time of 10 minutes;

• Minimum of 5 minutes, cumulatively, of operation at vehicle speeds greater than 25 miles-per-hour for gasoline engines or calculated load greater than 15 percent for diesel engines; and

• At least one continuous idle for a minimum of 30 seconds encountered.

We intend to work with industry to collect data during the first few years of implementation and make any adjustments, if necessary, to the criteria used to increment the denominator to ensure that the in-use performance ratio provides a meaningful measure of in-use monitoring performance.

2. Proposed Performance Tracking Requirements

a. In-use Monitoring Performance Ratio Definition

For monitors required to meet the in-use performance tracking requirements,[44] we are proposing that the incrementing of numerators and denominators and the calculation of the in-use performance ratio be done in accordance with the following specifications.

The numerator(s) would be defined as a measure of the number of times a vehicle has been operated such that all monitoring conditions necessary for a specific monitor to detect a malfunction have been encountered. Except for systems using alternative statistical MIL illumination protocols, the numerator is to be incremented by an integer of one. The numerator(s) may not be incremented more than once per drive cycle. The numerator(s) for a specific monitor would be incremented within 10 seconds if and only if the following criteria are satisfied on a single drive cycle:

• Every monitoring condition necessary for the monitor of the specific component to detect a malfunction and store a pending DTC has been satisfied, including enable criteria, presence or absence of related DTCs, sufficient length of monitoring time, and diagnostic executive priority assignments (e.g., diagnostic ''A'' must execute prior to diagnostic ''B''). For the purpose of incrementing the numerator, satisfying all the monitoring conditions necessary for a monitor to determine that the component is passing may not, by itself, be sufficient to meet this criteria.

• For monitors that require multiple stages or events in a single drive cycle to detect a malfunction, every monitoring condition necessary for all events to have completed must be satisfied.

• For monitors that require intrusive operation of components to detect a malfunction, a manufacturer would be required to request Administrator approval of the strategy used to determine that, had a malfunction been present, the monitor would have detected the malfunction. Administrator approval of the request would be based on the equivalence of the strategy to actual intrusive operation and the ability of the strategy to determine accurately if every monitoring condition was satisfied as necessary for the intrusive event to occur.

• For the secondary air system monitor, the three criteria above are satisfied during normal operation of the secondary air system. Monitoring during intrusive operation of the secondary air system later in the same drive cycle solely for the purpose of monitoring may not, by itself, be sufficient to meet these criteria.

The third bullet item above requires explanation. There may be monitors, and there have been monitors in light-duty, designed to use what could be termed a two stage or two step process. The first step is usually a passive and/or short evaluation that can be used to ''pass'' a properly working component where ''pass'' refers to evaluating the component and determining that it is not malfunctioning. The second step is usually an intrusive and/or longer evaluation that is necessary to ''fail'' a malfunctioning component or ''pass'' a component nearing the point of failure. An example of such an approach might be an evaporative leak detection monitor that uses an intrusive vacuum pull-down/bleed-up evaluation during highway cruise conditions. If the evaporative system is sealed tight, the monitor ''passes'' and is done with testing for the given drive cycle. If the monitor senses a leak close to the required detection limit, the monitor does not ''pass'' and an internal flag is stored that will trigger the second stage of the test during the next cold start when a more accurate evaluation can be conducted. On the next cold start, provided the internal flag is set, an intrusive vacuum pull-down/bleed up monitor might be conducted during engine idle a very short time after the cold start. This second evaluation stage, being at idle and cold, gives a more accurate indication of the evaporative system's integrity and provides for a more accurate decision regarding the presence and size of a leak.

In this example, the second stage of this monitor would run less frequently in real use than the first stage since it is activated only on those occasions where the first stage suggests that a leak may be present (which most cars will not have). The rate-based tracking requirements are meant to give a measure of how often a monitor could detect a malfunction. To know the right answer, we need to know how often the first stage is running and could ''fail'', thus triggering the second stage, and then how often the second stage is completing. If we track only the first stage, we would get a false indication of how often the monitor could really detect a leak. But, if we track only the second stage, most cars would never increment the counter since most cars do not have leaks and would not trigger stage two.

In considering this, we see two possible solutions: (1) Always activate the second stage evaluation in which case there would be an intrusive monitor being performed that does not really need to be performed; or, (2) implement a ''ghost'' monitor that pretends that the first stage evaluation triggers the second stage evaluation and then also looks for when the second stage evaluation could have completed had it been necessary. The third bullet item in the list above requires that, if a manufacturer intends to implement a two stage monitor and intends to implement such a ''ghost'' monitor as described here for rate based tracking, approval must be sought for doing so to make sure we agree that you are doing it correctly and properly.

For monitors that can generate results in a ''gray zone'' or ''non-detection zone'' (i.e., results that indicate neither a passing system nor a malfunctioning system) or in a ''non-decision zone'' (e.g., monitors that increment and decrement counters until a pass or fail threshold is reached), the manufacturer would be responsible for incrementing the numerator appropriately. In general, the numerator should not be incremented when the monitor indicates a result in the ''non-detection zone'' or prior to the monitor reaching a decision. When necessary, the Administrator would consider data and/or engineering analyses submitted by the manufacturer demonstrating the expected frequency of results in the ''non-detection zone'' and the ability of the monitor to determine accurately, had an actual malfunction been present, whether or not the monitor would have detected a malfunction instead of a result in the ''non-detection zone.''

[44] These monitors, as presented in section II.A.3, are, for diesel engines: the NMHC catalyst, the CDPF system, the NO_X adsorber system, the NO_X converting catalyst system, and the boost system; and, for gasoline engines: the catalyst, the evaporative system, and the secondary air system; and, for all engines, the exhaust gas sensors, the EGR system, and the VVT system.

For monitors that run or complete their evaluation with the engine off, the numerator must be incremented either within 10 seconds of the monitor completing its evaluation in the engine off state, or during the first 10 seconds of engine start on the subsequent drive cycle.

Manufacturers using alternative statistical MIL illumination protocols for any of the monitors that require a numerator would be required to increment the numerator(s) appropriately. The manufacturer may be required to provide supporting data and/or engineering analyses demonstrating both the equivalence of their incrementing approach to the incrementing specified above for monitors using the standard MIL illumination protocol, and the overall equivalence of their incrementing approach in determining that the minimum acceptable in-use performance ratio has been satisfied.

Regarding the denominator(s), defined as a measure of the number of times a vehicle has been operated, we are proposing that it also be incremented by an integer of one. The denominator(s) may not be incremented more than once per drive cycle. The general denominator and the denominators for each monitor would be incremented within 10 seconds if and only if the following criteria are satisfied on a single drive cycle during which ambient temperature remained at or above 20 degrees Fahrenheit and altitude remained below 8,000 feet:

- Cumulative time since the start of the drive cycle is greater than or equal to 600 seconds (10 minutes);
- Cumulative gasoline engine operation at or above 25 miles per hour or diesel engine operation at or above 15 percent calculated load, either of which occurs for greater than or equal to 300 seconds (5 minutes); and
- Continuous engine operation at idle (e.g., accelerator pedal released by driver and vehicle speed less than or equal to one mile per hour) for greater than or equal to 30 seconds.

In addition to the requirements above, the evaporative system monitor denominator(s) must be incremented if and only if:

- Cumulative time since the start of the drive cycle is greater than or equal to 600 seconds (10 minutes) while at an ambient temperature of greater than or equal to 40 degrees Fahrenheit but less than or equal to 95 degrees Fahrenheit; and
- Engine cold start occurs with engine coolant temperature at engine start greater than or equal to 40 degrees Fahrenheit but less than or equal to 95 degrees Fahrenheit and less than or equal to 12 degrees Fahrenheit higher than ambient temperature at engine start.

In addition to the requirements above, the denominator(s) for the following monitors must be incremented if and only if the component or strategy is commanded ''on'' for a time greater than or equal to 10 seconds:

- Gasoline secondary air system;
- Cold start emission reduction strategy;
- Components or systems that operate only at engine start-up (e.g., glow plugs, intake air heaters) and are subject to monitoring under ''other emission control systems'' (section II.D.5) or comprehensive component output components (see section II.D.4).

For purposes of determining this commanded ''on'' time, the OBD system may not include time during intrusive operation of any of the components or strategies later in the same drive cycle solely for the purposes of monitoring.

In addition to the requirements above, the denominator(s) for the monitors of the following output components (except those operated only at engine start-up as outlined above) must be incremented if and only if the component is commanded to function (e.g., commanded ''on'', ''open'', ''closed'', ''locked'') two or more times during the drive cycle or for a time greater than or equal to 10 seconds, whichever occurs first:

- Variable valve timing and/or control system
- ''Other emission control systems''
- Comprehensive component (output component only, e.g., turbocharger waste-gates, variable length manifold runners)

For monitors of the following components, the manufacturer may use alternative or additional criteria to that set forth above for incrementing the denominator. To do so, the manufacturer would need to be able to demonstrate that the criteria would be equivalent to the criteria outlined above at measuring the frequency of monitor operation relative to the amount of engine operation:

- Engine cooling system input components (section II.D.2)
- ''Other emission control systems'' (section II.D.5)
- Comprehensive component input components that require extended monitoring evaluation (section II.D.4, e.g., stuck fuel level sensor rationality)

For monitors of the following components or other emission controls that experience infrequent regeneration events, the manufacturer may use alternative or additional criteria to that set forth above for incrementing the denominator. To do so, the manufacturer would need to demonstrate that the criteria would be equivalent to the criteria outlined above at measuring the frequency of monitor operation relative to the amount of engine operation:

- Oxidation catalysts
- Diesel particulate filters

For hybrid engine systems, engines that employ alternative engine start hardware or strategies (e.g., integrated starter and generators), or alternative fueled engines (e.g., dedicated, bi-fuel, or dual-fuel applications), the manufacturer may request Administrator approval to use alternative criteria to that set forth above for incrementing the denominator. In general, approval would not be given for alternative criteria that only employ engine shut off at or near idle/vehicle stationary conditions. Approval of the alternative criteria would be based on the equivalence of the alternative criteria at determining the amount of engine operation relative to the measure of conventional engine operation in accordance with the criteria above.

The numerators and denominators may need to be disabled at some times. To do this, within 10 seconds of a malfunction being detected (i.e., a pending, MIL-on, or active DTC being stored) that disables a monitor required to meet the performance tracking requirements,[45] the OBD system must disable further incrementing of the corresponding numerator and denominator for each monitor that is disabled. When the malfunction is no longer detected (e.g., the pending DTC is erased through self-clearing or through a scan tool command), incrementing of all corresponding numerators and denominators should resume within 10 seconds. Also, within 10 seconds of the start of a power takeoff unit (PTO) that disables a monitor required to meet the performance tracking requirements, the OBD system should disable further incrementing of the corresponding numerator and denominator for each monitor that is disabled. When the PTO operation ends, incrementing of all corresponding numerators and denominators should resume within 10 seconds. The OBD system must disable further incrementing of all numerators

[45] These monitors, as presented in section II.A.3, are, for diesel engines: the NMHC catalyst, the CDPF system, the NO_X adsorber system, the NO_X converting catalyst system, and the boost system; and, for gasoline engines: the catalyst, the evaporative system, and the secondary air system; and, for all engines, the exhaust gas sensors, the EGR system, and the VVT system.

and denominators within 10 seconds if a malfunction has been detected in any component used to determine if: vehicle speed/calculated load; ambient temperature; elevation; idle operation; engine cold start; or, time of operation has been satisfied, and the corresponding pending DTC has been stored. Incrementing of all numerators and denominators should resume within 10 seconds when the malfunction is no longer present (e.g., pending DTC erased through self-clearing or by a scan tool command).

The in-use performance monitoring ratio itself is defined as the numerator for the given monitor divided by the denominator for that monitor.

b. Standardized Tracking and Reporting of Monitor Performance

We are proposing that the OBD system separately report an in-use monitor performance numerator and denominator for each of the following components:

• For diesel engines: NMHC catalyst bank 1, NMHC catalyst bank 2, NO_X catalyst bank 1, NO_X catalyst bank 2, exhaust gas sensor bank 1, exhaust gas sensor bank 2, EGR/VVT system, DPF system, turbo boost control system, and the NO_X adsorber. The OBD system must also report a general denominator and an ignition cycle counter in the standardized format discussed below and in section II.F.5.

• For gasoline engines: catalyst bank 1, catalyst bank 2, oxygen sensor bank 1, oxygen sensor bank 2, evaporative leak detection system, EGR/VVT system, and secondary air system. The OBD system must also report a general denominator and an ignition cycle counter in the standardized format specified below and in section II.F.5.

The OBD system would be required to report a separate numerator for each of the components listed in the above bullet lists. For specific components or systems that have multiple monitors that are required to be reported under section II.B—e.g., exhaust gas sensor bank 1 may have multiple monitors for sensor response or other sensor characteristics—the OBD system should separately track numerators and denominators for each of the specific monitors and report only the corresponding numerator and denominator for the specific monitor that has the lowest numerical ratio. If two or more specific monitors have identical ratios, the corresponding numerator and denominator for the specific monitor that has the highest denominator should be reported for the specific component. The numerator(s) must be reported in accordance with the specifications in section II.F.5.

The OBD system would also be required to report a separate denominator for each of the components listed in the above bullet lists. The denominator(s) must be reported in accordance with the specifications in section II.F.5.

Similarly, for the in-use performance ratio, determining which corresponding numerator and denominator to report as required for specific components or systems that have multiple monitors that are required to be reported—e.g., exhaust gas sensor bank 1 may have multiple monitors for sensor response or other sensor characteristics'the ratio should be calculated in accordance with the specifications in section II.F.5.

The ignition cycle counter is defined as a counter that indicates the number of ignition cycles a vehicle has experienced. The ignition cycle counter must also be reported in accordance with the specifications in section II.F.5. The ignition cycle counter, when incremented, should be incremented by an integer of one. The ignition cycle counter may not be incremented more than once per ignition cycle. The ignition cycle counter should be incremented within 10 seconds if and only if the engine exceeds an engine speed of 50 to 150 rpm below the normal, warmed-up idle speed (as determined in the drive position for vehicles equipped with an automatic transmission) for at least two seconds plus or minus one second. The OBD system should disable further incrementing of the ignition cycle counter within 10 seconds if a malfunction has been detected in any component used to determine if engine speed or time of operation has been satisfied and the corresponding pending DTC has been stored. The ignition cycle counter may not be disabled from incrementing for any other condition. Incrementing of the ignition cycle counter should resume within 10 seconds after the malfunction is no longer present (e.g., pending DTC erased through self-clearing or by a scan tool command).

F. Standardization Requirements

The heavy-duty OBD regulation would include requirements for manufacturers to standardize certain features of the OBD system. Effective standardization assists all repair technicians in diagnosing and repairing malfunctions by providing equal access to essential repair information, and requires structuring the information in a common format from manufacturer to manufacturer. Additionally, the standardization would help to facilitate the potential use of OBD checks in heavy-duty inspection and maintenance programs.

Among the features that would be standardized under the proposed heavy-duty OBD regulation include:

• The diagnostic connector, the computer communication protocol;

• The hardware and software specifications for tools used by service technicians;

• The information communicated by the onboard computer and the methods for accessing that information;

• The numeric designation of the DTCs stored when a malfunction is detected; and,

• The terminology used by manufacturers in their service manuals.

Our proposal would require that only a certain minimum set of emissions-related information be made available through the standardized format, protocol, and connector. We are not limiting engine manufacturers as to what protocol they use for engine control, communication between onboard computers, or communication to manufacturer-specific scan tools or test equipment. Further, we are not prohibiting engine manufacturers from equipping the vehicle with additional diagnostic connectors or protocols as required by other suppliers or purchasers. For example, fleets that use data logging or other equipment that requires the use of SAE J1587 communication and connectors could still be installed and supported by the engine and vehicle manufacturers. The OBD rules would only require that engine manufacturers also equip their vehicles with a specific connector and communication protocol that meet the standardized requirements to communicate a minimum set of emissions-related diagnostic, service and, potentially, inspection information.

Additionally, our proposal includes a phase-in of one engine family meeting the requirements of OBD in the model years 2010 through 2012. Because non-compliant engines would not require the proposed standardization features, truck and coach builders could be faced with several integration issues when building product in 2010 through 2012. Specifically, they could be faced with designing their vehicles to accommodate a standardized MIL, diagnostic connector, and communication protocol when using a compliant engine yet to not accommodate those features when using a non-compliant engine. This outcome could easily arise since only one engine-family per manufacturer would be compliant and, therefore, a given truck designed to accommodate several engines from several engine manufacturers would very likely need to accommodate a compliant engine from manufacturer A and a non-compliant engine from manufacturer B. It should be noted that engine choices are typically driven by the end user—the truck buyer—and not by the truck or coach builder. For that reason, the truck builder must accommodate all possible engines for the truck size and cannot necessarily demand from the engine manufacturer a compliant versus a non-compliant engine.

As a result, rather than force truck and coach builders to accommodate two different systems and risk incompatibilities, we are proposing to exempt the 2010 through 2012 model year engines from meeting certain standardization requirements of OBD. This should allow truck and coach builders to integrate engines in the same manner as done currently and then to switch over to integrating a single system in 2013 when all engines are required to meet all of the standardization requirements of OBD. The proposed implementation schedule for standardization features is shown in Table II.G–2.

1. Reference Documents

We are proposing that OBD systems comply with the following provisions laid out in the following Society of Automotive Engineers (SAE) and/or International Organization of Standards (ISO) documents that are or would be incorporated by reference (IBR) into federal regulation:

TABLE II.F—1. REFERENCE DOCUMENTS FOR OVER 14,000 POUND OBD

Document No.	Document title	Date	Comment
SAE J1962	"Diagnostic Connector—Equivalent to ISO/DIS 15031–3: December 14, 2001".	April 2002	Updated IBR.
SAE J1930	"Electrical/Electronic Systems Diagnostic Terms, Definitions, Abbreviations, and Acronyms—Equivalent to ISO/TR 15031–2: April 30, 2002".	April 2002	Updated IBR.
SAE J1978	"OBD II Scan Tool—Equivalent to ISO/DIS 15031–4: December 14, 2001"	April 2002	Updated IBR.
SAE J1979	"E/E Diagnostic Test Modes—Equivalent to ISO/DIS 15031–5: April 30, 2002".	April 2002	Updated IBR.
SAE J2012	"Diagnostic Trouble Code Definitions—Equivalent to ISO/DIS 15031–6: April 30, 2002".	April 2002	Updated IBR.
SAE J1939	"Recommended Practice for a Serial Control and Communications Vehicle Network," and the associated subparts included in SAE HS–1939, "Truck and Bus Control and Communications Network Standards Manual".	2005 Edition, March 2005	Updated IBR.
SAE J2403	"Medium/Heavy-Duty E/E Systems Diagnosis Nomenclature"	August 2004	New IBR.
SAE J2534	"Recommended Practice for Pass-Thru Vehicle Reprogramming"	February 2002	New IBR.
ISO 15765–4:2001.	"Road Vehicles—Diagnostics on Controller Area Network (CAN)—Part 4: Requirements for emission-related systems".	December 2001	New IBR.

Copies of these SAE materials may be obtained from Society of Automotive Engineers International, 400 Commonwealth Dr., Warrendale, PA, 15096–0001. Copies of these ISO materials may be obtained from the International Organization for Standardization, Case Postale 56, CH–1211 Geneva 20, Switzerland.

2. Diagnostic Connector Requirements

We are proposing that a standard data link connector conforming to either SAE J1962 or SAE J1939–13 specifications (except as noted below) would have to be included in each vehicle. The connector would have to be located in the driver's side foot-well region of the vehicle interior in the area bound by the driver's side of the vehicle and the driver's side edge of the center console (or the vehicle centerline if the vehicle does not have a center console) and at a location no higher than the bottom of the steering wheel when in the lowest adjustable position. The Administrator would not allow the connector to be located on or in the center console (i.e., neither on the horizontal faces near the floor-mounted gear selector, parking brake lever, or cup-holders, nor on the vertical faces near the car stereo, climate system, or navigation system controls). The location of the connector must be easily identifiable and accessed (e.g., to connect an off-board tool). For vehicles equipped with a driver's side door, the connector would have to be easily identified and accessed by someone standing (or "crouched") on the ground outside the driver's side of the vehicle with the driver's side door open.

If a manufacturer wants to cover the connector, the cover must be removable by hand without the use of any tools and be labeled "OBD" to aid technicians in identifying the location of the connector. Access to the diagnostic connector could not require opening or removing any storage accessory (e.g., ashtray, coinbox). The label would have to clearly identify that the connector is located behind the cover and is consistent with language and/or symbols commonly used in the automobile and/or heavy truck industry.

If the ISO 15765–4 protocol (see section II.F.3) is used for the required OBD standardized functions, the connector would have to meet the "Type A" specifications of SAE J1962. Any pins in the connector that provide electrical power must be properly fused to protect the integrity and usefulness of the connector for diagnostic purposes and may not exceed 20.0 Volts DC regardless of the nominal vehicle system or battery voltage (e.g., 12V, 24V, 42V).

If the SAE J1939 protocol (see section II.F.3)) is used for the required OBD standardized functions, the connector must meet the specifications of SAE J1939–13. Any pins in the connector that provide electrical power must be properly fused to protect the integrity and usefulness of the connector for diagnostic purposes.

Manufacturers would be allowed to equip engines/vehicles with additional diagnostic connectors for manufacturer-specific purposes (i.e., purposes other than the required OBD functions). However, if the additional connector conforms to the "Type A" specifications of SAE J1962 or the specifications of SAE J1939–13 and is located in the vehicle interior near the required connector as described above, the connector(s) must be clearly labeled to identify which connector is used to access the standardized OBD information proposed below.

3. Communications to a Scan Tool

a. Background

In light-duty OBD, manufacturers are allowed to use one of four protocols for communication between a generic scan tool and the vehicle's onboard computer. A generic scan tool automatically cycles through each of the allowable protocols until it hits upon the proper one with which to establish communication with the particular onboard computer. While this has generally worked successfully in the field, some communication problems have arisen.

In an effort to address these problems, CARB has made recent changes to their light-duty OBD II regulation that require all light-duty vehicle manufacturers to use only one communication protocol by the 2008 model year. In making these changes, CARB staff argued that their experience with standardization under the OBD II regulation showed that having a single set of standards used by all vehicles would be desirable. CARB staff argued that a single protocol offers a tremendous benefit to both scan tool designers and service technicians. Scan tool designers could focus on added feature content and could expend much less time and money validating basic functionality of their product on all the various permutations of protocol interpretations that are implemented. In turn, technicians would likely get a scan tool that works properly on all vehicles without the need for repeated software updates that incorporate ''work-arounds'' or other patches to fix bugs or adapt the tool to accommodate slight variances in how the multiple protocols interact with each other or are implemented by various manufacturers. Further, a single protocol should also be beneficial to fleet operators that use add-on equipment such as data loggers, and for vehicle manufacturers that integrate parts from various engine and component suppliers all of which must work together.

Based on our similar experiences at the federal level with communication protocols giving rise to service and inspection/maintenance program issues, we initially wanted to propose a single communication protocol for engines used in over 14,000 pound vehicles. However, the affected industry has been divided over which single protocol should be required and has strongly argued for more than one protocol to be allowed. Therefore, for vehicles with diesel engines, we are proposing that manufacturers be required to use either the standards set forth in SAE J1939, or those set forth in the 500 kbps baud rate version of ISO 15765. For vehicles with gasoline engines, we are proposing that manufacturers be required to use the 500 kbps baud rate version of ISO 15765. Manufacturers would be required to use only one standard to meet all the standardization requirements on a single vehicle; that is, a vehicle must use only one protocol for all OBD modules on the vehicle.

Several in the heavy-duty industry have argued for options that would allow the use of more than these two protocols on heavy-duty engines. Some have even argued for combinations of these protocols—e.g., diagnostic connector and messages of ISO 15765 on an SAE J1939 physical layer network. However, as described above, experience from multiple protocols and multiple variants within the protocols has unnecessarily caused a significant number of problems with engine and vehicle related computer communications.

b. Requirements for Communications to a Scan Tool

We are proposing that all OBD control modules—e.g., engine, auxiliary emission control module—on a single vehicle be required to use the same protocol for communication of required emissions-related messages from onboard to off-board network communications to a scan tool meeting SAE J1978 specifications or designed to communicate with a SAE J1939 network. Engine manufacturers would not be allowed to alter normal operation of the engine emissions control system due to the presence of off-board test equipment accessing the OBD information proposed below. The OBD system would be required to use one of the following standardized protocols:

- ISO 15765–4 and all required emission-related messages using this protocol would have to use a 500 kbps baud rate.
- SAE J1939 which may only be used on vehicles with diesel engines.

4. Required Emissions Related Functions

Most of the proposed emissions related functions are elements that exist in our light-duty OBD requirements. We are proposing several required functions, these are:

- Readiness status
- Distance and number of warm-up cycles since DTC clear
- Permanent DTC storage
- Real time indication of monitor status
- Communicating readiness status to the vehicle operator
- Diagnostic trouble codes (DTC)
- Data stream
- Freeze frame
- Test results
- Software calibration identification
- Software calibration verification number
- Vehicle identification number (VIN)

i. Readiness Status

The main intent of readiness status is to ensure that a vehicle is ready for an OBD-based inspection—by indicating that monitors have run and operational status of the emissions-control system has been fully evaluated—and to prevent fraudulent testing in inspection programs. In general, for OBD-based inspections, technicians ''fail'' a vehicle with an illuminated MIL since this would indicate the presence of an emissions control system malfunction. Without the readiness status indicators, technicians would not have a clear indication from the OBD system that it had sufficiently evaluated the emissions control system prior to the inspection. Since the potential exists for OBD checks to be used as part of a heavy truck inspection program, we believe that having readiness status indicators as part of this proposal is important—waiting for a subsequent OBD–I/M rulemaking to require such indicators would unnecessarily delay implementation of such OBD–I/M programs.

Absent such OBD–I/M programs, we still believe that readiness indicators are an important OBD tool. Technicians would be expected to use the readiness status to verify OBD-related repairs. Specifically, technicians would clear the computer memory after repairing an OBD-detected fault in order to erase the DTC, extinguish the MIL, and reset the readiness status to ''incomplete.'' Then the vehicle could be operated in such a manner that the monitor of the repaired component would run (i.e., the readiness status of the monitor would be set to ''complete''). The absence of any DTCs or MIL illumination upon readiness status indicating ''complete'' would indicate a successful repair.

Therefore, we are proposing that manufacturers be required to indicate the readiness status of the OBD monitors. This would serve to indicate whether or not engine operation has been sufficient to allow certain OBD monitors to perform their system evaluations. The OBD system would be required to report a readiness status of either ''complete'' if the monitor has run a sufficient number of times to detect a malfunction since computer memory was last cleared, ''incomplete'' if the monitor has not yet run a sufficient number of times since the memory was last cleared, or ''not applicable'' if the monitor is not present or if the specific monitored component is not equipped on the vehicle. The readiness status of monitors that are required to run continuously would always indicate ''complete.'' The details of the proposal discussed below clarify that the readiness status would be set to ''incomplete'' whenever memory is cleared either by a battery disconnect or by a scan tool but not after a normal vehicle shutdown (i.e., key-off).

ii. Distance Traveled and Number of Warm-Up Cycles Since DTC Clear

As originally envisioned in our OBD–I/M rulemaking (61 FR 40940), we intended to require that all readiness status indicators be set to ''complete'' prior to accepting a vehicle for I/M inspection. However, it became clear that some vehicles were being rejected from inspection for reasons beyond the driver's control. For example, a vehicle driven in extreme ambient conditions would prohibit monitors from running and setting readiness status indicators to ''complete.'' Also, a vehicle repaired just prior to arriving at the inspection station may not have been operated sufficiently to set the readiness status of the monitor for the recently repaired component to ''complete.'' The driver of such a vehicle would, in essence, be punished unintentionally for having taken the time and expense to repair the vehicle just prior to the inspection. As a result, we issued guidance (cite) to state inspectors recommending that vehicles be accepted for I/M inspection provided two or fewer readiness status indicators are ''incomplete.'' Note that most light-duty gasoline vehicles—the bulk of the vehicle fleet facing OBD–I/M checks—have only four monitors for which the readiness status indicator is meaningful (all of their other monitors being continuous monitors). However, there exists evidence that this policy is perhaps accepting vehicles for I/M inspection that should not be accepted due to unscrupulous clearing of DTCs and readiness status by people that understand how to do so and then operate their vehicles just enough to set the required minimum number of readiness indicators to ''complete.''

As a result, we are proposing some additional features that should better differentiate between vehicles that have been repaired recently or have ''incomplete'' readiness indicators through circumstances outside the driver's control, and those vehicles operated by drivers that are attempting to fraudulently get through an OBD-based inspection. We are proposing that the OBD system make available data that would report the distance traveled or engine run time for those engines that do not use vehicle speed information, and the number of warm-up cycles since the fault memory was last cleared.[46] By combining these data with the readiness data, technicians or inspectors would better be able to determine if ''incomplete'' readiness status indicators or an extinguished MIL are due to unscrupulous memory clearing or circumstances beyond the driver's control. For example, a vehicle with several ''incomplete'' readiness indicators but with a high distance traveled/engine run time and a high number of warm-up cycles since the last clearing of fault memory would be unlikely to have undergone a recent fault memory clearing for the purpose of extinguishing the MIL prior to inspection. On the other hand, a vehicle with only one or two ''incomplete'' readiness indicators and a very low distance traveled/engine run time and a low number of warm-up cycles since fault memory clearing should probably be rejected or failed at an inspection. This would better allow an inspection program to be set up to reject only those vehicles with recently cleared memories while minimizing the chances of rejecting vehicles that driven such that monitors rarely run whether by unique driver behaviors or extreme ambient conditions.

iii. Permanent Diagnostic Trouble Code Storage

Consistent with the proposal for distance traveled/engine run time and number of warm-up cycles, we are proposing a requirement to make it much more difficult for a vehicle owner or technician to clear the fault memory and erase all traces of a previously detected malfunction. Current OBD systems on under 14,000 pound vehicles allow a technician or vehicle owner to erase all DTCs and extinguish the MIL by issuing a command from a generic scan tool or, in many cases, simply by disconnecting the vehicle battery. This would set to ''incomplete'' the readiness status indicators for all monitors and would remove all record of the malfunction that had been detected.

We are proposing that manufacturers be required to store in non-volatile memory random access memory (NVRAM) a minimum of four MIL-on DTCs that are, at present, commanding the MIL-on. These ''permanent'' DTCs would have to be stored in NVRAM at the end of every key cycle. By requiring these permanent DTCs to be stored in NVRAM, one would not be able to erase them simply by disconnecting the battery. Further, manufacturers would not be allowed to design their OBD systems such that these permanent DTCs could be erased by any generic or manufacturer-specific scan tool command. Instead, the permanent DTCs could be erased only via an OBD system self-clearing—i.e., upon evaluating the component or system for which the permanent DTC has been stored and detecting on sufficient drive cycles that the malfunction is no longer present, the OBD system would erase the fault memory as discussed in section II.A.2. Once this has occurred, the permanent DTC stored in NVRAM would be erased also.

The permanent DTCs should help if states choose to implement OBD-based I/M programs for heavy trucks. A truck with readiness status indicators for EGR and boost control set to ''incomplete'' and with permanent DTCs stored for both EGR and boost control would quite probably be a truck that should be rejected from inspection. The OBD system on such a truck has almost certainly had its fault memory cleared—via scan tool command or battery disconnect—which would set the readiness indicators to ''incomplete'' and erase all MIL-on DTCs but would still have permanent DTCs stored (only the OBD system itself can erase permanent DTCs). Likewise, a truck with the same readiness indicators set to ''incomplete'' and no permanent DTCs for those monitors should almost certainly be accepted for inspection since the lack of readiness is almost certainly due to circumstances outside the driver's control.

We believe that the permanent DTCs also provide advantages to technicians attempting to repair a malfunction and prepare it for subsequent inspection or proof of correction. The permanent DTC would identify the specific monitor that would need to be exercised after repair and prior to inspection to be sure that the malfunction has been repaired. By combining this information with the vehicle manufacturer's service information, technicians could identify the exact conditions necessary to exercise the particular monitor. As such, technicians could more effectively verify that the specific monitor (that monitor having illuminated the MIL for which the repair has been done) has run and confirmed that the malfunction no longer exists and the repair has been made correctly. This should also reduce vehicle owner ''come-backs'' for incomplete or ineffective repairs.

[46] The fault memory being any DTCs, readiness status indicators, freeze frame information, etc.

iv. Real Time Indication of Monitor Status

We are also proposing provisions to make it easier for technicians to prepare a vehicle for an inspection following a repair. These provisions would require that the OBD system provide real time data that indicate whether the necessary conditions are present currently to set all of the readiness indicators to ''complete.'' These data would indicate whether a particular monitor may still have an opportunity to run on the current drive cycle or whether a condition has been encountered that has disabled the monitor for the rest of the drive cycle regardless of the driving conditions that might be encountered. While these data would not provide technicians with the exact conditions necessary to exercise the monitors (only service information would provide such information), the date in combination with the service information should assist technicians in verifying repairs and/or preparing a vehicle for inspection. Technicians would be able to use this information to identify when specific monitors have indeed completed or to identify situations where they have overlooked one or more of the enable criteria and need to check the service information and try again.

v. Communicating Readiness Status to the Vehicle Operator

As mentioned above, substantial feedback has been received from OBD-based I/M programs throughout the U.S. Much of this feedback pertains to the effect on vehicle owners caused by being rejected from I/M inspection due to ''incomplete'' readiness status indicators. To address this, some light-duty vehicle manufacturers requested that they be allowed to communicate the vehicle's readiness status to the vehicle owner directly without need of a scan tool. This would provide assurance to the vehicle owner that their vehicle is ready for inspection prior to taking the vehicle to the I/M station. We are proposing that heavy-duty engine manufacturers be allowed to do the same thing (this is a proposed option, not a proposed requirement). If a manufacturer chooses to implement this option, though, they would be required to do so in a standardized manner. On engines equipped with this option, the owner would be able to initiate a self-check of the readiness status, thereby greatly reducing the possibility of being rejected at a roadside inspection.

vi. Diagnostic Trouble Codes (DTC)

Malfunctions are reported by the OBD system and displayed on a scan tool for service technicians in the form of diagnostic trouble codes (DTCs). We are proposing that manufacturers be required to report all emissions-related DTCs using a standardized format and to make them accessible to all service technicians, including the independent service industry. The reference document standards selected by the manufacturer would define many generic DTCs to be used by all manufacturers. In the rare circumstances that a manufacturer cannot find within the reference documents a suitable DTC, a unique ''manufacturer-specific'' DTC could be used. However, such manufacturer-specific DTCs are not as easily interpreted by the independent service industry. Excessive use of manufacturer-specific DTCs may increase the time and cost for vehicle repairs. Thus, we are proposing to restrict the use of manufacturer-specific DTCs. If a generic DTC suitable for a given malfunction cannot be found, the manufacturer would be expected to pursue approval and addition of appropriate generic DTCs into the reference documents; the intent being to standardize as much information as possible.

Additionally, we are proposing that the OBD system store DTCs that are as specific as possible to identify the nature of the malfunction. The intent being to provide service technicians with as detailed information as possible to diagnose and repair vehicles in an efficient manner. In other words, manufacturers should use separate DTCs for every monitor where the monitor and repair procedure, or likely cause of the failure, is different. Generally, a manufacturer would design an OBD monitor that detects different root causes (e.g., sensor shorted to ground or battery) for a malfunctioning component or system. We would expect manufacturers to store a specific DTC such as ''sensor circuit high input'' or ''sensor circuit low input'' rather than a general code such as ''sensor circuit malfunction.'' Further, we expect manufacturers to store different DTCs that distinguish circuit malfunctions from rationality and functional malfunctions since the root cause for each is different and, thus, the repair procedures may be different.

We are also proposing specific provisions for storage of pending and MIL-on DTCs. These proposed provisions were discussed in section II.A.2.

We are also proposing requirements that would help to distinguish between DTCs stored for malfunctions that are currently present and for malfunctions that are no longer present. These requirements would apply only to those engines using ISO 15765–4 as the communication protocol. As described in section II.A.2, the OBD system would generally extinguish the MIL if the malfunction responsible for the MIL illumination has not been detected (i.e., the monitor runs and determines that the malfunction no longer exists) on three subsequent sequential drive cycles. However, a manufacturer would not be allowed to erase the associated MIL-on DTC until 40 engine warm-up cycles have occurred without again detecting the malfunction. So even though the malfunction is no longer present and a MIL-on is not being commanded, the DTC would still remain (termed a ''history'' code in the ISO standard). Consequently, if another unrelated malfunction occurs and results in a MIL-on, a new DTC would be stored along with the history DTC. When trying to diagnose the OBD problem, technicians accessing DTC information may have trouble distinguishing which DTC is responsible for illuminating the MIL (i.e., which malfunction is present currently), and thus could have trouble determining what exactly must be repaired. Therefore, we are proposing this requirement for ISO engines to help distinguish between DTCs stored for malfunctions that are present and those that were present. Note that, for engines using SAE J1939 as the communication protocol, such a distinction is already provided for.

Permanent DTCs would also need to be separately identified from the other types of DTCs. Additionally, as described above, manufacturers would be required to develop additional software routines to store and erase permanent DTCs in NVRAM and to prevent erasure from any battery disconnect or scan tool command.

vii. Data Stream/Freeze Frame/Test Results

An important aspect of OBD is the ability of technicians to access critical information from the onboard computer to diagnose and repair emissions-related malfunctions. We believe that having access through the diagnostic connector to real-time electronic information regarding certain emissions critical components and systems would provide valuable assistance for repairing vehicles properly. The availability of real-time information would also provide assistance to technicians responding to drivability complaints since the vehicle could be operated within the necessary operating conditions and the technician could see how various sensors and systems were acting. Similarly, fuel economy complaints, loss of performance complaints, intermittent problems, and others issues could also be addressed.

We are proposing a number of data parameters that the OBD system would be required to report to a generic scan tool. These parameters, which would include information such as engine speed and exhaust gas sensor readings, would allow technicians to understand how the vehicle engine control system is functioning, either as the vehicle operates in a service bay or during actual driving. They would also help technicians diagnose and repair emission-related malfunctions by allowing them to watch instantaneous changes in the values while operating the vehicle.

Some of the data parameters we are proposing are intended to assist us in performing in-use testing of heavy-duty engines for compliance with emissions standards. One of the parameters that manufacturers would be required to report is the real-time status of the NO_X and PM ''not-to-exceed'' (NTE) control areas. The NTE standards define a wide range of engine operating points where a manufacturer must design the engine to be below a maximum emission level. In theory, whenever the engine is operated within the speed and load region defined as the NTE zone, emissions will be below the required standards. However, within the NTE zone, manufacturers are allowed, if justified on a case-by-case basis, to either modify the time frame in which the standard must be met, and in the second case to be exempted from the emission standards under specific conditions (e.g., an NTE deficiency). Manufacturers can request two types of modifications: first, a five percent limited testing region within which no more than five percent of in-use operation is expected to occur and, thus, no more than five percent of NTE emissions sampling within that region can be compared to the NTE standard for a given sampling event; and second, NTE deficiencies which are precisely defined exemption conditions where compliance cannot be met due to technical reasons or for engine protection. These regions and conditions can be defined by directly measured signals or, in some cases, by complicated modeled values calculated internally in the engine computer. When conducting emissions testing of these engines, knowing if the engine is inside the NTE zone—and subject to the NTE standards—or is outside of the NTE zone or, perhaps, in an NTE limited testing region or covered by an NTE deficiency is imperative. As our in-use testing program requirements are written currently, we must post process data to determine which data points were generated within a compliance zone and which were generated within an exempted zone. Such post processing, while possible, is inefficient, time consuming, and resource intensive. Having the NTE zone data broadcast in real-time over the engine's network would allow for a much more efficient use of our resources.

The specific parameters we are proposing for inclusion in the data stream are, for gasoline engines: calculated load value, engine coolant temperature, engine speed, vehicle speed, time elapsed since engine start, absolute load, fuel level (if used to enable or disable any other monitors), barometric pressure (directly measured or estimated), engine control module system voltage, commanded equivalence ratio, number of stored MIL-on DTCs, catalyst temperature (if directly measured or estimated for purposes of enabling the catalyst monitor(s)), monitor status (i.e., disabled for the rest of this drive cycle, complete this drive cycle, or not complete this drive cycle) since last engine shut-off for each monitor used for readiness status, distance traveled/ engine run time with a commanded MIL-on, distance traveled/engine run time since fault memory last cleared, number of warm-up cycles since fault memory last cleared, OBD requirements to which the engine is certified (e.g., California OBD, EPA OBD, non-OBD) and MIL status (i.e., commanded-on or commanded-off). And, for diesel engines: calculated load (engine torque as a percentage of maximum torque available at the current engine speed),[47] driver's demand engine torque (as a percentage of maximum engine torque), actual engine torque (as a percentage of maximum engine torque), reference engine maximum torque, reference maximum engine torque as a function of engine speed (suspect parameter numbers (SPN) 539 through 543 defined in SAE J1939 within parameter group number (PGN) 65251 for engine configuration), engine coolant temperature, engine oil temperature (if used for emission control or any OBD monitors), engine speed, time elapsed since engine start, fuel level (if used to enable or disable any other diagnostics), vehicle speed (if used for emission control or any OBD monitors), barometric pressure (directly measured or estimated), engine control module system voltage, number of stored MIL-on DTCs, monitor status (i.e., disabled for the rest of this drive cycle, complete this drive cycle, or not complete this drive cycle) since last engine shut-off for each monitor used for readiness status, distance traveled/engine run time with a commanded MIL-on, distance traveled/engine run time since fault memory last cleared, number of warm-up cycles since DTC memory last cleared, OBD requirements to which the engine is certified (e.g., EPA OBD parent rating, EPA OBD child rating, non-OBD), and MIL status (i.e., commanded-on or commanded-off). Also for diesel engines, as discussed above, separate NO_X and PM NTE control area status (i.e., inside control area, outside control area, inside manufacturer-specific NTE carve-out area, or deficiency active area). Also, for all engines so equipped (and only those so equipped): absolute throttle position, relative throttle position, fuel control system status (e.g., open loop, closed loop), fuel trim, fuel pressure, ignition timing advance, fuel injection timing, intake air/manifold temperature, engine intercooler (aftercooler) temperature, manifold absolute pressure, air flow rate from mass air flow sensor, secondary air status (upstream, downstream, or atmosphere), ambient air temperature, commanded purge valve duty cycle/ position, commanded EGR valve duty cycle/position, actual EGR valve duty cycle/position, EGR error between actual and commanded, PTO status (active or not active), redundant absolute throttle position (for electronic throttle or other systems that utilize two or more sensors), absolute pedal position, redundant absolute pedal position, commanded throttle motor position, fuel rate, boost pressure, commanded/target boost pressure, turbo inlet air temperature, fuel rail pressure, commanded fuel rail pressure, DPF inlet pressure, DPF inlet temperature, DPF outlet pressure, DPF outlet temperature, DPF delta pressure, exhaust pressure sensor output, exhaust gas temperature sensor output, injection control pressure, commanded injection control pressure, turbocharger/turbine speed,

[47] Note that, for purposes of the calculated load and torque parameters for diesel engines, manufacturers would be required to report the most accurate values that are calculated within the applicable electronic control unit (e.g., the engine control computer). ''Most accurate values,'' in this context, would be those of sufficient accuracy, resolution, and filtering that they could be used for the purpose of in-use emissions testing with the engine still in a vehicle (e.g., using portable emissions measurement equipment).