FINAL REGULATION ORDER

Amend section 1971.1, title 13, California Code of Regulations, to read as follows:

(Note: The proposed amendments are shown in underline to indicate additions and ~~strikeout~~ to indicate deletions from the existing regulatory text.)

§1971.1. On-Board Diagnostic System Requirements--2010 and Subsequent Model-Year Heavy-Duty Engines

(a) *Purpose*.

The purpose of this regulation is to reduce motor vehicle and motor vehicle engine emissions by establishing emission standards and other requirements for onboard diagnostic systems (OBD systems) that are installed on 2010 and subsequent model-year engines certified for sale in heavy-duty applications in California. The OBD systems, through the use of an onboard computer(s), shall monitor emission systems in-use for the actual life of the engine and shall be capable of detecting malfunctions of the monitored emission systems, illuminating a malfunction indicator light (MIL) to notify the vehicle operator of detected malfunctions, and storing fault codes identifying the detected malfunctions. The use and operation of OBD systems will ensure reductions in in-use motor vehicle and motor vehicle engine emissions through improvements of emission system durability and performance.

(b) *Applicability*.

Except as specified in section (d)(7) and elsewhere in this regulation (title 13, CCR section 1971.1), all 2010 and subsequent model-year heavy-duty engines shall be equipped with an OBD system that has been certified by the Executive Officer as meeting all applicable requirements of this regulation (title 13, CCR section 1971.1).[1]

(c) *Definitions*.

"Active technology" refers to a system, device, or distinct operational mode that reduces carbon dioxide emissions or fuel consumption when activated, and is either controlled by the engine or required to be monitored by the OBD system in accordance with section 1971.1. Some examples of this technology include active technologies that improve the aerodynamic profile of the vehicle (e.g., adjustable grille shutters, retractable gap fairings), intelligent control technologies that, when activated, control a vehicle in such a way as to obtain maximum fuel efficiency (e.g., predictive cruise control, neutral coast), vehicle speed limiter, cylinder deactivation, and driver-selectable hybrid modes (e.g., eco mode, sport mode, mountain mode).

"Actual life" refers to the entire period that an engine is operated on public roads in California up to the time an engine is retired from use.

"Alternate-fueled engine" refers to an engine using a fuel different from or in addition to gasoline fuel or diesel fuel (e.g., compressed natural gas (CNG),

[1] Unless otherwise noted, all section references refer to section 1971.1 of title 13, CCR.

liquefied petroleum gas). For the purposes of this regulation, alternate-fueled engines include dedicated alternate-fueled engines (i.e., engines designed to operate exclusively on the alternate fuel) and engines that can use more than one type of fuel but cannot be reasonably operated in-use exclusively on gasoline or diesel fuel (e.g., engines with diesel pilot injection and CNG main injection where engine operation is limited to idle if CNG fuel is not available or engines which use gasoline-only operation during cold start and CNG-only operation for the rest of the driving cycle and engine operation defaults to a limp-home restricted speed and load if CNG fuel is not available). For engines that can use more than one type of fuel but can be operated in-use exclusively on gasoline or diesel fuel, the engines are considered alternate-fueled engines only for the portion of operation the engine uses a fuel other than exclusively gasoline or diesel (e.g., a gasoline and CNG engine that can operate exclusively on gasoline is considered an alternate-fueled engine only while operating on CNG and is not subject to the provisions or relief of this regulation for alternate-fueled engines while operating exclusively on gasoline). For alternate-fueled engines, the manufacturer shall meet the requirements of section (d)(7.5).

"Alternate phase-in", as allowed in section (g)(5.8), is a phase-in schedule that achieves equivalent compliance volume by the end of the last year of a scheduled phase-in provided in this regulation. The compliance volume is the number calculated by multiplying the percent of engines (based on the manufacturer's projected sales volume of all engines unless specifically stated otherwise in section (e), (f), or (g)) meeting the new requirements per year by the number of years implemented prior to and including the last year of the scheduled phase-in and then summing these yearly results to determine a cumulative total (e.g., a three year, 20/50/100 percent scheduled phase-in would be calculated as (20*3 years) + (50*2 years) + (100*1 year) = 260; a two-year 20/50 percent scheduled phase-in would be calculated as (20*2 years) + (50*1 year) = 90). Manufacturers are allowed to include engines introduced before the first year of the scheduled phase-in (e.g., in the previous example, 10 percent introduced one year before the scheduled phase-in begins would be calculated as (10*4 years) and added to the cumulative total). However, manufacturers are only allowed to include engines introduced up to one model year before the first year of the scheduled phase-in. The Executive Officer shall consider acceptable any alternate phase-in that results in an equal or larger cumulative total by the end of the last year of the scheduled phase-in and ensures that all engines subject to the phase-in will comply with the respective requirements no later than two model years following the last year of the scheduled phase-in.

For alternate phase-in schedules resulting in all engines complying one model year following the last year of the scheduled phase-in, the compliance volume shall be calculated as described directly above. For example, a 20/50/100 percent scheduled phase-in during the 2016-2018 model years would have a cumulative total of 260. If the manufacturer's planned alternate phase-in schedule is 40/50/80/100 percent during the 2016-2019 model years, the final compliance volume calculation would be (40*3 years) + (50*2 years) + (80*1 year) = 300, which is greater than 260 and therefore would be acceptable as an alternate phase-in schedule.

For alternate phase-in schedules resulting in all engines complying two model years following the last year of the scheduled phase-in, the compliance volume calculation shall be calculated as described directly above and shall also include a negative calculation for engines not complying until one or two model years following the last year of the scheduled phase-in. The negative calculation shall be calculated by multiplying the percent of engines not meeting the new requirements in the final year of the phase-in by negative one and the percent of engines not meeting the new requirements in the one year after the final year of the phase-in by negative two. For example, if 10 percent of a manufacturer's engines did not comply by the final year of the scheduled phase-in and 5 percent did not comply by the end of the first year after the final year of the scheduled phase-in, the negative calculation result would be (10*(-1 years)) + (5*(-2 years)) = -20. The final compliance volume calculation is the sum of the original compliance volume calculation and the negative calculation. For example, a 20/50/100 percent scheduled phase-in during the 2016-2018 model years would have a cumulative total of 260. If a manufacturer's planned alternate phase-in schedule is 40/70/80/90/100 percent during the 2016-2020 model years, the final compliance volume calculation would be (40*3 years) + (70*2 years) + (80*1 year) + (20*(-1 year)) + (10*(-2 years)) = 300, which is greater than 260 and therefore would be acceptable as an alternate phase-in schedule.

"Applicable standards" refers to the specific exhaust emission standards or family emission limits (FEL), including the Federal Test Procedure (FTP) and Supplemental Emission Test (SET) standards, to which the engine is certified.

"Automatic engine shutdown technology" refers to a technology that shuts down the engine within a threshold inactivity period (e.g., 300 seconds or less for tractors) when the transmission is set to park, or the transmission is in neutral and the parking brake is engaged.

"Auxiliary Emission Control Device (AECD)" refers to any approved AECD (as defined by 40 Code of Federal Regulations (CFR) 86.082-2 and 86.094-2 as they existed on January 25, 2018, and incorporated by reference herein).

"Emission Increasing Auxiliary Emission Control Device (EI-AECD)" refers to any approved AECD that~~:~~ reduces the effectiveness of the emission control system under conditions which may reasonably be expected to be encountered in normal vehicle operation and use~~;~~, and meets (1) or (2): (1) the need for the AECD is justified in terms of protecting the vehicle against damage or accident, or (2) for 2024 and subsequent model year engines, is related to adaptation or learning (e.g., selective catalytic reduction (SCR) system adaptation). An AECD that is certified as an NTE deficiency shall not be considered an EI-AECD. An AECD that does not sense, measure, or calculate any parameter or command or trigger any action, algorithm, or alternate strategy shall not be considered an EI-AECD. An AECD that is activated solely due to any of the following conditions shall not be considered an EI-AECD: (1) operation of the vehicle above 8000 feet in elevation; (2) ambient temperature; (3) when the engine is warming up and is not reactivated once the engine has warmed up in the same driving cycle; (4) failure detection (storage of a fault code) by the OBD system; (5) execution of an OBD monitor; or (6) execution of an infrequent regeneration event.

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

"Calculated load value" refers to the percent of engine capacity being used and is defined in ~~Society of Automotive Engineers (~~SAE~~)~~ International (SAE) J1979 "E/E Diagnostic Test Modes," ~~February 2012~~ (SAE J1979), incorporated by reference (section (h)(1.4)). For diesel applications, the calculated load value is determined by the ratio of current engine output torque to maximum engine output torque at current engine speed as defined by suspect parameter ~~definition 5.2.1.7~~number (SPN) 92 of SAE J1939-71 "Vehicle Application Layer ~~(Through May 2010)~~," ~~March 2011~~ incorporated by reference (section (h)(1.7.8)).

"Charge depleting operation" means the state of vehicle operation when the current battery state of charge (SOC) is higher than the charge sustaining target SOC value and, while it may fluctuate, the intent of the vehicle control system is to deplete the SOC from a higher level down to the charge sustaining target SOC value. For the purposes of tracking grid energy consumed in charge depleting operation in section (h)(5), charge depleting operation shall also include when the vehicle is connected to the grid for charging. For the purposes of defining the transition of the control system from charge depleting operation to charge sustaining operating once the charge sustaining target SOC value has been met, the first occurrence of fueled engine operation once the SOC is less than or equal to the charge sustaining target SOC value shall be used as the transition point.

"Charge sustaining operation" means the state of vehicle operation when the battery SOC may fluctuate but the intent of the vehicle control system is to maintain, on average, the current SOC. Examples of this state include when a plug-in hybrid electric vehicle is operating as a conventional hybrid vehicle (i.e., if the vehicle has depleted all of the grid energy from the battery and is controlling to the charge sustaining target SOC value) as well as operation in any driver-selectable modes designed to maintain the current SOC (e.g., a 'hold' button intended to save electric drive operation for later in the driving cycle, a 'charge now' button after it has reached its target SOC and the intent of the control system is to maintain, on average, that target SOC).

"Charge sustaining target SOC value" means the nominal target SOC that the control system is designed to maintain, on average, when operating as a conventional hybrid vehicle after depletion of any grid energy in the battery.

"Chassis odometer" refers to lifetime vehicle distance.

"Confirmed fault code," for purposes of engines using International Standards Organization (ISO) 15765-4, is defined as the diagnostic trouble code stored when an OBD system has confirmed that a malfunction exists (e.g., typically on the second driving cycle that the malfunction is detected) in accordance with the requirements of sections (d)(2), ~~(f),~~(e) through (g), and (h)(4.4).

"Continuously," if used in the context of monitoring conditions for circuit continuity, lack of circuit continuity, circuit faults, and out-of-range values, means monitoring is always enabled, unless alternate enable conditions have been approved by the Executive Officer in accordance with section (d)(3.1.1), and sampling of the signal used for monitoring occurs at a rate no less than two samples per second. If a computer input component is sampled less frequently for control purposes, the signal of the component may instead be evaluated each time sampling occurs.

"Deactivate" means to turn-off, shutdown, desensitize, or otherwise make inoperable through software programming or other means during the actual life of the engine.

"Diagnostic or emission critical" electronic control unit refers to the engine control unit and any other on-board electronic powertrain control unit that:

(1) has primary control over any of the monitors required by sections (e)(1) through (f)(9), (g)(1) through (g)(2), and (g)(4), but does not include circuit or out-of-range fault monitors required by sections (e)(9.2.1)(A)(ii), (e)(9.2.1)(B)(ii), (e)(9.2.2)(B), (e)(9.2.4)(B), (f)(8.2.1)(B), (f)(8.2.2)(B), (f)(8.2.2)(D), ~~(f)(8.2.3)(A),~~ (f)(8.2.3)(B), and (g)(~~1.1.2~~1.2.2)(A); or

(2) except for anti-lock brake system (ABS) control units or stability/traction control units,:

(a) has primary control over any rationality fault diagnostic or functional check for more than four input components or more than two output components required to be monitored by section (g)(3); or

(b) for 2016 and subsequent model year engines, is field reprogrammable and has primary control over any rationality fault diagnostic or function check for any input or output component required to be monitored by section (g)(3).

For purposes of criteria (1) and (2) above, "primary control" over a monitor means the control unit does any of the following: (a) determines if any enable conditions are satisfied; (b) calculates all or part of the diagnostic decision statistic or metric by which pass or fail decisions are made (e.g., the comparison of a component's measured or calculated level of performance to a fault threshold); or (c) makes or processes pass or fail decisions (e.g., debounces diagnostic decision statistics or commands MIL illumination or fault code storage). Further, for purposes of criterion (2)(a) above, all glow plugs in an engine shall be considered "one" output component in lieu of each glow plug being considered a separate component. ~~Additionally, for purposes of criterion (2)(b) above, "field reprogrammable" means a control unit that is capable of supporting a manufacturer service procedure intended to be executed in a dealership or other vehicle service environment that results in the downloading of new software and/or calibration data into the control unit.~~For purposes of criteria (2)(a) and (2)(b) above, "input component" and "output component" includes hybrid components required to be monitored in accordance with the requirements under sections (g)(3.2.1) and (g)(3.2.2).

"Diesel engine" refers to an engine using a compression ignition thermodynamic cycle.

"Driver-selectable charge increasing operation" means the state of vehicle operation where both: (a) the driver has selected a mode of operation different than the default or normal mode of the vehicle that is intended to increase the battery SOC (e.g., 'charge now' button); and (b) that the current intent of the vehicle control system is to increase the battery SOC from its current level to a higher SOC target value (i.e., the current SOC is lower than the target SOC). This state does not include operation in a driver-selectable mode where the control system has reached the target SOC and is now operating with the intent to maintain, on average, the target SOC. For the purposes of defining the transition of the control system from an intent to increase the SOC to an intent to maintain the SOC once the target has been reached, either the first time the SOC is greater than or equal to the target SOC or the first occurrence of engine off once the SOC is greater than or equal to the target SOC shall be used as the transition point. For continued operation in the driver-selectable mode once the system has transitioned to an intent to maintain the SOC, the operation shall be considered charge sustaining operation unless the actual SOC falls below the target SOC by more than five percent at which time the system will be considered as transitioned back to an intent to increase the SOC (driver-selectable charge increasing operation).

"Driving cycle" is defined as a trip that meets any of the four conditions below:

(1) Begins with engine start and ends with engine shutoff;

(2) Begins with engine start and ends after four hours of continuous engine-on operation;

(3) Begins at the end of the previous four hours of continuous engine-on operation and ends after four hours of continuous engine-on operation; or

(4) Begins at the end of the previous four hours of continuous engine-on operation and ends with engine shutoff.

For monitors that run during engine-off conditions, the period of engine-off time following engine shutoff and up to the next engine start may be considered part of the driving cycle for conditions (1) and (4). For vehicles that employ engine shutoff strategies that do not require the vehicle operator to restart the engine to continue driving (e.g., hybrid bus with engine shutoff at idle), the manufacturer may request Executive Officer approval to use an alternate definition for driving cycle (e.g., key on and key off). Executive Officer approval of the alternate definition shall be based on equivalence to engine startup and engine shutoff signaling the beginning and ending of a single driving event for a conventional vehicle. Engine restarts following an engine shut-off that has been neither commanded by the vehicle operator nor by the engine control strategy but caused by an event such as an engine stall may be considered a new driving cycle or a continuation of the existing driving cycle. For engines that are not likely to be routinely operated for long continuous periods of time, a manufacturer may also request Executive Officer approval to use an alternate definition for driving cycle (e.g., solely based on engine start and engine shutoff without regard to four hours of continuous engine-on time). Executive Officer approval of the alternate definition shall be based on manufacturer-submitted data and/or information demonstrating the typical usage, operating habits, and/or driving patterns of these vehicles.

"Engine family" means a grouping of vehicles or engines in a manufacturer's product line determined in accordance with 40 CFR ~~86.098-24~~86.096-24 as it existed on January 25, 2018, and incorporated by reference herein.

"Engine odometer" refers to lifetime vehicle distance with the current engine installed.

"Engine rating" means a unique combination of displacement, rated power, calibration (fuel, emission, and engine control), AECDs, and other engine and emission control components within an engine family.

"OBD parent rating" means the specific engine rating selected according to section (d)(7.1.1) or (d)(7.2.2)(B) for compliance with section 1971.1.

"OBD child rating" means an engine rating (other than the OBD parent rating) within the engine family containing the OBD parent rating selected according to section (d)(7.1.1) or an engine rating within the OBD group(s) defined according to section (d)(7.2.1) and subject to section (d)(7.2.3).

~~“Engine misfire” means lack of combustion in the cylinder due to absence of spark, poor fuel metering, poor compression, or any other cause. This does not include lack of combustion events in non-active cylinders due to default fuel shut-off or cylinder deactivation strategies.~~

“Engine start” is defined as the point when the engine reaches a speed 150 rpm below the normal, warmed-up idle speed (as determined in the drive position for vehicles equipped with an automatic transmission). For hybrid vehicles or for engines employing alternate engine start hardware or strategies (e.g., integrated starter and generators), the manufacturer may request Executive Officer approval to use an alternate definition for engine start (e.g., ignition key “on”). Executive Officer approval of the alternate definition shall be based on equivalence to an engine start for a conventional vehicle.

“Family Emission Limit (FEL)” refers to the exhaust emission levels to which an engine family is certified under the averaging, banking, and trading program incorporated by reference in title 13, CCR section 1956.8.

“Fault memory” means information pertaining to malfunctions stored in the onboard computer, including fault codes, stored engine conditions, and MIL status.

“Federal Test Procedure (FTP) test” refers to an exhaust emission test conducted according to the test procedures incorporated by reference in title 13, CCR section 1956.8(b) and (d) that is used to determine compliance with the FTP standard to which an engine is certified.

“FTP cycle”. For engines certified on an engine dynamometer, FTP cycle refers to the engine dynamometer schedule in 40 CFR appendix 1 of part 86, section (f)(1), entitled, “EPA Engine Dynamometer Schedule for Heavy-Duty Otto-Cycle Engines,” or section (f)(2), entitled, “EPA Engine Dynamometer Schedule for Heavy-Duty Diesel Engines~~.~~,” as those sections existed on January 25, 2018, and incorporated by reference herein.

“FTP standard” refers to the certification exhaust emission standards and test procedures applicable to the FTP cycle incorporated by reference in title 13, CCR sections 1956.8(b) and (d) to which the engine is certified.

“Field fix” refers to an emission control system or OBD system-related calibration or hardware change to an engine (family, rating, or model) which occurs after certification (i.e., the Executive Order has been issued) and after production of the engine.

“Field reprogrammable” means a control unit that is capable of supporting a manufacturer service procedure intended to be executed in a dealership or other vehicle service environment that results in the downloading of new software and/or calibration data into the control unit.

“Fuel trim” refers to feedback adjustments to the base fuel schedule. Short-term fuel trim refers to dynamic or instantaneous adjustments. Long-term fuel trim refers to much more gradual adjustments to the fuel calibration schedule than short-term trim adjustments.

“Fueled engine operation” is the state where any fuel is introduced into the engine for the purposes of combustion.

“Functional check” for an output component or system means verification of proper response of the component and system to a computer command.

“Gasoline engine” refers to an ~~Otto-cycle~~ engine using a spark ignition thermodynamic cycle.

"Grid energy", for the purposes of tracking grid energy parameters in section (h)(5), means all energy into the battery while connected to grid power (e.g., plugged-in) and with the engine off. Grid energy shall not include electrical losses between the grid and the battery (e.g., from on-board charger inefficiency) or energy directly used by the vehicle without first going into the battery (e.g., electricity utilized directly from before or after the on-board charger to power on-vehicle devices for cabin conditioning, charging control). For the purposes of tracking grid energy consumed in charge depleting operation in section (h)(5), energy consumed (i.e., out of the battery) shall be considered non-grid energy until all non-grid energy is depleted. Additionally, on any trip where the vehicle transitions from charge depleting operation to charge sustaining operation once the charge sustaining target SOC value has been met, the values currently assumed for grid and non-grid energy remaining in the battery shall be reset to zero to minimize the accumulation of errors over time.

"Heavy-duty engine" means an engine that is used to propel a heavy-duty vehicle.

"Heavy heavy-duty engine" is defined in title 13, CCR section 1956.8(i).

"Heavy-duty vehicle" means any motor vehicle having a manufacturer's gross vehicle weight rating (GVWR) greater than 14,000 pounds.

"Hybrid vehicle" refers to a vehicle (including a plug-in hybrid electric vehicle) that has both of the following on-vehicle sources of stored energy and can draw propulsion energy from the source mentioned in 2): 1) a consumable fuel and 2) an energy storage device such as a battery, capacitor, pressure reservoir, ~~or~~ flywheel, or hydraulic energy storage.

"Ignition ~~C~~cycle," except as noted below for hybrid vehicles, means a ~~driving cycle~~trip that begins with engine start, meets the engine start definition for at least two seconds plus or minus one second, and ends with engine shutoff. For hybrid vehicles and non-hybrid vehicles with engine start-stop systems (e.g., engine shutoff at idle), "ignition cycle" means a ~~driving cycle~~trip that begins when the propulsion system active definition is met for at least two seconds plus or minus one second, and ends when the propulsion system active definition is no longer met. For plug-in hybrid electric vehicles, for purposes of the second ignition cycle counter under section (d)(5.5.2)(C), "ignition cycle" means a trip that begins when the fueled engine operation definition is met for at least two seconds plus or minus one second and ends when the propulsion system active definition is no longer met.

"Intrusive diagnostic" refers to an AECD that is activated for the purposes of determining whether or not a component or system is failing or for purposes of pinpointing the fault by the OBD system.

"Keep-alive memory (KAM)," for the purposes of this regulation, is defined as a type of memory that retains its contents as long as power is provided to the on-board control unit. KAM is not erased upon shutting off the engine but may be erased if power to the on-board control unit is interrupted (e.g., vehicle battery disconnected, fuse to control unit removed). In some cases, portions of KAM may be erased with a scan tool command to reset KAM.

"Key on, engine off position" refers to a vehicle with the ignition key in the engine run position (not engine crank or accessory position) but not in the state of propulsion system active and not with the engine ~~not~~ running.

"Light heavy-duty engine" is defined in title 13, CCR section 1956.8(i).

"Malfunction" means any deterioration or failure of a component or system that causes the performance to be outside of the applicable limits in sections (e) through (g).

"Manufacturer" for the purpose of this regulation means the holder of the Executive Order for the engine family.

"Medium heavy-duty engine" is defined in title 13, CCR section 1956.8(i).

"MIL-on fault code," for purposes of engines using SAE J1939, refers to the diagnostic trouble code stored when an OBD system has confirmed that a malfunction exists (e.g., typically on the second driving cycle that the malfunction is detected) and has commanded the MIL on in accordance with the requirements of sections (d)(2), (e)~~,~~ through (g), and (h)(4.4).

"Misfire" means lack of combustion in the cylinder due to absence of spark, poor fuel metering, poor compression, or any other cause. This does not include lack of combustion events in non-active cylinders due to default fuel shut-off or cylinder deactivation strategies.

"Non-grid energy", for the purposes of tracking grid energy parameters in section (h)(5), means all energy into the battery during charge depleting operation and during driver-selectable charge increasing operation from any source other than grid power (i.e., while not connected to a source of power for charging). Examples of non-grid energy include energy recovered during braking and energy supplied to the battery during engine operation. If an engine running condition exists while connected to a source of grid power for charging, all energy going into the battery during the engine running event shall be considered non-grid energy. Non-grid energy may not include any energy into the battery during charge sustaining operation.

"Non-volatile random access memory (NVRAM)," for the purposes of this regulation, is defined as a type of memory that retains its contents even when power to the on-board control unit is interrupted (e.g., vehicle battery disconnected, fuse to control unit removed). NVRAM is typically made non-volatile either by use of a back-up battery within the control unit or through the use of an electrically erasable and programmable read-only memory (EEPROM) chip.

"Not-To-Exceed (NTE) control area" refers to the bounded region of the engine's torque and speed map, as defined in 40 CFR 86.1370~~-2007~~ as it existed on January 25, 2018, and incorporated by reference herein, where emissions must not exceed a specific emission cap for a given pollutant under the NTE requirement.

"Manufacturer-specific NOx NTE carve-out area" refers to regions within the NTE control area for NOx where the manufacturer has limited NTE testing as allowed by 40 CFR 86.1370~~-2007~~(b)(7) as it existed on January 25, 2018, and incorporated by reference herein.

"Manufacturer-specific PM NTE carve-out area" refers to regions within the NTE control area for PM where the manufacturer has limited NTE testing as allowed by 40 CFR 86.1370~~-2007~~(b)(7) as it existed on January 25, 2018, and incorporated by reference herein.

"NTE deficiency" refers to regions or conditions within the NTE control area for NOx or PM where the manufacturer has received a deficiency as allowed by 40 CFR 86.007-11(a)(4)(iv) as it existed on January 25, 2018, and incorporated by reference herein.

"OBD group" refers to a combination of engines, engine families, or engine ratings that use the same OBD strategies and similar calibrations. A manufacturer is required to submit a grouping plan for Executive Officer review and approval detailing the OBD groups and the engine families and engine ratings within each group for a model year.

"Over-the-air reprogramming" refers to the remote reprogramming of a vehicle or engine electronic control unit using wireless technologies. No physical connection between any reprogramming equipment and the vehicle is made when using over-the-air reprogramming.

"Pending fault code" is defined as the diagnostic trouble code stored upon the initial detection of a malfunction (e.g., typically on a single driving cycle) prior to illumination of the MIL in accordance with the requirements of sections (d)(2), (e) through (g), and (h)(4.4).

"Permanent fault code" is defined as a confirmed or MIL-on fault code that is stored in NVRAM as specified in sections (d)(2) and (h)(4.4).

"Percentage of misfire" as used in sections (e)(2) and (f)(2) means the percentage of misfires out of the total number of ~~firing~~ intended combustion events for the specified interval.

"Plug-in hybrid electric vehicle" means a hybrid vehicle that has the capability to charge a battery from an off-vehicle electric source, such that the off-vehicle source cannot be connected to the vehicle while the vehicle is in motion.

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

"Previously MIL-on fault code," for purposes of engines using SAE J1939, is defined as the diagnostic trouble code stored when an OBD system has confirmed that a malfunction no longer exists (e.g., after the third consecutive driving cycle in which the corresponding monitor runs and the malfunction is not detected), extinguishes the MIL, and erases the corresponding MIL-on fault code in accordance with the requirements of sections (d)(2), (e)~~,~~ through (g), and (h)(4.4).

"Propulsion system active" is the state where the powertrain (e.g., engine, electric machine) is enabled by the driver (e.g., after ignition on for conventional vehicles, after power button pushed for some hybrid vehicles) such that the vehicle is ready to be used (e.g., vehicle is ready to be driven, ready to be shifted from "park" to "drive"). For purposes of this definition, "the state where the powertrain is enabled" does not include activations that are not driver-initiated (e.g., conditions where portions of the vehicle system wake up to perform OBD monitoring). This state also does not include remote start activations that cannot cause the engine to start (e.g., in a remote activation to condition the cabin, the engine will not start until there is further action by the driver to enable the vehicle for operation regardless of cabin conditioning demand or length of cabin conditioning operation).

"Rationality fault diagnostic" for an input component means verification of the accuracy of the input signal while in the range of normal operation and when compared to all other available information.

"Redline engine speed" shall be 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.

"Response rate" for exhaust gas sensors refers to the delay from when the sensor is exposed to a different make-up of exhaust gas constituents until it outputs a signal reflecting the different make-up of exhaust gas constituents. For example, for oxygen sensors, response rate is the delay from when the oxygen sensor is exposed to a change in exhaust gas from richer/leaner than stoichiometric to leaner/richer than stoichiometric to the time when the oxygen sensor indicates the lean/rich condition. This includes delays in the sensor to initially react to a change in exhaust gas composition (i.e., delayed response) as well as slower transitions from a rich-to-lean (or lean-to-rich) sensor output (i.e., slow response). Similarly, for wide-range air-fuel (A/F) sensors, response rate is the delay from when the sensor is exposed to a different A/F ratio to the time it indicates the different A/F ratio. For NOx and PM sensors, response rate is the delay from when the sensor is exposed to a different NOx or PM exhaust gas level until it indicates the different NOx or PM exhaust gas level.

"Running change" refers to an emission or OBD system-related calibration, software, or hardware change to an engine (family, rating, or model) or an addition of an engine (rating or model) which occurs after certification (i.e., the Executive Order has been issued) but during engine production.

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

"Similar conditions" as used in sections (e)(1), (e)(2), (e)(3), (e)(4), (f)(1), and (f)(2) 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 the engine conditions stored pursuant to (e)(1.4.2)(E), (e)(2.4.2)(C), (e)(3.4.2)(D), (e)(4.4.2)(D), (f)(1.4.5), and (f)(2.4.4). The Executive Officer may approve other definitions of similar conditions based on comparable timeliness and reliability in detecting similar engine operation.

"Small volume manufacturer" is defined in title 13, CCR section 1900(b), with the exception that California sales of less than 1200 heavy-duty engines will be used in lieu of 4500 heavy-duty engines.

"Smart device" refers to an electronic powertrain component or system that uses a microprocessor or microcontroller and does not meet the criteria to be classified as a "diagnostic or emission critical electronic powertrain control unit." Devices that provide high level control of transmissions or battery packs are excluded from this definition. Any component or system externally connected to the smart device shall not be considered part of the smart device unless:

(1) It is a subcomponent integral to the function of the smart device;

(2) It is permanently attached to the smart device with wires or one-time connectors; and

(3) The smart device and subcomponent are designed, manufactured, installed, and serviced (per manufacturer published procedures) as a single component.

"Start of production" is the time when the manufacturer has produced two percent of the projected volume for the engine or vehicle, whichever is specified in sections (k) and (l).

"Start-stop technology" refers to a technology that shuts down a vehicle's engine within a threshold inactivity period (e.g., 5 seconds) after the vehicle's brake pedal is depressed when the vehicle speed is zero.

"Supplemental Emission Test (SET) cycle" refers to the driving schedule defined as the "supplemental ~~steady state~~ emission test" in 40 CFR 86.1360~~-2007~~ as it existed on January 25, 2018, and incorporated by reference herein.

"SET standard" refers to the certification exhaust emission standards and test procedures applicable to the SET cycle incorporated by reference in title 13, CCR sections 1956.8(b) and (d) to which the engine is certified

"Warm-up cycle" means an ~~driving~~ ignition cycle with sufficient vehicle operation such that the coolant temperature has risen by at least 40 degrees Fahrenheit or 22.2 degrees Celsius from engine start and reaches a minimum temperature of at least 160 degrees Fahrenheit or 71.1 degrees Celsius (140 degrees Fahrenheit or 60 degrees Celsius for applications with diesel engines). Alternatively, manufacturers may define warm-up cycle as an ~~driving~~ ignition cycle with vehicle operation in which the following criteria are met: for vehicles using the ISO 15765-4 protocol, the manufacturers may use the criteria specified in sections (d)(2.3.1)(C)(ii)b.3.i. (or v. if applicable), ii., and iii. herein, and for vehicles using the SAE J1939 protocol, the manufacturer may use the criteria specified in sections (d)(2.3.2)(D)(ii)b.3.i. (or v. is applicable), ii., and iii. herein.

"Waste heat recovery (WHR) technology" refers to a technology that captures heat that would otherwise be lost through the exhaust system or through the engine cooling system and converts that heat to electrical or mechanical energy to meet the requirements of the vehicle. Examples include Rankine WHR and turbo-compounding with clutch.

"Weighted sales number" means a manufacturer's projected sales number for engines to be used in California heavy-duty vehicles multiplied by a weight class factor. Sales numbers for diesel engines for heavy-duty vehicles less than 19,499 pounds GVWR shall be multiplied by 1.0. Sales numbers for diesel engines for heavy-duty vehicles from 19,500 to 33,000 pounds shall be multiplied by 1.68. Sales numbers for diesel engines for heavy-duty vehicles greater than 33,000 pounds and urban buses shall be multiplied by 3.95. Sales numbers for all gasoline engines for heavy-duty vehicles shall be multiplied by 1.0.

(d) *General Requirements.*

Section (d) sets forth the general requirements of the OBD system. Specific performance requirements for components and systems that shall be monitored are set forth in sections (e) through (g) below. The OBD system is required to detect all malfunctions specified in sections (e) through (g). However, except as specified elsewhere, the OBD system is not required to use a unique monitor to detect each malfunction specified.

(1) The OBD System.

(1.1) If a malfunction is present as specified in sections (e) through (g), the OBD system shall detect the malfunction, store a pending, confirmed, MIL-on, or previously MIL-on fault code in the onboard computer's memory, and illuminate the MIL as required.

(1.2) The OBD system shall be equipped with a standardized data link connector to provide access to the stored fault codes as specified in section (h).

(1.3) The OBD system shall be designed to operate, without any required scheduled maintenance, for the actual life of the engine in which it is installed and may not be programmed or otherwise designed to deactivate based on age and/or mileage of the vehicle during the actual life of the engine. This section is not intended to alter existing law and enforcement practice regarding a manufacturer's liability for an engine beyond its 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.

(1.4) Computer-coded engine operating parameters may not be changeable without the use of specialized tools and procedures (e.g. soldered or potted computer components or sealed (or soldered) computer enclosures). Subject to Executive Officer approval, manufacturers may exempt from this requirement those product lines that are unlikely to require protection. Criteria to be evaluated in making an exemption include current availability of performance chips, performance capability of the engine, and sales volume.

(2) MIL and Fault Code Requirements.

(2.1) MIL Specifications.

(2.1.1) The MIL shall be located on the driver's side instrument panel and be of sufficient illumination and location to be readily visible under all lighting conditions and shall be amber in color when illuminated. The MIL, when illuminated, shall display the International Standards Organization (ISO) engine symbol <u>(i.e., symbol number F.01 as described in ISO 2575 "Road Vehicles – Symbols for Controls, Indicators and Tell-Tales," incorporated by reference (section (h)(1.12))</u>. There shall be only one MIL used to indicate all faults detected by the OBD system on a single vehicle.

(2.1.2) The MIL shall illuminate in the key on, engine off position before engine cranking to indicate that the MIL is functional. <u>For all 2024 and subsequent model year vehicles containing a non-analog MIL (e.g., liquid-crystal display (LCD)), any delay in MIL illumination prior to the functional check may not exceed 5 seconds.</u> The MIL shall continuously illuminate during this functional check for a minimum of 15 seconds. During this functional check of the MIL, the data stream value for MIL status shall indicate commanded off (see section (h)(4.2)) unless the MIL has also been commanded on for a detected malfunction. This functional check of the MIL is not 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).

(2.1.3) At the manufacturer's option, the MIL may be used to indicate readiness status in a standardized format (see section (h)(4.1.6)) in the key on, engine off position.

(2.1.4) A manufacturer may request Executive Officer approval to also use the MIL to indicate which, if any, fault codes are currently stored (e.g., to "blink" the stored codes). The Executive Officer shall approve the request upon determining that the manufacturer has demonstrated that the method used to indicate the fault codes will not be unintentionally activated during a California inspection test or during routine driver operation.

(2.1.5) The MIL may not be used for any purpose other than specified in this regulation.

(2.2) MIL Illumination and Fault Code Storage Protocol.

(2.2.1) For vehicles using the ISO 15765-4 protocol for the standardized functions required in section (h):

(A) Upon detection of a malfunction, the OBD system shall store a pending fault code within 10 seconds indicating the likely area of the malfunction.

(B) After storage of a pending fault code, if the identified malfunction is again detected before the end of the next driving cycle in which monitoring occurs, the OBD system shall illuminate the MIL continuously, keep the pending fault code stored, and store a confirmed fault code within 10 seconds. If a malfunction is not detected before the end of the next driving cycle in which monitoring occurs (i.e., there is no indication of the malfunction at any time during the driving cycle), the corresponding pending fault code set according to section (d)(2.2.1)(A) shall be erased at the end of the driving cycle.

(C) A manufacturer may request Executive Officer approval to employ alternate statistical MIL illumination and fault code storage protocols to those specified in these requirements. The Executive Officer shall grant approval upon determining that the manufacturer has provided data and/or engineering evaluation that demonstrate that the alternative protocols can evaluate system performance and detect malfunctions in a manner that is equally effective and timely. Strategies requiring on average more than six driving cycles for MIL illumination may not be accepted.

(D) Storage and erasure of freeze frame conditions.

(i) The OBD system shall store and erase "freeze frame" conditions (as defined in section (h)(4.3)) present at the time a malfunction is detected.

(ii) For 2010 through 2015 model year engines, the OBD system shall store and erase freeze frame conditions in conjunction with the storage and erasure of either pending or confirmed fault codes as required elsewhere in section (d)(2.2).

(iii) For 2016 and subsequent model year engines, except as provided for in section (d)(2.2.1)(D)(iv), the OBD system shall store freeze frame conditions in conjunction with the storage of a pending fault code.

a. If the pending fault code is erased in the next driving cycle in which monitoring occurs and a malfunction is not detected (as described in section (d)(2.2.1)(B)), the OBD system may erase the corresponding freeze frame conditions.

b. If the pending fault code matures to a confirmed fault code (as described in section (d)(2.2.1)(B)), the OBD system shall either retain the currently stored freeze frame conditions or replace the stored freeze frame conditions with freeze frame conditions regarding the confirmed fault code. The OBD system shall erase the freeze frame information in conjunction with the erasure of the confirmed fault code (as described under section (d)(2.3.1)(B)).

(iv) For alternate strategies that ~~do not store pending fault codes~~store both a pending fault code and confirmed fault code and illuminate the MIL upon the first detection of a malfunction (i.e., monitors using alternate statistical strategies described in section (d)(2.2.1)(C)~~ such as monitors that store a confirmed fault code and illuminate the MIL upon the first detection of a malfunction~~), the OBD system shall store and erase freeze frame conditions in conjunction with the storage and erasure of the confirmed fault code.

(v) If freeze frame conditions are currently stored for a fault code, the freeze frame conditions may not be replaced with freeze frame conditions for another fault code except as allowed for confirmed fault codes in sections (d)(2.2.1)(D)(ii) and (iii) above, and for gasoline and diesel misfire and fuel system monitors under sections (e)(1.4.2)(D), (e)(2.4.2)(B), (f)(1.4.4), and (f)(2.4.3).

(E) Except as provided for in section (d)(2.4), ~~T~~the OBD system shall illuminate the MIL and store a pending fault code and confirmed fault code within 10 seconds to inform the vehicle operator whenever the engine enters a default or “limp home” mode of operation that can affect emissions or the performance of the OBD system or in the event of a malfunction of any on-board computer~~(s)~~ ~~itself~~ or its ability to successfully send or receive information to/from other on-board computers that can affect the performance of the OBD system. If the default or “limp home” mode of operation is recoverable (i.e., the diagnostic or control strategy that caused the default or “limp home” mode of operation can run on the next driving cycle and confirm the presence of the condition that caused the default or “limp home” operation), the OBD system may, in lieu of illuminating the MIL and storing a confirmed fault code within 10 seconds on the first driving cycle where the default or “limp home” mode of operation is entered, delay illumination of the MIL and storage of a confirmed fault code until the condition causing the default or “limp home” mode of operation is again detected before the end of the next driving cycle, in which case the OBD system shall illuminate the MIL and store a confirmed fault code within 10 seconds of detection.

(F) Before the end of an ignition cycle, the OBD system shall store confirmed fault codes that are currently causing the MIL to be illuminated in NVRAM as permanent fault codes (as defined in section (h)(4.4.1)(F)).

(2.2.2) For vehicles using the SAE J1939 protocol for the standardized functions required in section (h):

(A) Upon detection of a malfunction, the OBD system shall store a pending fault code within 10 seconds indicating the likely area of the malfunction.

(B) After storage of a pending fault code, if the identified malfunction is again detected before the end of the next driving cycle in which monitoring occurs, the OBD system shall illuminate the MIL continuously, erase the pending fault code, and store a MIL-on fault code within 10 seconds. If a malfunction is not detected before the end of the next driving cycle in which monitoring occurs (i.e., there is no indication of the malfunction at any time during the driving cycle), the corresponding pending fault code set according to section (d)(2.2.2)(A) shall be erased at the end of the driving cycle.

(C) A manufacturer may request Executive Officer approval to employ alternate statistical MIL illumination and fault code storage protocols to those specified in these requirements. The Executive Officer shall grant approval upon determining that the manufacturer has provided data and/or engineering evaluation that demonstrate that the alternative protocols can evaluate system performance and detect malfunctions in a manner that is equally effective and timely. Strategies requiring on average more than six driving cycles for MIL illumination may not be accepted.

(D) Storage and erasure of freeze frame conditions.

(i) The OBD system shall store and erase “freeze frame” conditions (as defined in section (h)(4.3)) present at the time a malfunction is detected.

(ii) The OBD system shall store freeze frame conditions in conjunction with the storage of a pending fault code.

(iii) If the pending fault code is erased in the next driving cycle in which monitoring occurs and a malfunction is not detected (as described under section (d)(2.2.2)(B)), the OBD system may erase the corresponding freeze frame conditions.

(iv) If the pending fault code matures to a MIL-on fault code (as described under section (d)(2.2.2)(B)), the OBD system shall either retain the currently stored freeze frame conditions or replace the stored freeze frame conditions with freeze frame conditions regarding the MIL-on fault code. The OBD system shall erase the freeze frame information in conjunction with the erasure of the previously MIL-on fault code (as described under section (d)(2.3.2)(C)).

(v) For alternate strategies that do not store pending fault codes (i.e., monitors using alternate statistical strategies described in section (d)(2.2.1)(C) such as monitors that store a MIL-on fault code and illuminate the MIL upon the first detection of a malfunction), the OBD system shall store and erase freeze frame conditions in conjunction with the storage and erasure of the MIL-on fault code.

<u>(vi) If freeze frame conditions are currently stored for a fault code, the freeze frame conditions may not be replaced with freeze frame conditions for another fault code except as allowed for MIL-on fault codes in section (d)(2.2.2)(D)(iv) above, and for gasoline and diesel misfire and fuel system monitors under sections (e)(1.4.2)(D), (e)(2.4.2)(B), (f)(1.4.4), and (f)(2.4.3).</u>

(E) <u>Except as provided for in section (d)(2.4), </u>~~T~~<u>t</u>he OBD system shall illuminate the MIL and store a MIL-on fault code within 10 seconds to inform the vehicle operator whenever the engine enters a default or “limp home” mode of operation that can affect emissions or the performance of the OBD system or in the event of a malfunction of an<u>y</u> on-board computer~~(s)~~ ~~itself~~ <u>or its ability to successfully send or receive information to/from other on-board computers</u> that can affect the performance of the

OBD system. If the default or "limp home" mode of operation is recoverable (i.e., the diagnostic or control strategy that caused the default or "limp home" mode of operation can run on the next driving cycle and confirm the presence of the condition that caused the default or "limp home" operation), the OBD system may, in lieu of illuminating the MIL and storing a MIL-on fault code within 10 seconds on the first driving cycle where the default or "limp home" mode of operation is entered, delay illumination of the MIL and storage of a MIL-on fault code until the condition causing the default or "limp home" mode of operation is again detected before the end of the next driving cycle, in which case the OBD system shall illuminate the MIL and store a MIL-on fault code within 10 seconds of detection.

(F) Before the end of an ignition cycle, the OBD system shall store MIL-on fault codes that are currently causing the MIL to be illuminated in NVRAM as permanent fault codes (as defined in section (h)(4.4.2)(F)).

(2.3) MIL Extinguishing and Fault Code Erasure Protocol.

(2.3.1) For vehicles using the ISO 15765-4 protocol for the standardized functions required in section (h):

(A) Extinguishing the MIL. Except as otherwise provided in sections (e)(1.4.2)(F), (e)(2.4.2)(D), (e)(3.4.2)(E), (e)(4.4.2)(E), (e)(6.4.2), (f)(1.4.6), (f)(2.4.5), and (f)(7.4.2) (for diesel fuel system, diesel misfire, diesel EGR system, diesel boost pressure control system, diesel empty reductant tank, gasoline fuel system, gasoline misfire, and gasoline evaporative system malfunctions), once the MIL has been illuminated~~,~~:

(i) For 2010 through 2023 model year engines, ~~it~~ the MIL shall be extinguished after at least three subsequent sequential driving cycles during which the monitoring system responsible for illuminating the MIL functions and the previously detected malfunction is no longer present provided no other malfunction has been detected that would independently illuminate the MIL according to the requirements outlined above.

(ii) For 2024 and subsequent model year engines, the MIL shall be extinguished after three subsequent sequential driving cycles during which the monitoring system responsible for illuminating the MIL functions and the previously detected malfunction is no longer present provided no other malfunction has been detected that would independently illuminate the MIL according to the requirements outlined above.

(B) Erasing a confirmed fault code. For 2010 through 2015 model year engines, the OBD system may erase a confirmed fault code if the identified malfunction has not been again detected in at least 40 warm-up cycles and the MIL is presently not illuminated for that malfunction. For 2016 and subsequent model year engines, the OBD system shall erase a confirmed fault code: ~~if the identified malfunction has not been again detected in 40 warm-up cycles and the MIL is presently not illuminated for that malfunction~~ (1) no sooner than the end of the driving cycle in which the identified malfunction has not been again detected in at least 40 consecutive warm-up cycles and the MIL has not been illuminated for that malfunction for at least 40 consecutive warm-up cycles, and (2) no later than the end of the driving cycle in which no malfunction has been detected in 41 consecutive warm-up cycles and the MIL has not been illuminated for any malfunction for 41 consecutive warm-up cycles.

(C) Erasing a permanent fault code.

(i) If the OBD system is commanding the MIL on, the OBD system shall erase a permanent fault code only if the OBD system itself determines that the malfunction that caused the permanent fault code to be stored is no longer present and is not commanding the MIL on, pursuant to the requirements of section (d)(2.3.1)(A) (which for the purposes of this section shall apply to all monitors). Erasure of the permanent fault code shall occur in conjunction with extinguishing the MIL or no later than the start of the first drive cycle that begins with the MIL commanded off.

(ii) If all fault information in the on-board computer other than the permanent fault code has been cleared (i.e., through the use of a scan tool or battery disconnect) and the OBD system is not commanding the MIL on:

a. Except as provided for in sections (d)(2.3.1)(C)(ii)c. and d., if the monitor of the malfunction that caused the permanent fault code to be stored is subject to the minimum ratio requirements of section (d)(3.2) (e.g., catalyst monitor, comprehensive component input component rationality ~~monitors~~fault diagnostics), the OBD system shall erase the permanent fault code at the end of a driving cycle if the monitor has run and made one or more determinations during a driving cycle that the malfunction of the component or the system is not present and has not made any determinations within the same driving cycle that the malfunction is present.

b. Except as provided for in sections (d)(2.3.1)(C)(ii)d. and e., ~~I~~if the monitor of the malfunction that caused the permanent fault code to be stored is not subject to the minimum ratio requirements of section (d)(3.2) (e.g., gasoline misfire monitor, gasoline fuel system monitor, comprehensive component circuit continuity monitors), the OBD system shall erase the permanent fault code at the end of a driving cycle if:

1. The monitor has run and made one or more determinations during a driving cycle that the malfunction of the component or the system is not present and has not made any determinations within the same driving cycle that the malfunction is present;
2. The monitor has not made any determinations that the malfunction is present subsequent to the most recent driving cycle in which the criteria of section (d)(2.3.1)(C)(ii)b.1. are met; and
3. The following criteria are satisfied on any single driving cycle (which may be a different driving cycle than that in which the criteria of section (d)(-2.3.1)(C)(ii)b.1. are satisfied):

i. Except as provided in section (d)(2.3.1)(C)(ii)b.3.v. below, cumulative time since engine start is greater than or equal to 600 seconds;

ii. Cumulative gasoline engine operation at or above 25 miles per hour or diesel engine operation at or above 1150 rpm, either of which occurs for greater than or equal to 300 seconds;

iii. Continuous vehicle operation at idle (i.e., accelerator pedal released by driver and either vehicle speed less than or equal to one mile per hour or engine speed less than or equal to 200 rpm above normal warmed-up idle (as determined in the drive position for vehicles equipped with an automatic transmission)) for greater than or equal to 30 seconds; and

iv. The monitor has not made any determinations that the malfunction is present.

v. For hybrid vehicles, manufacturers shall use "cumulative propulsion system active time" in lieu of "cumulative time since engine start" for the criterion in section (d)(2.3.1)(C)(ii)b.3.i.

4. Monitors required to use "similar conditions" as defined in section (c) to store and erase pending and confirmed fault codes may not require that the similar conditions be met prior to erasure of the permanent fault code.

c. For monitors subject to section (d)(2.3.1)(C)(ii)a., the manufacturer may choose to erase the permanent fault code using the criteria under section (d)(2.3.1)(C)(ii)b. in lieu of the criteria under section (d)(2.3.1)(C)(ii)a.

d. For 2010 through 2012 model year engines, manufacturers may request Executive Officer approval to use alternate criteria to erase the permanent fault code. The Executive Officer shall approve alternate criteria that will not likely require driving conditions that are longer and more difficult to meet than those required under section (d)(2.3.1)(C)(ii)b.

e. For engine cooling system monitors required to detect faults specified under sections (g)(1.2.1)(A), (g)(1.2.1)(B), and (g)(1.2.2)(B) (e.g., thermostat monitor and ECT sensor time to closed-loop monitor), the manufacturer may erase the permanent fault code using the criteria under section (d)(2.3.1)(C)(ii)a. in lieu of the criteria under section (d)(2.3.1)(C)(ii)b.

(iii) If more than one permanent fault code are currently stored, the OBD system shall erase a specific permanent fault code immediately after the monitor for the specific permanent fault code meets the criteria above in section (d)(2.3.1)(C)(i) or (ii). The OBD system may not require that the criteria under section (d)(2.3.1)(C)(i) or (ii) be met for all the stored permanent fault codes before erasing a specific permanent fault code.

(2.3.2) For vehicles using the SAE J1939 protocol for the standardized functions required in section (h):

(A) Extinguishing the MIL. Except as otherwise provided in sections (e)(1.4.2)(F), (e)(2.4.2)(D), (e)(3.4.2)(E), (e)(4.4.2)(E), ~~and~~ (e)(6.4.2), (f)(1.4.6), (f)(2.4.5), and (f)(7.4.2) (for diesel fuel system ~~malfunctions~~, diesel misfire ~~malfunctions~~, diesel EGR system, diesel boost pressure control system, ~~and~~ diesel empty reductant tank~~s~~, gasoline fuel system, gasoline misfire, and gasoline evaporative system malfunctions), once the MIL has been illuminated~~,~~:

(i) For 2010 through 2023 model year engines, ~~it~~the MIL shall be extinguished after at least three subsequent sequential driving cycles during which the monitoring system responsible for illuminating the MIL functions and the previously detected malfunction is no longer present provided no other malfunction has been detected that would independently illuminate the MIL according to the requirements outlined above.

(ii) For 2024 and subsequent model year engines, except as provided for below, the MIL shall be extinguished after three subsequent sequential driving cycles during which the monitoring system responsible for illuminating the MIL functions and the previously detected malfunction is no longer present provided no other malfunction has been detected that would independently illuminate the MIL according to the requirements outlined above. For hybrid vehicles with hybrid control units that use SPN 6810 to indicate hybrid-related malfunctions, in lieu of the three subsequent sequential driving cycles provided above, the MIL may be extinguished after more than three subsequent sequential driving cycles but may not be extinguished after more than six subsequent sequential driving cycles.

(B) Erasing a MIL-on fault code. The OBD system may erase a MIL-on fault code in conjunction with extinguishing the MIL as described under section (d)(2.3.2)(A). In addition to the erasure of the MIL-on fault code, the OBD system shall store a previously MIL-on fault code for that failure.

(C) Erasing a previously MIL-on fault code. For 2010 through 2015 model year engines, the OBD system may erase a previously MIL-on fault code if the identified malfunction has not been again detected in at least 40 warm-up cycles and the MIL is presently not illuminated for that malfunction. For 2016 and subsequent model year engines, the OBD system shall erase a previously MIL-on fault code: ~~if the identified malfunction has not been again detected in 40 warm-up cycles and the MIL is presently not illuminated for that malfunction~~(1) no sooner than the end of the driving cycle in which the identified malfunction has not been again detected in at least 40 consecutive warm-up cycles and the MIL has not been illuminated for that malfunction for at least 40 consecutive warm-up cycles, and (2) no later than the end of the driving cycle in which no malfunction has been detected in 41 consecutive warm-up cycles and the MIL has not been illuminated for any malfunction for 41 consecutive warm-up cycles.

(D) Erasing a permanent fault code. The OBD system shall erase a permanent fault code under the following conditions:

- (i) If the OBD system is commanding the MIL on, the OBD system shall erase a permanent fault code only if the OBD system itself determines that the malfunction that caused the permanent fault code to be stored is no longer present and is not commanding the MIL on, pursuant to the requirements of section (d)(2.3.2)(A) (which for the purposes of this section shall apply to all monitors). Erasure of the permanent fault code shall occur in conjunction with extinguishing the MIL or no later than the start of the first drive cycle that begins with the MIL commanded off.
- (ii) If all fault information in the on-board computer has been cleared (i.e., through the use of a scan tool or battery disconnect) and the OBD system is not commanding the MIL on:
  - a. Except as provided for in sections (d)(2.3.2)(D)(ii)c. and d., if the monitor of the malfunction that caused the permanent fault code to be stored is subject to the minimum ratio requirements of section (d)(3.2) (e.g., catalyst monitor, comprehensive component input component rationality ~~monitors~~fault diagnostics), the OBD system shall erase the permanent fault code at the end of a driving cycle if the monitor has run and made one or more determinations during a driving cycle that the malfunction of the component or the system is not present and has not made any determinations within the same driving cycle that the malfunction is present.
  - b. Except as provided for in sections (d)(2.3.2)(D)(ii)d. and e., ~~I~~if the monitor of the malfunction that caused the permanent fault code to be stored is not subject to the minimum ratio requirements of section (d)(3.2) (e.g., continuous diesel fuel system monitors, comprehensive component circuit continuity monitors), the OBD system shall erase the permanent fault code at the end of a driving cycle if:
    1. The monitor has run and made one or more determinations during a driving cycle that the malfunction of the component or the system is not present and has not made any determinations within the same driving cycle that the malfunction is present;
    2. The monitor has not made any determinations that the malfunction is present subsequent to the most recent driving cycle in which the criteria of section (d)(2.3.2)(D)(ii)b.1. are met; and
    3. The following criteria are satisfied on any single driving cycle (which may be a different driving cycle than that in which the criteria of section (d)(2.3.2)(D)(ii)b.1. are satisfied):
       - i. Except as provided in section (d)(2.3.2)(D)(ii)b.3.v. below, cumulative time since engine start is greater than or equal to 600 seconds;
       - ii. Cumulative gasoline engine operation at or above 25 miles per hour or diesel engine operation at or above 1150 rpm,

either of which occurs for greater than or equal to 300 seconds;

iii. Continuous vehicle operation at idle (i.e., accelerator pedal released by driver and either vehicle speed less than or equal to one mile per hour or engine speed less than or equal to 200 rpm above normal warmed-up idle (as determined in the drive position for vehicles equipped with an automatic transmission)) for greater than or equal to 30 seconds; and

iv. The monitor has not made any determinations that the malfunction is present.

v. For hybrid vehicles, manufacturers shall use "cumulative propulsion system active time" in lieu of "cumulative time since engine start" for the criterion in section (d)(2.3.2)(D)(ii)b.3.i.

4. Monitors required to use "similar conditions" as defined in section (c) to store and erase pending and confirmed/MIL-on fault codes may not require that the similar conditions be met prior to erasure of the permanent fault code.

c. For monitors subject to section (d)(2.3.2)(D)(ii)a., the manufacturer may choose to erase the permanent fault code using the criteria under section (d)(2.3.2)(D)(ii)b. in lieu of the criteria under section (d)(2.3.2)(D)(ii)a.

d. For 2010 through 2012 model year engines, manufacturers may request Executive Officer approval to use alternate criteria to erase the permanent fault code. The Executive Officer shall approve alternate criteria that will not likely require driving conditions that are longer and more difficult to meet than those required under section (d)(2.3.2)(D)(ii)b.

e. For engine cooling system monitors required to detect faults specified under sections (g)(1.2.1)(A), (g)(1.2.1)(B), and (g)(1.2.2)(B) (e.g., thermostat monitor and ECT sensor time to closed-loop monitor), the manufacturer may erase the permanent fault code using the criteria under section (d)(2.3.2)(D)(ii)a. in lieu of the criteria under section (d)(2.3.2)(D)(ii)b.

(iii) If more than one permanent fault code are currently stored, the OBD system shall erase a specific permanent fault code immediately after the monitor for the specific permanent fault code meets the criteria above in section (d)(2.3.2)(D)(i) or (ii). The OBD system may not require that the criteria under section (d)(2.3.2)(D)(i) or (ii) be met for all the stored permanent fault codes before erasing a specific permanent fault code.

(2.4) Exceptions to MIL and Fault Code Requirements.

(2.4.1) If the engine enters a default mode of operation that can affect emissions or the performance of the OBD system, a manufacturer may request Executive Officer approval to be exempt from illuminating the MIL and storing a fault code. The Executive Officer shall approve the request upon determining that the manufacturer has submitted data and/or engineering evaluation that verify either of the following:

(A) The default strategy (1) causes an overt indication (e.g., illumination of a red engine shut-down warning light) such that the driver is certain to respond and have the problem corrected, (2) is not otherwise caused by a component required to be monitored by the OBD system under sections (e) through (g), and (3) is not invoked to protect a component required to be monitored by the OBD system under sections (e) through (g); or

(B) The default strategy is an AECD that is properly activated due to the occurrence of conditions that have been approved by the Executive Officer.

(2.4.2) For gasoline engines, a manufacturer may elect to meet the MIL and fault code requirements in title 13, CCR section 1968.2(d)(2) in lieu of meeting the requirements of (d)(2).

(3) Monitoring Conditions.

Section (d)(3) sets forth the general monitoring requirements while sections (e) through (g) sets forth the specific monitoring requirements as well as identifies which of the following general monitoring requirements in section (d)(3) are applicable for each monitored component or system identified in sections (e) through (g).

(3.1) For all engines:

(3.1.1) As specifically provided for in sections (e) through (g), manufacturers shall define monitoring conditions, subject to Executive Officer approval, for detecting malfunctions identified in sections (e) through (g). The Executive Officer shall approve manufacturer-defined monitoring conditions that are determined (based on manufacturer-submitted data and/or other engineering documentation) to be: technically necessary to ensure robust detection of malfunctions (e.g., avoid false passes and false indications of malfunctions); designed to ensure monitoring will occur under conditions that may reasonably be expected to be encountered in normal vehicle operation and use; and designed to ensure monitoring will occur during the FTP cycle.

(3.1.2) Monitoring shall occur at least once per driving cycle in which the monitoring conditions are met.

(3.1.3) Manufacturers may request Executive Officer approval to define monitoring conditions that are not encountered during the FTP cycle as required in section (d)(3.1.1). Except as provided in section (d)(3.1.3)(A) below, i~~I~~n evaluating the manufacturer's request, the Executive Officer shall consider the degree to which the requirement to run 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 in section (d)(3.2), the ability of the manufacturer to demonstrate the monitoring conditions will satisfy the minimum acceptable in-use monitor performance ratio requirement as defined in section (d)(3.2) (e.g., data which show in-use driving meets the minimum requirements).

(A) For a monitor on 2024 and subsequent model year engines for which the in-use monitor performance is not required to be tracked and reported under section (d)(3.2.1), if a manufacturer requests Executive Officer approval to define monitoring conditions that are designed to ensure monitoring will occur during the SET cycle, the Executive Officer shall approve the request only if the following conditions are met:

(i) The manufacturer has submitted information and/or engineering evaluation that demonstrate that the monitoring conditions are appropriate for the monitor based on the considerations specified under section (d)(3.1.3) above;

(ii) The manufacturer has implemented enhanced tracking and reporting of the in-use monitor performance of the monitor (i.e., software algorithms to track the numerator and denominator in accordance with the specifications in sections (d)(4), (d)(5), and (h)(5.1) and report the data through an engineering or manufacturer-specific tool); and

(iii) The manufacturer has submitted a plan for the collection of in-use monitor performance data mentioned in section (d)(3.1.3)(A)(ii) above from in-use vehicles. The plan shall provide for effective collection of data that are representative of California drivers and temperatures, shall not, by design, exclude or include specific vehicles in an attempt to collect data only from vehicles with the highest in-use monitor performance ratios, and shall include an estimated deadline of when the manufacturer will submit the data to the Executive Officer that does not exceed 12 months after the production vehicles were first introduced into commerce. The data may be collected from the same vehicles described in section (l)(3).

(3.1.4) For intrusive diagnostics, the manufacturers shall submit a monitoring strategy plan to the Executive Officer for review and approval. The Executive Officer shall approve the plan if the manufacturer has submitted data and/or engineering evaluation demonstrating any of the following:

(A) Running the intrusive diagnostic will not affect the effectiveness of the emission control system during any reasonable in-use driving conditions.

(B) If running the intrusive diagnostic reduces the effectiveness of the emission control system during any reasonable in-use driving conditions, the intrusive diagnostic meets any of the following:

(i) The diagnostic runs only once after the MIL is illuminated for the fault by a non-intrusive diagnostic, or

(ii) The manufacturer is applying the best available monitoring technology that, to the extent feasible, results in the least possible emissions impact during any reasonable in-use driving conditions (e.g., exhaust gas sensor rationality monitor that runs during a fuel cut event). For purposes of this section, "to the extent feasible" is defined in section (g)(5.9).

(C) If running the intrusive diagnostic enhances the effectiveness of the emission control system (e.g., increase catalyst conversion efficiency for a few minutes at the beginning of a driving cycle) during any reasonable in-use driving conditions, the manufacturer shall meet the following requirements:

(i) If the manufacturer determines that emissions using the standard test procedures are not representative of real world driving, the manufacturer must submit a plan to the Executive Officer for approval of the use of alternate test procedures. Executive Officer approval of these alternate test procedures shall be based on the determination that the alternate test procedures would result in test cycle emissions representative of in-use driving conditions.

(3.2) As specifically provided for in sections (e) through (g), manufacturers shall define monitoring conditions in accordance with the criteria in sections (d)(3.2.1) through (3.2.3).

(3.2.1) Manufacturers shall implement software algorithms in the OBD system to individually track and report in-use performance of the ~~following~~ monitors specified in the sections referenced below for the following components/systems in the standardized format specified in section (d)(5):

(A) NMHC converting catalyst (section (e)(5.3.1))
(B) NOx converting catalyst (section (e)(6.3.1))
(C) Catalyst (section (f)(6.3));
(D) Exhaust gas sensor (section~~s~~ (e)(9.3.1)(A) or (f)(8.3.1)(A));
(E) Evaporative system (section (f)(7.3.2));
(F) EGR system (sections (e)(3.3.1), (e)(3.3.2) and (e)(3.3.3) or (f)(3.3.1)) and VVT system (section~~s~~ (e)(10.3) or (f)(9.3));
(G) Secondary air system (section (f)(5.3.1));
(H) PM filter (sections (e)(8.3.1) and (e)(8.3.2));
(I) Boost pressure control system (sections (e)(4.3.1), (e)(4.3.2) and (e)(4.3.3));
(J) NOx adsorber (section (e)(7.3.1));
(K) Fuel system (sections (e)(1.3.3) or (f)(1.3.2)); and
(L) Secondary oxygen sensor (section (f)(8.3.2)(A)).

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

(3.2.2) For all 2013 and subsequent model year engines, manufacturers shall define monitoring conditions that, in addition to meeting the criteria in sections (d)(3.1) (if applicable) and (d)(3.2.1), ensure that the monitor yields an in-use performance ratio (as defined in section (d)(4)) that meets or exceeds the minimum acceptable in-use monitor performance ratio for in-use vehicles. For purposes of this regulation, the following minimum acceptable in-use monitor performance ratio ~~is~~ shall apply for monitors specifically required in sections (e) through (g) to meet the monitoring condition requirements of section (d)(3.2):

(A) For 2013 through 2023 model year engines, 0.100 for all monitors ~~specifically required in sections (e) through (g) to meet the monitoring condition requirements of section (d)(3.2)~~.

(B) Except as provided below in section (d)(3.2.2)(C), for 2024 and subsequent model year engines, 0.300 for all monitors.

(C) For interim years:

(i) For 2024 through 2031 model year engines, 0.100 for crankcase ventilation (CV) system monitors specified in section (g)(2.2.3).

(ii) For 2024 through 2025 model year alternate-fueled engines, 0.100 for all monitors.

(iii) For hybrid systems on plug-in hybrid electric vehicles first certified in the 2022 through 2027 model years, 0.100 for the first three model years of hybrid system production for all monitors that are for systems or components that require engine operation. For example, the 0.100 ratio shall apply to the 2022, 2023, and 2024 model years for hybrid systems first certified in the 2022 model year and to the 2027, 2028, and 2029 model years for hybrid systems first certified in the 2027 model year. If the hybrid system is first certified in the 2028 or subsequent model year, the applicable ratios for all monitors are specified under section (d)(3.2.2)(B) above.

(3.2.3) 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 (e.g., using a low ratio to enable more frequent monitoring through diagnostic executive priority or modification of other monitoring conditions, or using a high ratio to enable less frequent monitoring).

(3.2.4) Upon request of a manufacturer or upon the best engineering judgment of ARB, the Executive Officer may revise the minimum acceptable in-use monitoring performance ratio specified in section (d)(3.2.2) for a specific monitor if the most reliable monitoring method developed requires a lower ratio.

(4) In-Use Monitor Performance Ratio Definition.

(4.1) For monitors required to meet the requirements in section (d)(3.2), the ratio shall be calculated in accordance with the following specifications for the numerator, denominator, and ratio.

(4.2) Numerator Specifications

(4.2.1) Definition: The numerator is 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.

(4.2.2) Specifications for incrementing:

(A) Except as provided for in section (d)(4.2.2)(E), the numerator, when incremented, shall be incremented by an integer of one. The numerator may not be incremented more than once per driving cycle.

(B) The numerator for a specific monitor shall be incremented within 10 seconds if and only if the following criteria are satisfied on a single driving cycle:

(i) Every monitoring condition necessary for the monitor of the specific component to detect a malfunction and store a pending fault code has been satisfied, including enable criteria, presence or absence of related fault codes, 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 the component is passing may not, by itself, be sufficient to meet this criteria.

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

(iii) For intrusive diagnostics~~monitors that require intrusive operation of components to detect a malfunction~~, a manufacturer shall request Executive Officer approval of the strategy used to determine that, had a malfunction been present, the monitor would have detected the malfunction. Executive Officer approval of the request shall be based on the equivalence of the strategy to actual intrusive operation and the ability of the strategy to accurately determine if every monitoring condition necessary for the intrusive event to occur was satisfied.

(iv) For the secondary air system monitor, the criteria in sections (d)(4.2.2)(B)(i) through (iii) above are satisfied during normal operation of the secondary air system. Monitoring during intrusive operation of the secondary air system later in the same driving cycle solely for the purpose of monitoring may not, by itself, be sufficient to meet this criteria.

(C) 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 shall submit a plan for appropriate incrementing of the numerator to the Executive Officer for review and approval. In general, the Executive Officer shall not approve plans that allow the numerator to be incremented when the monitor indicates a result in the “non-detection zone” or prior to the monitor reaching a decision. In reviewing the plan for approval, the Executive Officer shall consider data and/or engineering evaluation submitted by the manufacturer demonstrating the expected frequency of results in the “non-detection zone” and the ability of the monitor to accurately determine if a monitor would have detected a malfunction instead of a result in the “non-detection zone” had an actual malfunction been present.

(D) For monitors that run or complete during engine-off operation, the numerator shall be incremented within 10 seconds after the monitor has completed during engine-off operation or during the first 10 seconds of engine start on the subsequent driving cycle.

(E) Except as specified in section (d)(4.2.2)(F) for exponentially weighted moving averages, manufacturers utilizing alternate statistical MIL illumination protocols as allowed in sections (d)(2.2.1)(C) and (d)(2.2.2)(C) for any of the monitors requiring a numerator shall submit a plan for appropriate incrementing of the numerator to the Executive Officer for review and approval. Executive Officer approval of the plan shall be conditioned upon the manufacturer providing supporting data and/or engineering evaluation demonstrating the equivalence of the incrementing in the manufacturer's plan to the incrementing specified in section (d)(4.2.2) for monitors using the standard MIL illumination protocol and the overall equivalence of the manufacturer's plan in determining that the minimum acceptable in-use performance ratio in section (d)(3.2) is satisfied.

(F) Manufacturers using an exponentially weighted moving average (EWMA) as the alternate statistical MIL illumination protocol approved in accordance with sections (d)(2.2.1)(C) and (d)(2.2.2)(C) shall increment the numerator as follows:

(i) Following a reset or erasure of the EWMA result, the numerator may not be incremented until after the requisite number of decisions necessary for MIL illumination have been fully executed.

(ii) After the number of decisions required in section (d)(4.2.2)(F)(i) above, the numerator, when incremented, shall be incremented by an integer of one and may not be incremented more than once per driving cycle. Incrementing of the numerator shall also be in accordance with sections (d)(4.2.2)(B), (C), and (D).

(4.3) Denominator Specifications

(4.3.1) Definition: The denominator is defined as a measure of the number of times a vehicle has been operated as defined in (d)(4.3.2).

(4.3.2) Specifications for incrementing:

(A) The denominator, when incremented, shall be incremented by an integer of one. The denominator may not be incremented more than once per driving cycle.

(B) Except as provided for in sections (d)(4.3.2)(~~F~~C)~~,~~ through~~ (I), and~~ (~~J~~M), the denominator for each monitor shall be incremented within 10 seconds if and only if the following criteria are satisfied on a single driving cycle:

(i) Cumulative time since engine start of driving cycle is greater than or equal to 600 seconds while at an elevation of less than 8,000 feet above sea level and at an ambient temperature of greater than or equal to 20 degrees Fahrenheit (or -6.7 degrees Celsius);

(ii) Cumulative gasoline engine operation at or above 25 miles per hour or diesel engine operation at or above 1150 rpm, either of which occurs for greater than or equal to 300 seconds while at an elevation of less than 8,000 feet above sea level and at an ambient temperature of greater than or equal to 20 degrees Fahrenheit (or -6.7 degrees Celsius); and

(iii) Continuous vehicle operation at idle (i.e., accelerator pedal released by driver and either vehicle speed less than or equal to one mile per hour or engine speed less than or equal to 200 rpm above normal warmed-up idle (as determined in the drive position for vehicles equipped with an automatic transmission)) for greater than or equal to 30 seconds while at an elevation of less than 8,000 feet above sea level and at an ambient temperature of greater than or equal to 20 degrees Fahrenheit (or -6.7 degrees Celsius).

(iv) For 2010 through 2012 model year diesel engines, manufacturers may use diesel engine operation at or above 15% calculated load in lieu of 1150 rpm for the criterion in section (d)(4.3.2)(B)(ii) above.

(C) Except as provided for in section (d)(4.3.2)(K), ~~I~~in addition to the requirements of section (d)(4.3.2)(B) ~~above~~or (J) (whichever is applicable), for the evaporative system monitor (sections (f)(7.2.2)(A) and (B)), the comprehensive component input component temperature sensor rationality ~~monitors~~ fault diagnostics (section (g)(3)) (e.g., intake air temperature sensor, ambient temperature sensor, fuel temperature sensor, hybrid component temperature sensor), and the engine cooling system input component~~s~~ rationality fault diagnostics (section (g)(1)), the denominator(s) shall be incremented if and only if:

(i) Cumulative time since engine start of driving cycle is greater than or equal to 600 seconds while at an ambient temperature of greater than or equal to 40 degrees Fahrenheit (or 4.4 degrees Celsius) but less than or equal to 95 degrees Fahrenheit (or 35 degrees Celsius); and

(ii) Engine cold start occurs with engine coolant temperature at engine start greater than or equal to 40 degrees Fahrenheit (or 4.4 degrees Celsius) but less than or equal to 95 degrees Fahrenheit (or 35 degrees Celsius) and less than or equal to 12 degrees Fahrenheit (or 6.7 degrees Celsius) higher than ambient temperature at engine start.

(D) In addition to the requirements of section (d)(4.3.2)(B) ~~above~~or (J) (whichever is applicable), the denominator(s) for the following monitors shall be incremented if and only if the component or strategy is commanded "on" for a cumulative time greater than or equal to 10 seconds:

(i) Secondary Air System (section (f)(5))

(ii) Cold Start Emission Reduction Strategy (sections (e)(11) or (f)(4))

(iii) 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 (g)(4)) or comprehensive component output components (section (g)(3))

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 driving cycle solely for the purposes of monitoring.

(E) In addition to the requirements of section (d)(4.3.2)(B) ~~above~~or (J) (whichever is applicable), the denominator(s) for the following component monitors (except those operated only at engine start-up and subject to the requirements of the previous section (d)(4.3.2)(D)) shall be incremented if and only if the component is commanded to function (e.g., commanded "on", "open", "closed", "locked") for a cumulative time greater than or equal to 10 seconds:

(i) Variable valve timing and/or control system (sections (e)(10) or (f)(9))

~~(ii) "Other emission control systems" (section (g)(4))~~

(ii~~i~~) Comprehensive component output component (section (g)(3)) (e.g., turbocharger waste-gates, variable length manifold runners, idle speed control system, idle fuel control system)

(~~iv~~iii) PM filter active/intrusive injection (section (e)(8.2.6))

(iv) PM sensor heater (section (e)(9.2.4)(A))

As an alternative, in addition to the requirements of section (d)(4.3.2)(B) or (J) (whichever is applicable), the manufacturer may use the criteria specified in title 13, CCR section 1968.2(d)(4.3.2)(F) in lieu of the criteria specified in section (d)(4.3.2)(E) above.

For the PM filter active/intrusive injection monitor, as an alternative for 2010 through 2015 model year engines, the manufacturer may use the criteria in section (d)(4.3.2)(H) in lieu of the criteria specified in section (d)(4.3.2)(E) above.

For the PM sensor heater monitor, as an alternative for 2010 through 2015 model year engines, the manufacturer may use the criteria specified in section (d)(4.3.2)(B) in lieu of the criteria specified in section (d)(4.3.2)(E) above.

(F) For the following component monitors, the manufacturer may request Executive Officer approval to use alternate or additional criteria to that set forth in section (d)(4.3.2)(B) ~~above~~ or (J) (whichever is applicable) for incrementing the denominator. Executive Officer approval of the proposed criteria shall be based on the equivalence of the proposed criteria in measuring the frequency of monitor operation relative to the amount of vehicle operation in accordance with the criteria in section (d)(4.3.2)(B) above:

(i) “Other emission control systems” (section (g)(4))

(ii) Comprehensive component input components that require extended monitoring evaluation (section (g)(3)) (e.g., stuck fuel level sensor rationality)

(iii) 2010 through 2023 model year diesel PM filter frequent regeneration (section (e)(8.2.2))

(iv) PM sensor monitoring capability monitor (section (e)(9.2.2)(D))

(G) For the following monitors of components or other emission controls that experience infrequent regeneration events, the denominator(s) shall be incremented during a driving cycle in which the following two criteria are met: (1) the requirements of section (d)(4.3.2)(B) or (J) (whichever is applicable) are met on the current driving cycle, and (2) the number of minutes of cumulative engine run time since the denominator was last incremented is greater than or equal to 800 minutes. The 800-minute engine run time counter shall be reset to zero and begin counting again after the denominator has been incremented and no later than the start of the next ignition cycle:

(i) Diesel NMHC converting catalyst (section (e)(5.2.2)) on 2010 through 2023 model year engines

(ii) Diesel NMHC converting catalyst other aftertreatment assistance functions (sections (e)(5.2.3)(B) and (D))

(iii) Diesel ~~C~~catalyzed PM filter NMHC conversion (section (e)(8.2.4)(A))

(iv) ~~2010 through 2015 model year~~ Diesel PM filter filtering performance and missing substrate (sections (e)(8.2.1) and (8.2.5)) on 2010 through 2015 model year engines

(v) Diesel catalyzed PM filter feedgas generation (section (e)(8.2.4)(B)) on 2024 and subsequent model year engines

(vi) Diesel PM filter frequent regeneration (section (e)(8.2.2)) on 2024 and subsequent model year engines

As an alternative, for 2010 through 2012 model year engines, the manufacturer may request Executive Officer approval to use alternate or additional criteria to that set forth in section (d)(4.3.2)(G) above for incrementing the denominator. Executive Officer approval of the proposed criteria shall be based on the effectiveness of the proposed criteria in measuring the frequency of monitor operation relative to the amount of vehicle operation.

For the diesel NMHC converting catalyst monitor (section (e)(5.2.2)), as an alternative for 2010 through 2023 model year engines, the manufacturer may use the criteria in section (d)(4.3.2)(H) in lieu of the criteria specified in section (d)(4.3.2)(G) above.

(H) For 2013 and subsequent model year engines, in addition to the requirements of section (d)(4.3.2)(B) ~~above~~or (J) (whichever is applicable), the denominator(s) for the following monitors shall be incremented if and only if a regeneration event (e.g., parked/manual regeneration, desulfurization, decrystallization, desoot) is commanded for a time greater than or equal to 10 seconds:

(i) Diesel NMHC converting catalyst other aftertreatment assistance functions (sections (e)(5.2.3)(A) and (C))

(ii) PM filter incomplete regeneration (section (e)(8.2.3))

(iii) Diesel NMHC converting catalyst (section (e)(5.2.2)) on 2024 and subsequent model year engines

(I) For vehicles that employ alternate engine start hardware or strategies (e.g., a vehicle with a start-stop system that does not meet the definition of a hybrid vehicle as defined in section (c)) or alternate-fueled engines, the manufacturer may request Executive Officer approval to use alternate criteria to that set forth in section (d)(4.3.2)(B) ~~above~~ or (J) (whichever is applicable) for incrementing the denominator. In general, the Executive Officer shall not approve alternate criteria for vehicles that only employ engine shut off at or near idle/vehicle stop conditions. Executive Officer approval of the alternate criteria shall be based on the equivalence of the alternate criteria to determine the amount of vehicle operation relative to the measure of conventional vehicle operation in accordance with the criteria in section (d)(4.3.2)(B) ~~above~~or (J) (whichever is applicable).

(J) For hybrid vehicles, in lieu of the criteria in section (d)(4.3.2)(B) above, the denominator for each monitor shall be incremented within ten seconds if and only if the following criteria are satisfied on a single driving cycle:

(i) Cumulative propulsion system active time is greater than or equal to 600 seconds while at an elevation of less than 8,000 feet above sea level and at an ambient temperature of greater than or equal to 20 degrees Fahrenheit (or -6.7 degrees Celsius);

(ii) Cumulative gasoline engine operation at or above 25 miles per hour or diesel engine operation at or above 1150 rpm, either of which occurs for greater than or equal to 300 seconds while at an elevation of less than 8,000 feet above sea level and at an ambient temperature of greater than or equal to 20 degrees Fahrenheit (or -6.7 degrees Celsius);

(iii) Continuous vehicle operation at idle (i.e., accelerator pedal released by driver and either vehicle speed less than or equal to one mile per hour or engine speed less than or equal to 200 rpm above normal warmed-up idle (as determined in the drive position for vehicles equipped with an automatic transmission)) for greater than or equal to 30 seconds while at an elevation of less than 8,000 feet above sea level and at an ambient temperature of greater than or equal to 20 degrees Fahrenheit (or -6.7 degrees Celsius); and

(iv) Cumulative fueled engine operation for greater than or equal to 10 seconds while at an elevation of less than 8,000 feet above sea level and at an ambient temperature of greater than or equal to 20 degrees Fahrenheit (or -6.7 degrees Celsius).

As an alternative, for 2010 through 2015 model year hybrid vehicles, the manufacturer may use the criteria specified in section (d)(4.3.2)(I) in lieu of the criteria specified in section (d)(4.3.2)(J) above.

(K) For 2024 and subsequent model year hybrid systems in plug-in hybrid electric vehicles, the denominators for the evaporative system monitors (sections (f)(7.2.2)(A) and (B)), the comprehensive component input component temperature sensor rationality fault diagnostics (section (g)(3))(e.g., intake air temperature sensor, hybrid component temperature sensor), and the engine cooling system input component rationality monitors (sections (g)(1.2.2)(C) and (D)) shall be incremented if and only if:

(i) The requirements of section (d)(4.3.2)(J)(i) through (iv) have been met for the evaporative system purge flow monitor (section (f)(7.2.2)(A)), or the requirements of section (d)(4.3.2)(J)(i) through (iii) have been met for all other monitors specified in section (d)(4.3.2)(K) above;

(ii) Cumulative propulsion system active time is greater than or equal to 600 seconds while at an ambient temperature of greater than or equal to 40 degrees Fahrenheit (or 4.4 degrees Celsius) but less than or equal to 95 degrees Fahrenheit (or 35 degrees Celsius);

(iii) Engine coolant temperature at the start of propulsion system active is greater than or equal to 40 degrees Fahrenheit (or 4.4 degrees Celsius) but less than or equal to 95 degrees Fahrenheit (or 35 degrees Celsius); and

(iv) Continuous time while the vehicle is not in the state of 'propulsion system active' during the period immediately preceding the start of propulsion system active is greater than or equal to 6 hours.

(L) For the evaporative system high-load purge flow monitor (section (f)(7.2.2)(C)) and the crankcase ventilation monitor for lines through which crankcase vapor flows under conditions where the intake manifold pressure is greater than ambient pressure on vehicles with forced induction engines (section (g)(2.2.3)), the denominator(s) shall be incremented if and only if:

(i) The requirements of section (d)(4.3.2)(B) or (J) (whichever is applicable) have been met;

(ii) Cumulative time since engine start is greater than or equal to 600 seconds while at an ambient temperature of greater than or equal to 40 degrees Fahrenheit (or 4.4 degrees Celsius) (hybrid vehicles shall use cumulative propulsion system active time in lieu of cumulative time since engine start); and

(iii) High-load purging conditions occur on two or more occasions for greater than two seconds during the driving cycle or for a cumulative time greater than or equal to ten seconds, whichever occurs first.

(iv) For purposes of section (d)(4.3.2)(L)(iii) above, “high-load purging conditions” means an event during which the engine manifold pressure is greater than or equal to 7 kPa above atmospheric pressure.

As an alternative for 2010 through 2023 model year engines, the manufacturer may use the criteria in section (d)(4.3.2)(C) for the evaporative system high-load purge flow monitor in lieu of the criteria specified above in section (d)(4.3.2)(L).

(M) For a monitor designed to detect malfunctions specified under more than one section (e.g., one NMHC converting catalyst monitor to detect malfunctions under sections (e)(5.2.2) and (e)(5.2.3)(A)), if each section is subject to different denominator incrementing criteria, the manufacturer shall request Executive Officer approval of the criteria used for incrementing the monitor denominator. Executive Officer approval of the criteria shall be based manufacturer data and/or engineering evaluation demonstrating that the proposed denominator incrementing criteria results in the lowest in-use monitor performance ratio for the monitor.

(4.4) Ratio Specifications

(4.4.1) Definition: The ratio is defined as the numerator divided by the denominator.

(4.5) Disablement of Numerators and Denominators

(4.5.1) Within 10 seconds of a malfunction being detected (i.e., a pending, confirmed, or MIL-on fault code being stored) that disables a monitor required to meet the monitoring conditions in section (d)(3.2), the OBD system shall 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 code is erased through self-clearing or through a scan tool command), incrementing of all corresponding numerators and denominators shall resume within 10 seconds.

(4.5.2) Within 10 seconds of the start of a PTO (see section (c)) operation that disables a monitor required to meet the monitoring conditions in section (d)(3.2), the OBD system shall 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 shall resume within 10 seconds.

(4.5.3) The OBD system shall disable further incrementing of all numerators and denominators within 10 seconds if a malfunction of any component used to determine if the criteria of sections (d)(4.3.2)(B) or (d)(4.3.2)(J), whichever is applicable, are satisfied (i.e., vehicle speed/calculated load, ambient temperature, elevation, idle operation, or time of operation) has been detected (i.e., a pending, confirmed, or MIL-on fault code has been stored). When the malfunction is no longer detected (e.g., the pending fault code is erased through self-clearing or through a scan tool command), ~~I~~incrementing of all numerators and denominators shall resume within 10 seconds ~~from when the malfunction is no longer present (e.g., pending code erased through self-clearing or by a scan tool command)~~.

(4.5.4) For 2024 and subsequent model year engines, within ten seconds of a malfunction being detected for any component used to determine if any of the criteria in sections (d)(4.3.2)(C) through (I), (K), and (L) are satisfied (e.g., engine cold start), the OBD system shall disable further incrementing of the corresponding numerator and denominator for each monitor that is affected. When the malfunction is no longer detected (i.e., the pending code is erased through self-clearing or through a scan tool command), incrementing of the corresponding numerators and denominators shall resume within 10 seconds.

(5) Standardized tracking and reporting of monitor performance.

(5.1) For monitors required to track and report in-use monitor performance in section (d)(3.2), the performance data shall be tracked and reported in accordance with the specifications in sections (d)(4), (d)(5), and (h)(5.1). ~~The OBD system shall separately report an in-use monitor performance numerator and denominator for each of the following components:~~

(5.1.1) For diesel engines, the OBD system shall separately report an in-use monitor performance numerator and denominator for each of the following components: fuel system, NMHC catalyst, NOx catalyst, exhaust gas sensor, EGR/VVT system, PM filter, boost pressure control system, and NOx adsorber. The OBD system shall also report a general denominator and an ignition cycle counter in the standardized format specified in sections (d)(5.5), (d)(5.6), and (h)(5.1).

(5.1.2) For gasoline engines, the OBD system shall separately report an in-use monitor performance numerator and denominator for each of the following components: catalyst bank 1, catalyst bank 2, primary oxygen sensor bank 1, primary oxygen sensor bank 2, secondary oxygen sensor, evaporative leak detection system, EGR/VVT system, and secondary air system. The OBD system shall also report a general denominator and an ignition cycle counter in the standardized format specified in sections (d)(5.5), (d)(5.6), and (h)(5.1).

(5.2) Numerator

(5.2.1) The OBD system shall report a separate numerator for each of the components listed in section (d)(5.1).

(5.2.2) For specific components or systems that have multiple monitors that are required to be reported under section (e) (e.g., exhaust gas sensor bank 1 may have multiple monitors for sensor response or other sensor characteristics), the OBD system shall 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.

(5.2.3) The numerator(s) shall be reported in accordance with the specifications in section (h)(5.1.2)(A).

(5.3) Denominator

(5.3.1) The OBD system shall report a separate denominator for each of the components listed in section (d)(5.1).

(5.3.2) The denominator(s) shall be reported in accordance with the specifications in section (h)(5.1.2)(A).

(5.4) Ratio

(5.4.1) For purposes of determining which corresponding numerator and denominator to report as required in section (d)(5.2.2), the ratio shall be calculated in accordance with the specifications in section (h)(5.1.2)(B).

(5.5) Ignition cycle counter

(5.5.1) Definition:

(A) The ignition cycle counter is defined as a counter that indicates the number of ignition cycles a vehicle has experienced as defined in section (d)(5.5.2)(B).

(B) Except as required in section (d)(5.5.1)(C) below, the OBD system shall report one ignition cycle counter (as defined in section (d)(5.5.2)(B)).

(C) For 2024 and subsequent model year hybrid systems in plug-in hybrid electric vehicles, the OBD system shall report two ignition cycle counters (as defined in sections (d)(5.5.2)(B) and (C)).

(~~B~~D) The ignition cycle counter shall be reported in accordance with the specifications in section (h)(5.1.2)(A).

(5.5.2) Specifications for incrementing:

(A) The ignition cycle counter, when incremented, shall be incremented by an integer of one. The ignition cycle counter may not be incremented more than once per ignition cycle.

(B) The ignition cycle counter shall be incremented within 10 seconds if and only if the following criteria are met:

(i) Except as required in section (d)(5.5.2)(B)(ii) below, 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.

(ii) For hybrid vehicles, the vehicle meets the propulsion system active definition (see section (c)) for at least two seconds plus or minus one second.

(C) In addition to the counter described in section (d)(5.5.2)(B) above, 2024 and subsequent model year hybrid systems in plug-in hybrid electric vehicles shall track and report a second ignition cycle counter that shall be incremented within ten seconds if and only if the vehicle has met the fueled engine operation definition (see section (c)) for at least two seconds plus or minus one second.

(~~C~~D) The OBD system shall disable further incrementing of the ignition cycle counter within 10 seconds if a malfunction has been detected and the corresponding pending fault code has been stored ~~of~~ for any component used to determine if the criteria in sections (d)(5.5.2)(B) and (C) are satisfied (~~i.e.~~e.g., engine speed or time of operation)~~ has been detected and the corresponding pending fault code has been stored~~. The ignition cycle counter may not be disabled from incrementing for any other condition. Incrementing of the ignition cycle counter shall resume within 10 seconds when the malfunction is no longer present (e.g., pending code erased through self-clearing or by a scan tool command).

(5.6) General Denominator

(5.6.1) Definition:

(A) The general denominator is defined as a measure of the number of times a vehicle has been operated as defined in section (d)(5.6.2)(B).

(B) The general denominator shall be reported in accordance with the specifications in section (h)(5.1.2)(A).

(5.6.2) Specifications for incrementing:

(A) The general denominator, when incremented, shall be incremented by an integer of one. The general denominator may not be incremented more than once per driving cycle.

(B) The general denominator shall be incremented within 10 seconds if and only if the criteria identified below are satisfied on a single driving cycle:

(i) For non-hybrid vehicles, the criteria identified in section (d)(4.3.2)(B) ~~are satisfied on a single driving cycle~~.

(ii) For hybrid vehicles (except as provided in section 1971.1(d)(5.6.2)(B)(iii) below), the criteria identified in section (d)(4.3.2)(J)(i) through (iv).

(iii) For plug-in hybrid electric vehicles, the criteria identified in sections (d)(4.3.2)(J)(i) through (iii). For 2010 through 2023 model year hybrid systems in plug-in hybrid electric vehicles, manufacturers may increment the general denominator using the criteria identified in sections (d)(4.3.2)(J)(i) through (iv).

(C) The OBD system shall disable further incrementing of the general denominator within 10 seconds if a malfunction has been detected and the corresponding pending fault code has been stored ~~of~~for any component used to determine if the criteria in section (d)(4.3.2)(B) or (d)(4.3.2)(J) (whichever is applicable) are satisfied (i.e., vehicle speed/load, ambient temperature, elevation, idle operation, or time of operation) ~~has been detected and the corresponding pending fault code has been stored~~. The general denominator may not be disabled from incrementing for any other condition (e.g., the disablement criteria in sections (d)(4.5.1) and (d)(4.5.2) may not disable the general denominator). Incrementing of the general denominator shall resume within 10 seconds when the malfunction is no longer present (e.g., pending code erased through self-clearing or by a scan tool command).

(6) Malfunction Criteria Determination and Adjustment Factors.

(6.1) In determining the malfunction criteria for diesel engine monitors in sections (e) and (g) that are required to indicate a malfunction before emissions exceed an emission threshold based on any applicable standard (e.g., 2.0 times any of the applicable standards), the manufacturer shall:

(6.1.1) Use the emission test cycle and standard (i.e., FTP or SET) determined by the manufacturer, through use of data and/or engineering analysis, to be more stringent (i.e., to result in higher emissions with the same level of monitored component malfunction) as the “applicable standard”. The manufacturer shall use data and/or engineering analysis to determine the test cycle and standard that is more stringent.

(6.1.2) Identify in the certification documentation required under section (j), the test cycle and standard determined by the manufacturer to be more stringent for each applicable monitor.

(6.1.3) If the Executive Officer reasonably believes that a manufacturer has incorrectly determined the test cycle and standard that is more stringent, the Executive Officer shall require the manufacturer to provide emission data and/or engineering analysis showing that the other test cycle and standard are less stringent.

(6.2) On engines equipped with emission controls that experience infrequent regeneration events, a manufacturer shall adjust the emission test results that are used to determine the malfunction criterion for monitors that are required to indicate a malfunction before emissions exceed a certain emission threshold (e.g., 2.0 times any of the applicable standards). Except as provided in section (d)(6.2.~~3~~4), for each monitor, the manufacturer shall adjust the emission result using the procedure described in CFR title 40, part 86.004-28(i) (current as of August 21, 2018, and hereby incorporated by reference) on 2020 and earlier model year engines, and part 1065.680 (current as of August 21, 2018 and hereby incorporated by reference) on 2021 and subsequent model year engines, with the component for which the malfunction criteria is being established deteriorated to the malfunction threshold. The adjusted emission value shall be used for purposes of determining whether or not the specified emission threshold is exceeded (e.g., a malfunction must be detected before the adjusted emission value exceeds 2.0 times any applicable standard).

(6.2.1) For purposes of sections (d)(6.2) and (d)(6.3), "regeneration" means an event during which emissions levels change while the emission control performance is being restored by design.

(6.2.2) For purposes of sections (d)(6.2) and (d)(6.3), "infrequent" means having an expected frequency of less than once per FTP cycle.

(6.2.3) For calculating the adjustment factors in section (d)(6.2), the manufacturer shall submit a frequency factor derivation plan to the Executive Officer for approval. The Executive Officer shall approve the plan upon determining the frequency factor derivation appropriately incorporates the impact of the malfunction on the regeneration event frequency.

(6.2.~~3~~4) In lieu of using the procedures described in CFR title 40, parts 86.004-28(i) and 1065.680, the manufacturer may submit an alternate plan to calculate the adjustment factors for determining the adjusted emission values to the Executive Officer for review and approval. Executive Officer approval of the plan shall be conditioned upon the manufacturer providing data and/or engineering evaluation demonstrating the procedure is consistent with good engineering judgment in determining appropriate modifications to the tailpipe certification adjustment factors, and that the frequency factor derivation plan appropriately incorporates the impact of the malfunction on the regeneration event frequency.

(6.3) For 2024 and subsequent model year engines equipped with emission controls that experience infrequent regeneration events, a manufacturer shall adjust the emission test results using the procedure described in CFR title 40, part 1065.680 (current as of August 21, 2018, and incorporated by reference in section (d)(6.2)) when determining if a component meets specific test-out criteria to be exempt from monitoring. For calculating the adjustment factors, the manufacturer shall submit a frequency factor derivation plan to the Executive Officer for approval. The Executive Officer shall approve the plan upon determining the frequency factor derivation appropriately incorporates the impact of the malfunction on the regeneration event frequency. The manufacturer shall conduct testing to determine the adjustment factors using the same deteriorated component(s) used to determine if the test-out criteria in the following sections are met:

(6.3.1) Section (e)(3.2.6)(B)

(6.3.2) Section (e)(5.2.3)(B)(i)

(6.3.3) Section (e)(5.2.3)(D)

(6.3.4) Section (e)(8.2.4)(A)(iii)

(6.3.5) Section (e)(8.2.4)(B)(i)

(6.3.6) Section (g)(3.1.2)

(6.3.7) Section (g)(3.2.2)(F)(ii)

(6.4) Except as provided below, for purposes of determining the malfunction criteria for monitors described in sections (e), (f), and (g) that do not have specified deterioration criteria (e.g., deterioration criteria in section (e)(6.2.3) for NOx converting catalyst conversion efficiency monitors), the manufacturer shall use a component/system deteriorated to the malfunction criteria using methods established by the manufacturer to represent real world deterioration and failure modes under normal and malfunctioning engine and emission control system operating conditions. For monitors described in section (g)(3), the manufacturer is not required to deteriorate the component/system using methods established by the manufacturer to represent real world deterioration and failure modes for purposes of determining the malfunction criteria, but is required to design the monitor to detect real world deterioration and failure modes under normal and malfunctioning engine and emission control system operating conditions.

(6.~~3~~5) In lieu of meeting the malfunction criteria for gasoline engine monitors in sections (f) and (g), the manufacturer may request Executive Officer approval to utilize OBD systems certified to the requirements of title 13, CCR section 1968.2 on medium-duty engines or vehicles. The Executive Officer shall approve the request upon finding that the manufacturer has used good engineering judgment in determining equivalent malfunction detection criteria on the heavy-duty engine.

(7) Implementation Schedule

(7.1) Except as specified in sections (d)(7.4) and (d)(7.5) for small volume manufacturers and alternate-fueled engines, for the 2010 through 2012 model year engines:

(7.1.1) Full OBD. Except as specified in section (d)(7.1.3) below, a manufacturer shall implement an OBD system meeting the requirements of section 1971.1 on one engine rating (i.e., the OBD parent rating) within one of the manufacturer's engine families. The OBD parent rating shall be from the manufacturer's heavy-duty engine family with the highest weighted sales number for the 2010 model year and shall be the engine rating with the highest weighted sales number within that engine family.

(7.1.2) Extrapolated OBD. For all other engine ratings within the engine family selected according to section (d)(7.1.1) (i.e., the OBD child ratings), except as specified in section (d)(7.1.3) below), a manufacturer shall implement an OBD system meeting the requirements of section 1971.1 with the exception that the OBD system is not required to detect a malfunction prior to exceeding the emission thresholds specified in the malfunction criteria in sections (e) through (g). In lieu of detecting a malfunction prior to exceeding the emission thresholds, a manufacturer shall submit a plan for Executive Officer review and approval detailing the engineering evaluation the manufacturer will use to establish the malfunction criteria for the OBD child ratings. The Executive Officer shall approve the plan upon determining that the manufacturer is using good engineering judgment to establish the malfunction criteria for robust detection of malfunctions, including consideration of differences of base engine, calibration, emission control components, and emission control strategies.

(7.1.3) For all engine ratings (i.e., OBD parent and OBD child ratings) within the engine family selected according to (d)(7.1.1):

(A) The OBD system is exempt from having to comply with the standardization requirements set forth in the incorporated documents to this regulation (e.g., SAE J1939 defined format) within the following sections:

(i) (d)(1.2) and (h)(2) (standardized connector)

(ii) (d)(2.1.1) and (2.1.5) (dedicated standardized MIL)

(iii) (h)(3) (communication protocol)

(iv) (h)(4) (standardized communication functions with respect to the requirements to make the data available in a standardized format or in accordance with SAE J1979/1939 specifications)

(v) (h)(5.1.1) and (h)(5.2.1) with respect to the requirements to make the data available in a standardized format or in accordance with SAE J1979/1939 specifications.

(B) The OBD system shall meet the requirements of either sections (d)(2.2.1) and (2.3.1) or (d)(2.2.2) and (2.3.2) regardless of the communication protocol (e.g., standardized, proprietary) used by the OBD system.

(7.1.4) Engine Manufacturer Diagnostic (EMD) Systems. For all engine ratings in the manufacturer’s engine families not selected according to section (d)(7.1.1), a manufacturer shall:

(A) Implement an EMD system meeting the requirements of title 13, CCR section 1971 in lieu of meeting the requirements of section 1971.1; and

(B) Monitor the NOx aftertreatment (i.e., catalyst, adsorber) on engines so-equipped. A malfunction shall be detected if:

(i) The NOx aftertreatment system has no detectable amount of NOx aftertreatment capability (i.e., NOx catalyst conversion or NOx adsorption);

(ii) The NOx aftertreatment substrate is completely destroyed, removed, or missing; or

(iii) The NOx aftertreatment assembly is replaced with a straight pipe.

(7.2) Except as specified in section (d)(7.5) for alternate-fueled engines, for the

2013 through 2015 model year engines:

(7.2.1) A manufacturer shall be required to define one or more OBD groups to cover all engine ratings in all engine families.

(7.2.2) Full OBD. A manufacturer shall implement an OBD system meeting the requirements of section 1971.1:

(A) On all engine ratings (i.e., OBD parent and OBD child ratings) within the engine family selected according to section (d)(7.1.1); and

(B) On one engine rating (i.e., OBD parent rating) within each of the manufacturer's OBD groups. The OBD parent rating shall be the engine rating with the highest weighted sales number for the 2013 model year within each OBD group.

(7.2.3) Extrapolated OBD. For all engine ratings not subject to section (d)(7.2.2) (i.e., OBD child ratings), a manufacturer shall implement an OBD system meeting the requirements of section 1971.1 with the exception that the OBD system is not required to detect a malfunction prior to exceeding the emission thresholds specified in the malfunction criteria in sections (e) through (g). In lieu of detecting a malfunction prior to exceeding the emission thresholds, a manufacturer shall submit a plan for Executive Officer review and approval detailing the engineering evaluation the manufacturer will use to establish the malfunction criteria for the OBD child ratings. The Executive Officer shall approve the plan upon determining that the manufacturer is using good engineering judgment to establish the malfunction criteria for robust detection of malfunctions, including consideration of differences of base engine, calibration, emission control components, and emission control strategies.

(7.3) Except as specified in section (d)(7.5) for alternate-fueled engines, for the 2016 and subsequent model year engines:

(7.3.1) A manufacturer shall implement an OBD system meeting the requirements of section 1971.1 on all engine ratings in all engine families.

(7.3.2) For the tracking requirements described in sections (h)(5.3) through (5.7) for diesel engines, a manufacturer shall meet one of the following two options:

(A) Option 1: The manufacturer shall meet (i) and may meet (ii) below:

(i) For all 2022 and subsequent model year diesel engines, the manufacturer shall meet all requirements of sections (h)(5.3) through (5.7).

(ii) For demonstration testing of 2022 and 2023 model year diesel engines under section (i), the manufacturer may test 15 Executive Officer-selected component/system monitors in lieu of testing all the monitors listed under sections (i)(3.1) and (3.3). The Executive Officer shall inform the manufacturer of the monitors to be tested during engine selection of the demonstration test engine under section (i)(2.1).

(B) Option 2: The manufacturer shall meet both (i) and (ii) below:

(i) For 2022 and 2023 model year diesel engines, the manufacturer shall meet all the requirements of sections (h)(5.3) through (h)(5.7) with the exception of sections (h)(5.3.2)(A), (h)(5.3.2)(B), (h)(5.7.2)(A), and (h)(5.7.2)(B) (i.e,. the active 100 hour array and stored 100 hour array requirements); and

(ii) For 2024 and subsequent model year diesel engines, the manufacturer shall meet all the requirements of sections (h)(5.3) through (h)(5.7).

(7.4) Small volume manufacturers shall be exempt from the requirements of section 1971.1 for 2010 through 2012 model year engines. For purposes of this requirement, a small volume manufacturer is defined as a manufacturer with projected engine sales for California heavy-duty vehicles of less than 1200 engines per year for the 2010 model year.

(7.5) For alternate-fueled engines:

(7.5.1) For 2010 through 2012 model year engines, a manufacturer shall be exempt from the requirements of section 1971.1.

(7.5.2) For 2013 through 2017 model year engines, the manufacturer shall:

(A) Implement an EMD system meeting the requirements of title 13, CCR section 1971 in lieu of meeting the requirements of section 1971.1; and

(B) Monitor the NOx aftertreatment (i.e., catalyst, adsorber) on engines so-equipped. A malfunction shall be detected if:

(i) The NOx aftertreatment system has no detectable amount of NOx aftertreatment capability (i.e., NOx catalyst conversion or NOx adsorption);

(ii) The NOx aftertreatment substrate is completely destroyed, removed, or missing; or

(iii) The NOx aftertreatment assembly is replaced with a straight pipe.

(7.5.3) For 2018 and subsequent model year engines, a manufacturer shall implement an OBD system meeting the requirements of section 1971.1. The manufacturer shall submit a plan to the Executive Officer for approval as described under section (d)(8.1.2) below~~of the monitoring requirements in sections (e) through (g) determined by the manufacturer to be applicable to the engine. Executive Officer approval shall be based on the appropriateness of the monitoring plan with respect to the components and systems on the engine (e.g., a spark-ignited dedicated CNG engine with a particulate matter (PM) filter and a selective catalytic reduction (SCR) system would be monitored in accordance with the misfire monitoring requirements in section (f) for spark-ignited engines and with the PM filter and SCR system monitoring requirements in section (e) for diesel engines typically equipped with the same components)~~.

(7.6) For 2013 model year hybrid vehicles: In lieu of meeting all other requirements of section 1971.1, a manufacturer may meet the alternative requirements set forth in sections (d)(7.6.1) through (d)(7.6.5) below for 2013 model year hybrid vehicles:

(7.6.1) A California-certified 2013 model year engine shall be used as the base engine in the hybrid vehicle design.

(7.6.2) Any modifications made to the base engine's certified OBD system shall be solely for the purpose of preventing false malfunction determinations that could otherwise occur as a result of the integration of the hybrid system hardware and software, and such modifications shall only be made to the extent necessary to achieve this purpose. All modifications are subject to Executive Officer approval. The Executive Officer shall grant approval upon determining that the modifications are necessary and reasonable for the purposes of preventing false malfunction determinations on in-use hybrid vehicles.

(7.6.3) Notwithstanding section (d)(7.6.2) above, no modifications shall be made that would render the certified base engine noncompliant with the EMD plus NOx aftertreatment monitoring requirements set forth in section (d)(7.1.4).

(7.6.4) For all hybrid components, manufacturers shall be exempt from the monitoring requirements of section (g)(3).

(7.6.5) Manufacturers shall apply for certification to the requirements of this section. The application for certification shall identify and describe the certified base engine, the hybrid system mated to it, all changes made to the certified engine along with the rationale describing the need for each change, and the vehicle applications into which the hybrid system will be installed.

(8) Determination of Requirements for Applicable Engines

(8.1) Alternate-Fueled Engines:

(8.1.1) For 2013 through 2017 model year engines, the manufacturer shall meet the requirements described under section (d)(7.5.2) above.

(8.1.2) For 2018 and subsequent model year engines, the manufacturer shall submit a plan to the Executive Officer for review and approval of the requirements in section 1971.1 (including the in-use monitor performance requirements in section (d), the monitoring requirements in sections (e) through (g), and the standardization requirements of section (h)) determined by the manufacturer to be applicable to the engine. Executive Officer approval shall be based on the appropriateness of the monitoring plan with respect to the components and systems on the engine (e.g., a spark-ignited dedicated CNG engine with a particulate matter (PM) filter and a selective catalytic reduction (SCR) system would be monitored in accordance with the misfire monitoring requirements in section (f) for spark-ignited engines and with the PM filter and SCR system monitoring requirements in section (e) for diesel engines typically equipped with the same components).

(8.2) The requirements of section (d)(8.2) apply to gasoline engines equipped with components/systems that are not covered under section (f) but are analogous to components/systems covered under section (e), and apply to diesel engines equipped with components/systems that are not covered under section (e) but are analogous to components/systems covered under section (f). For these engines, the manufacturer shall submit a plan to the Executive Officer for review and approval of the requirements in section 1971.1 (including the in-use monitor performance requirements in section (d), the monitoring requirements in sections (e) through (g) and the standardization requirements of section (h)), determined by the manufacturer to be applicable to the engine. Executive Officer approval shall be based on the appropriateness of the plan with respect to the components and systems on the engine (e.g., a spark-ignited gasoline lean-burn engine with a NOx adsorber and an SCR system would be monitored in accordance with the misfire monitoring requirements in section (f) for spark-ignited engines and with the NOx adsorber and SCR system monitoring requirements in section

(e) for diesel engines typically equipped with the same components).

(8.3) For 2024 and subsequent model year hybrid systems in plug-in hybrid electric vehicles, malfunction criteria for each monitor in sections (e) through (g) that are required to indicate a malfunction before emissions exceed an emission threshold based on the applicable standard shall be determined in the driving mode that results in the worst case emissions (i.e., charge depleting or charge sustaining operation) for each monitor.

(e) *Monitoring Requirements for Diesel/Compression-Ignition Engines.*

(1) Fuel System Monitoring

(1.1) Requirement:

The OBD system shall monitor the fuel delivery system to determine its ability to comply with applicable standards. 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 (g)(3).

(1.2) Malfunction Criteria:

(1.2.1) Fuel system pressure control: The OBD system shall detect a malfunction of the fuel system pressure control system (e.g., fuel, hydraulic fluid) when the fuel system pressure control system is unable to maintain an engine's NMHC, NOx, or CO emissions at or below 2.0 times the applicable standards or the engine's PM emissions at or below the applicable standard plus 0.02 grams per brake horsepower-hour (g/bhp-hr). For engines in which no failure or deterioration of the fuel system pressure control could result in an engine's emissions exceeding these emission levels, the OBD system shall detect a malfunction when the system has reached its control limits such that the commanded fuel system pressure cannot be delivered.

(1.2.2) Injection quantity: The OBD system shall 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 NMHC, CO, and NOx emissions at or below 2.0 times the applicable standards or the engine's PM emissions at or below the applicable standard plus 0.02 g/bhp-hr. For engines in which no failure or deterioration of the fuel injection quantity could result in an engine's emissions exceeding these emission levels, the OBD system shall detect a malfunction when the system has reached its control limits such that the commanded fuel quantity cannot be delivered.

(1.2.3) Injection Timing: The OBD system shall 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 NMHC, CO, and NOx emissions at or below 2.0 times the applicable standards or the engine's PM emissions at or below the applicable standard plus 0.02 g/bhp-hr. For engines in which no failure or deterioration of the fuel injection timing could result in an engine's emissions exceeding these emission levels, the OBD system shall detect a malfunction when the system has reached its control limits such that the commanded fuel injection timing cannot be achieved.

(1.2.4) Feedback control: Except as provided for in section (e)(1.2.5), if the engine is equipped with feedback or feed-forward control of the fuel system (e.g., feedback control of pressure or pilot injection quantity), the OBD system shall detect a malfunction:

(A) If the system fails to begin control within a manufacturer specified time interval;

(B) If a failure or deterioration causes open loop or default operation; or

(C) If the control system has used up all of the adjustment allowed by the manufacturer and cannot achieve the target, or reached its maximum authority and cannot achieve the target.

(1.2.5) A manufacturer may request Executive Officer approval to temporarily disable monitoring for the malfunction criteria specified in section (e)(1.2.4)(C) during conditions that a manufacturer cannot robustly distinguish between a malfunctioning system and a properly operating system. The Executive Officer shall approve the disablement upon the manufacturer submitting data and/or analysis 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.

(1.2.6) In lieu of detecting the malfunctions specified in sections (e)(1.2.4)(A) and (B) with a fuel system-specific monitor, 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 that meet the criteria in sections (e)(1.2.4)(A) and (B).

(1.2.7) For purposes of determining the fuel system malfunction criteria in sections (e)(1.2.1) through (1.2.3):

(A) For 2010 through 2012 model year engines, the malfunction criteria shall be established by using a fault that affects either a single injector or all injectors equally.

(B) For 2013 and subsequent model year engines, for section (e)(1.2.1), the malfunction criteria shall be established by using a fault that affects all injectors equally. Additionally, for systems that have single component failures which could affect a single injector (e.g., systems that build injection pressure within the injector that could have a single component pressure fault caused by the injector itself), the malfunction criteria shall also be established by using a fault that affects a single injector.

(C) For 2013 and subsequent model year engines, for sections (e)(1.2.2) through (1.2.3), the malfunction criteria shall be established by both (1) a fault that affects all the injectors equally and (2) a fault that affects only one injector.

(1.3) Monitoring Conditions:

(1.3.1) Except as provided in sections (e)(1.3.2) and (e)(1.3.4), the OBD system shall monitor continuously for malfunctions identified in sections (e)(1.2.1) and (e)(1.2.4) (i.e., fuel pressure control and feedback operation).

(1.3.2) For fuel systems that achieve injection fuel pressure within the injector or increase pressure within the injector (e.g. in the injector of an amplified common rail system), manufacturers may request Executive Officer approval to define the monitoring conditions for malfunctions identified in sections (e)(1.2.1) in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements). The Executive Officer shall approve the monitoring conditions upon the manufacturer submitting data and/or analysis identifying all possible failure modes and the effect each has (e.g., failure modes and effects analysis) on fuel pressure across the entire range of engine operating conditions, and upon the Executive Officer determining based on the data and/or analysis that the monitoring conditions allow for robust detection of all causes of fuel pressure malfunctions.

(1.3.3) Manufacturers shall define the monitoring conditions for malfunctions identified in sections (e)(1.2.2) and (e)(1.2.3) (i.e., injection quantity and timing) in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements). Additionally, ~~F~~for all 2013 and subsequent model year engines, manufacturers shall track and report the in-use performance of the fuel system monitors under sections (e)(1.2.2) and (e)(1.2.3) in accordance with section (d)(3.2.1). ~~f~~For purposes of tracking and reporting as required in section (d)(3.2.1), all monitors used to detect malfunctions identified in sections (e)(1.2.2) and (e)(1.2.3) shall be tracked separately but reported as a single set of values as specified in section (d)(5.2.2).

(1.3.4) Manufacturers may request Executive Officer approval to temporarily disable continuous monitoring under conditions technically necessary to ensure robust detection of malfunctions and to avoid false passes and false indications of malfunctions. The Executive Officer shall approve the request upon determining that the manufacturer has submitted data and/or an engineering evaluation which demonstrate that a properly operating system cannot be distinguished from a malfunctioning system and that the disablement interval is limited only to that which is technically necessary.

(1.4) MIL Illumination and Fault Code Storage:

(1.4.1) General requirements for MIL illumination and fault code storage are set forth in section (d)(2).

(1.4.2) Additionally, for malfunctions identified in section (e)(1.2.1) (i.e., fuel pressure control) on all 2013 and subsequent model year engines:

(A) A pending fault code shall be stored immediately upon the fuel system exceeding the malfunction criteria established pursuant to section (e)(1.2.1).

(B) Except as provided below, if a pending fault code is stored, the OBD system shall immediately illuminate the MIL and store a confirmed/MIL-on fault code if a malfunction is again detected during either of the following two events: (a) the driving cycle immediately following the storage of the pending fault code, regardless of the conditions encountered during the driving cycle; or (b) on the next driving cycle in which similar conditions (see section (c)) to those that occurred when the pending fault code was stored are encountered.

(C) The pending fault code ~~may~~ shall be erased at the end of the next driving cycle in which similar conditions have been encountered without an exceedance of the specified fuel system malfunction criteria. The pending code may also be erased if similar conditions are not encountered during the 80 driving cycles immediately after the initial detection of a malfunction for which the pending code was set.

(D) Storage of freeze frame conditions.

(i) For 2013 through 2015 model year engines, a manufacturer shall store and erase freeze frame conditions either in conjunction with storing and erasing a pending fault code or in conjunction with storing and erasing a confirmed/MIL-on fault code. For 2016 and subsequent model year engines, a manufacturer shall store and erase freeze frame conditions ~~in conjunction with storing and erasing a pending fault code~~ in accordance with section (d)(2.2.1)(D)(iii) or (d)(2.2.2)(D).

(ii) If freeze frame conditions are stored for a malfunction other than misfire (see section (e)(2)) or fuel system malfunction when a fault code is stored as specified in section (e)(1.4.2) above, the stored freeze frame information shall be replaced with freeze frame information regarding the fuel system malfunction.

(E) Storage of fuel system conditions for determining similar conditions of operation.

(i) Upon detection of a fuel system malfunction under section (e)(1.4.2), the OBD system shall store the engine speed, load, and warm-up status of the first fuel system malfunction that resulted in the storage of the pending fault code.

(ii) The manufacturer may request Executive Officer approval to use an alternate definition of similar conditions in lieu of the definition specified in section (c). The Executive Officer shall approve the alternate definition upon the manufacturer providing data or analysis demonstrating that the alternate definition provides for equivalent robustness in detection of fuel system faults that vary in severity depending on engine speed, load, and/or warm-up status.

(F) Extinguishing the MIL. The MIL may be extinguished after three sequential driving cycles in which similar conditions have been encountered without a malfunction of the fuel system.

(2) Misfire Monitoring

(2.1) Requirement:

(2.1.1) The OBD system shall monitor the engine for misfire. The OBD system shall 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 shall also identify the specific misfiring cylinder.

(2.1.2) If more than one cylinder is continuously misfiring, a separate fault code shall 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 fault codes.

(2.2) Malfunction Criteria:

(2.2.1) The OBD system shall detect a misfire malfunction when one or more cylinders are continuously misfiring.

(2.2.2) Additionally, for 2013 through 2015 model year engines equipped with sensors that can detect combustion or combustion quality (e.g., for use in homogeneous charge compression ignition (HCCI) control systems) and for 20 percent of 2016 model year diesel engines, 50 percent of 2017 model year diesel engines, and 100 percent of 2018 model year diesel engines (percentage based on the manufacturer's projected California sales volume of all diesel engines subject to this regulation), the OBD system shall detect a misfire malfunction when the percentage of misfire is equal to or exceeds five percent.

(A) Manufacturers shall evaluate the percentage of misfire in 1000 revolution increments.

(B) Subject to Executive Officer approval, a manufacturer may employ other revolution increments. The Executive Officer shall grant approval upon determining that the manufacturer has demonstrated that the strategy would be equally effective and timely in detecting misfire.

(2.2.3) A malfunction shall be detected if the percentage of misfire specified in section (e)(2.2.2) is exceeded regardless of the pattern of misfire events (e.g., random, equally spaced, continuous).

(2.2.4) For multiple cylinder misfire situations that result in a misfire rate greater than or equal to 50 percent of all engine firings, the OBD system shall only be required to detect a misfire malfunction for situations that are caused by a single component failure.

(2.2.5) Upon request by the manufacturer and upon determining that the manufacturer has submitted data and/or engineering evaluation that support the request, the Executive Officer shall revise the percentage of misfire malfunction criteria in section (e)(2.2.2) upward to exclude detection of misfire that cannot cause the engine's NMHC, CO, and NOx emissions to exceed 2.0 times the applicable standards and the engine's PM emissions to exceed the applicable standard plus 0.02 g/bhp-hr.

(2.3) Monitoring Conditions:

(2.3.1) Except as provided in section (e)(2.3.2), the OBD system shall monitor for misfires identified in section (e)(2.2.1) during engine idle conditions at least once per driving cycle in which the monitoring conditions for misfire are met. A manufacturer shall submit monitoring conditions to the Executive Officer for approval. The Executive Officer shall approve manufacturer-defined monitoring conditions that are determined (based on manufacturer-submitted data and/or other engineering documentation) to: (i) be technically necessary to ensure robust detection of malfunctions (e.g., avoid false passes and false detection of malfunctions), (ii) require no more than 1000 cumulative engine revolutions, and (iii) 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); or satisfy the requirements of (d)(3.1) with alternative engine operating conditions.

(2.3.2) Manufacturers may request Executive Officer approval to use alternate monitoring conditions (e.g., off-idle) in lieu of the monitoring conditions specified in section (e)(2.3.1). The Executive Officer shall approve alternate monitoring conditions that are determined (based on manufacturer-submitted data and/or other engineering documentation) to ensure equivalent robust detection of malfunctions and equivalent timeliness in detection of malfunctions.

(2.3.3) For misfires identified in section (e)(2.2.2):

(A) The OBD system shall continuously monitor for misfire under the following conditions:

(i) For 2013 through 2018 model year engines and 2019 and subsequent model year engines that are not included in the phase-in specified in section (e)(2.3.3)(A)(ii), under positive torque conditions between 20 percent and 75 percent of peak torque with engine speed up to 75 percent of the maximum engine speed.

(ii) For 20 percent of 2019 model year diesel engines, 50 percent of 2020 model year diesel engines, and 100 percent of 2021 model year diesel engines (percentage based on the manufacturer's projected California sales volume of all diesel engines subject to this regulation), under all positive torque engine speed conditions except within the following range: the engine operating region bound by the positive torque line (i.e., engine torque with transmission in neutral) and the two following points: engine speed of 50 percent of maximum engine speed with the engine torque at the positive torque line, and 100 percent of the maximum engine speed with the engine torque at 10 percent of peak torque above the positive torque line.

(B) If a monitoring system cannot detect all misfire patterns under all required engine speed and load conditions as required in section (e)(2.3.3)(A), the manufacturer may request Executive Officer approval to accept the monitoring system. In evaluating the manufacturer's request, the Executive Officer shall 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, 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), and the extent to which the most reliable monitoring method developed is unable to ensure robust detection of misfire in the region(s). The evaluation shall 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.

(C) A manufacturer may request Executive Officer approval to disable misfire monitoring or employ an alternate malfunction criterion when misfire cannot be distinguished from other effects. Upon determining that the manufacturer has presented documentation that demonstrates the disablement interval or period of use of an alternate malfunction criterion is limited only to that necessary for avoiding false detection, the Executive Officer shall approve the disablement or use of the alternate malfunction criterion. Such disablements may include but are not limited to events involving:

(i) rough road,

(ii) fuel cut,

(iii) gear changes for manual transmission vehicles,

(iv) traction control or other vehicle stability control activation such as anti-lock braking or other engine torque modifications to enhance vehicle stability,

(v) off-board control or intrusive activation of vehicle components or diagnostics during service or assembly plant testing,

(vi) intrusive diagnostics during portions that can significantly affect engine stability, ~~or~~

(vii) infrequent regeneration events during portions that can significantly affect engine stability~~.~~, or

(viii) conditions where the engine coolant temperature is below 70 degrees Fahrenheit (or 21.1 degrees Celsius) on driving cycles where the engine coolant temperature at engine start is below 20 degrees Fahrenheit (or -6.7 degrees Celsius).

(2.4) MIL Illumination and Fault Code Storage:

(2.4.1) General requirements for MIL illumination and fault code storage are set forth in section (d)(2).

(2.4.2) Additionally, for misfires identified in section (e)(2.2.2):

(A) Upon detection of the percentage of misfire specified in section (e)(2.2.2), the following criteria shall apply for MIL illumination and fault code storage:

(i) A pending fault code shall be stored no later than after the fourth exceedance of the percentage of misfire specified in section (e)(2.2.2) during a single driving cycle.

(ii) If a pending fault code is stored, the OBD system shall illuminate the MIL and store a confirmed/MIL-on fault code within 10 seconds if the percentage of misfire specified in section (e)(2.2.2) is again exceeded four times during: (a) the driving cycle immediately following the storage of the pending fault code, regardless of the conditions encountered during the driving cycle; or (b) on the next driving cycle in which similar conditions (see section (c)) to the engine conditions that occurred when the pending fault code was stored are encountered.

(iii) The pending fault code ~~may~~ shall be erased at the end of the next driving cycle in which similar conditions to the engine conditions that occurred when the pending fault code was stored have been encountered without an exceedance of the specified percentage of misfire. The pending code may also be erased if similar conditions are not encountered during the next 80 driving cycles immediately following initial detection of the malfunction.

(B) Storage of freeze frame conditions.

(i) For 2013 through 2015 model year engines, the OBD system shall store and erase freeze frame conditions either in conjunction with storing and erasing a pending fault code or in conjunction with storing a confirmed/MIL-on fault code and erasing a confirmed/previously MIL-on fault code. For 2016 and subsequent model year engines, a manufacturer shall store and erase freeze frame conditions ~~in conjunction with storing and erasing a pending fault code~~ in accordance with section (d)(2.2.1)(D)(iii) or (d)(2.2.2)(D).

(ii) If freeze frame conditions are stored for a malfunction other than a misfire or fuel system malfunction (see section (e)(1)) when a misfire fault code is stored as specified in section (e)(2.4.2), the stored freeze frame information shall be replaced with freeze frame information regarding the misfire malfunction. Alternatively, for the 2010 through 2023 model years, if freeze frame conditions are stored and reported for a fuel system malfunction (section (e)(1)) when a misfire fault code is stored as specified in section (e)(2.4.2) above, the stored freeze frame information may be replaced with freeze frame information regarding the misfire malfunction.

(C) Storage of misfire conditions for similar conditions determination. Upon detection of misfire under section (e)(2.4.2), the OBD system shall 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 fault code.

(D) Extinguishing the MIL. 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

(3.1) Requirement:

(3.1.1) The OBD system shall monitor the EGR system on engines so-equipped for low flow rate, high flow rate, and slow response malfunctions. For engines equipped with EGR coolers (e.g., heat exchangers), the OBD system shall monitor the cooler system for insufficient cooling malfunctions. The individual electronic components (e.g., actuators, valves, sensors) that are used in the EGR system shall be monitored in accordance with the comprehensive component requirements in section (g)(3).

(3.1.2) For engines with other charge control strategies that affect EGR flow (e.g., systems that modify EGR flow to achieve a desired fresh air flow rate instead of a desired EGR flow rate), the manufacturer shall submit a monitoring plan to the Executive Officer for approval. The Executive Officer shall approve the request upon determining that the manufacturer has submitted data and an engineering evaluation that demonstrate that the monitoring plan is as reliable and effective as the monitoring plan required for EGR systems under section (e)(3).

(3.2) Malfunction Criteria:

(3.2.1) Low Flow: The OBD system shall detect a malfunction of the EGR system prior to a decrease from the manufacturer's specified EGR flow rate that would cause an engine's NMHC, CO, or NOx emissions to exceed 2.0 times any of the applicable standards or the engine's PM emissions to exceed the applicable standard plus 0.02 g/bhp-hr. 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 these levels, the OBD system shall detect a malfunction when either the EGR system has reached its control limits such that it cannot increase EGR flow to achieve the commanded flow rate or, for non-feedback controlled EGR systems, the EGR system has no detectable amount of EGR flow when EGR flow is expected.

(3.2.2) High Flow: The OBD system shall 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 NMHC, CO, or NOx emissions to exceed 2.0 times any of the applicable standards or the engine's PM emissions to exceed the applicable standard plus 0.02 g/bhp-hr. 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 these levels, the OBD system shall detect a malfunction when either the EGR system has reached its control limits such that it cannot reduce EGR flow to achieve the commanded flow rate or, for non-feedback controlled EGR systems, the EGR system has maximum detectable EGR flow when little or no EGR flow is expected.

(3.2.3) Slow Response: The OBD system shall detect a malfunction of the EGR system prior to any failure or deterioration in the EGR system response (e.g., capability to achieve the specified flow rate within a manufacturer-specified time) that would cause an engine's NMHC, CO, or NOx emissions to exceed 2.0 times any of the applicable standards or the engine's PM emissions to exceed the applicable standard plus 0.02 g/bhp-hr. The OBD system shall monitor the EGR system response under both increasing and decreasing EGR flow rates. For engines in which no failure or deterioration of the EGR system response could result in an engine's emissions exceeding these levels, the OBD system shall detect a malfunction of the EGR system when no detectable response to a change in commanded or expected flow rate occurs.

(3.2.4) Feedback control: Except as provided for in section (e)(3.2.7), if the engine is equipped with feedback or feed-forward control of the EGR system (e.g., feedback control of flow, valve position, pressure differential across the valve via intake throttle or exhaust backpressure), the OBD system shall detect a malfunction:

(A) If the system fails to begin control within a manufacturer specified time interval;

(B) If a failure or deterioration causes open loop or default operation; or

(C) If the control system has used up all of the adjustment allowed by the manufacturer <u>and cannot achieve the target,</u> or reached its maximum authority and cannot achieve the target.

(3.2.5) EGR Cooler Performance: The OBD system shall detect a malfunction of the EGR cooler system prior to a reduction from the manufacturer's specified cooling performance that would cause an engine's NMHC, CO, or NOx emissions to exceed 2.0 times any of the applicable standards or the engine's PM emissions to exceed the applicable standard plus 0.02 g/bhp-hr. For engines in which no failure or deterioration of the EGR cooler system could result in an engine's emissions exceeding these levels, the OBD system shall detect a malfunction when the system has no detectable amount of EGR cooling.

(3.2.6) EGR Catalyst Performance: For catalysts located in the EGR system on 2013 and subsequent model year engines and used to convert constituents to reduce emissions or protect or extend the durability of other emission-related components (e.g., to reduce fouling of an EGR cooler or valve):

(A) Except as provided for in section (e)(3.2.6)(B) below, the OBD system shall detect a malfunction when the catalyst has no detectable amount of constituent (e.g., hydrocarbons, soluble organic fractions) oxidation.

(B) EGR catalysts are exempt from this monitoring if both of the following criteria are satisfied: (1) no malfunction of the EGR catalyst can cause emissions to increase by 15 percent or more of the applicable NMHC, NOx, CO, or PM standard as measured from an applicable emission test cycle; and (2) no malfunction of the EGR catalyst can cause emissions to exceed the applicable NMHC, NOx, CO, or PM standard as measured from an applicable emission test cycle~~Monitoring of the catalyst is not required if there is no measurable emission impact on the criteria pollutants (i.e., NMHC, CO, NOx, and PM) during any reasonable driving condition in which the catalyst is most likely to affect criteria pollutants~~.

(3.2.7) A manufacturer may request Executive Officer approval to temporarily disable monitoring for the malfunction criteria specified in section (e)(3.2.4)(C) during conditions that a manufacturer cannot robustly distinguish between a malfunctioning system and a properly operating system. The Executive Officer shall approve the disablement upon the manufacturer submitting data and/or analysis 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.

(3.2.8) In lieu of detecting the malfunctions specified in sections (e)(3.2.4)(A) and (B) with an EGR system-specific monitor, the OBD system may monitor the individual parameters or components that are used as inputs for EGR system feedback control provided that the monitors detect all malfunctions that meet the criteria in sections (e)(3.2.4)(A) and (B).

(3.2.9) For purposes of determining the EGR cooler performance malfunction criteria in section (e)(3.2.5) for EGR cooler systems that consist of more than one cooler (e.g., a pre-cooler and a main cooler, two or more coolers in series), the manufacturer shall submit an EGR cooler system aging and monitoring plan to the Executive Officer for review and approval. The plan shall include the description and location of each component, the monitoring strategy for each component and combination of components, and the method for determining the malfunction criteria of section (e)(3.2.5) including the deterioration/aging process. Executive Officer approval of the plan shall be based on the representativeness of the aging to real world EGR cooler system component deterioration under normal and malfunctioning engine operating conditions and the effectiveness of the method used to determine the malfunction criteria of section (e)(3.2.5).

(3.3) Monitoring Conditions:

(3.3.1) Except as provided in section (e)(3.3.4), the OBD system shall monitor continuously for malfunctions identified in sections (e)(3.2.1), (e)(3.2.2), and (e)(3.2.4) (i.e., EGR low and high flow, feedback control). Additionally, for all 2024 and subsequent model year engines, manufacturers shall define monitoring conditions for malfunctions identified in sections (e)(3.2.1), (e)(3.2.2), and (e)(3.2.4) that are continuous and in accordance with section (d)(3.2) (i.e., the minimum ratio requirements), and manufacturers shall track and report the in-use performance of the EGR system monitors under sections (e)(3.2.1), (e)(3.2.2), and (e)(3.2.4) in accordance with section (d)(3.2.1). For purposes of tracking and reporting as required in section (d)(3.2.1), all monitors used to detect malfunctions identified in sections (e)(3.2.1), (e)(3.2.2), and (e)(3.2.4) shall be tracked separately but reported as a single set of values as specified in section (d)(5.2.2).

(3.3.2) Manufacturers shall define the monitoring conditions for malfunctions identified in section (e)(3.2.3) (i.e., slow response) in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements), with the exception that monitoring shall occur every time the monitoring conditions are met during the driving cycle in lieu of once per driving cycle as required in section (d)(3.1.2). Additionally, manufacturers shall track and report the in-use performance of the EGR system monitors under section (e)(3.2.3) in accordance with section (d)(3.2.1). For purposes of tracking and reporting as required in section (d)(3.2.1), all monitors used to detect malfunctions identified in section (e)(3.2.3) shall be tracked separately but reported as a single set of values as specified in section (d)(5.2.2).

(3.3.3) Manufacturers shall define the monitoring conditions for malfunctions identified in sections (e)(3.2.5) and (e)(3.2.6) (i.e., cooler performance and EGR catalyst performance) in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements). Additionally, manufacturers shall track and report the in-use performance of the EGR system monitors under section (e)(3.2.5) in accordance with section (d)(3.2.1). For purposes of tracking and reporting as required in section (d)(3.2.1), all monitors used to detect malfunctions identified in section (e)(3.2.5) shall be tracked separately but reported as a single set of values as specified in section (d)(5.2.2).

(3.3.4) Manufacturers may request Executive Officer approval to temporarily disable continuous monitoring under specific conditions technically necessary to ensure robust detection of malfunctions and to avoid false passes and false indications of malfunctions (e.g., disable EGR low flow monitoring when no or very little flow is commanded, disable EGR high and low flow monitoring when freezing may affect performance of the system). The Executive Officer shall approve the request upon determining that the manufacturer has submitted data and/or an engineering evaluation which demonstrate that a properly operating EGR system cannot be distinguished from a malfunctioning EGR system and that the disablement interval is limited only to that which is technically necessary.

(3.4) MIL Illumination and Fault Code Storage:

(3.4.1) General requirements for MIL illumination and fault code storage are set forth in section (d)(2).

(3.4.2) Additionally, for malfunctions identified in sections (e)(3.2.1) and (e)(3.2.2) (i.e., EGR low and high flow) on all 2024 and subsequent model year engines:

(A) A pending fault code shall be stored immediately upon the EGR flow failing the malfunction criteria established pursuant to section (e)(3.2.1) or (3.2.2).

(B) Except as provided below, if a pending fault code is stored, the OBD system shall immediately illuminate the MIL and store a confirmed/MIL-on fault code if a malfunction is again detected during either of the following two events: (a) the driving cycle immediately following the storage of the pending fault code, regardless of the conditions encountered during the driving cycle; or (b) on the next driving cycle in which similar conditions (see section (c)) to those that occurred when the pending fault code was stored are encountered.

(C) The pending fault code shall be erased at the end of the next driving cycle in which similar conditions have been encountered without an exceedance of the specified EGR system malfunction criteria. The pending code may also be erased if similar conditions are not encountered during the 80 driving cycles immediately after the initial detection of a malfunction for which the pending code was set.

(D) Storage of EGR system conditions for determining similar conditions of operation.

(i) Upon detection of a EGR system malfunction under section (e)(3.4.2), the OBD system shall store the engine speed, load, and warm-up status of the first EGR system malfunction that resulted in the storage of the pending fault code.

(ii) The manufacturer may request Executive Officer approval to use an alternate definition of similar conditions in lieu of the definition specified in section (c). The Executive Officer shall approve the alternate definition upon the manufacturer providing data or analysis demonstrating that the alternate definition provides for equivalent robustness in detection of EGR system faults that vary in severity depending on engine speed, load, and/or warm-up status.

(E) Extinguishing the MIL. The MIL may be extinguished after three sequential driving cycles in which similar conditions have been encountered without a malfunction of the EGR system.

(4) Boost Pressure Control System Monitoring

(4.1) Requirement:

(4.1.1) The OBD system shall monitor the boost pressure control system (e.g., turbocharger) on engines so-equipped for under and over boost malfunctions and slow response malfunctions. For engines equipped with charge air cooler systems, the OBD system shall 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 (g)(3).

(4.1.2) For engines with other charge control strategies that affect boost pressure (e.g., systems that modify boost pressure to achieve a desired air-fuel ratio instead of a desired boost pressure), the manufacturer shall submit a monitoring plan to the Executive Officer for approval. The Executive Officer shall approve the request upon determining that the manufacturer has submitted data and an engineering evaluation that demonstrate that the monitoring plan is as reliable and effective as the monitoring plan required for boost pressure control systems under section (e)(4).

(4.2) Malfunction Criteria:

(4.2.1) Underboost: The OBD system shall detect a malfunction of the boost pressure control system prior to a decrease from the manufacturer's commanded or expected boost pressure that would cause an engine's NMHC, CO, or NOx emissions to exceed 2.0 times any of the applicable standards or the engine's PM emissions to exceed the applicable standard plus 0.02 g/bhp-hr. 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 these levels, the OBD system shall detect a malfunction when either the boost system has reached its control limits such that it cannot increase boost to achieve the commanded boost pressure or, for non-feedback controlled boost systems, the boost system has no detectable amount of boost when boost is expected.

(4.2.2) Overboost: The OBD system shall detect a malfunction of the boost pressure control system prior to an increase from the manufacturer's commanded or expected boost pressure that would cause an engine's NMHC, CO, or NOx emissions to exceed 2.0 times any of the applicable standards or the engine's PM emissions to exceed the applicable standard plus 0.02 g/bhp-hr. 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 these levels, the OBD system shall detect a malfunction when either the boost system has reached its control limits such that it cannot decrease boost to achieve the commanded boost pressure or, for non-feedback controlled boost systems, the boost system has maximum detectable boost when little or no boost is expected.

(4.2.3) Slow response:

(A) For 2010 through 2012 model year engines equipped with variable geometry turbochargers (VGT), the OBD system shall 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 NMHC, CO, or NOx emissions to exceed 2.0 times any of the applicable standards or the engine’s PM emissions to exceed the applicable standard plus 0.02 g/bhp-hr. For engines in which no failure or deterioration of the VGT system response could result in an engine’s emissions exceeding these levels, the OBD system shall detect a malfunction of the VGT system when no detectable response to a change in commanded turbocharger geometry occurs.

(B) For 2013 and subsequent model year engines, the OBD system shall detect a malfunction prior to any failure or deterioration in the boost pressure control system response (e.g., capability to achieve the commanded or expected boost pressure within a manufacturer-specified time) that would cause an engine's NMHC, CO, or NOx emissions to exceed 2.0 times any of the applicable standards or the engine’s PM emissions to exceed the applicable standard plus 0.02 g/bhp-hr. For engines in which no failure or deterioration of the boost system response could result in an engine’s emissions exceeding these levels, the OBD system shall detect a malfunction of the boost system when no detectable response to a commanded or expected change in boost pressure occurs.

(4.2.4) Charge Air Undercooling: The OBD system shall 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 NMHC, CO, or NOx emissions to exceed 2.0 times any of the applicable standards or the engine’s PM emissions to exceed the applicable standard plus 0.02 g/bhp-hr. 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 these levels, the OBD system shall detect a malfunction when the system has no detectable amount of charge air cooling.

(4.2.5) Feedback control: Except as provided for in section (e)(4.2.6), if the engine is equipped with feedback or feed-forward control of the boost pressure system (e.g., control of variable geometry turbocharger position, turbine speed, manifold pressure) the OBD system shall detect a malfunction:

(A) If the system fails to begin control within a manufacturer specified time interval;

(B) If a failure or deterioration causes open loop or default operation; or

(C) If the control system has used up all of the adjustment allowed by the manufacturer <u>and cannot achieve the target,</u> or reached its maximum authority and cannot achieve the target.

(4.2.6) A manufacturer may request Executive Officer approval to temporarily disable monitoring for the malfunction criteria specified in section (e)(4.2.5)(C) during conditions that a manufacturer cannot robustly distinguish between a malfunctioning system and a properly operating system. The Executive Officer shall approve the disablement upon the manufacturer submitting data and/or analysis 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.

(4.2.7) In lieu of detecting the malfunctions specified in sections (e)(4.2.5)(A) and (B) with a boost pressure system-specific monitor, the OBD system may monitor the individual parameters or components that are used as inputs for boost pressure system feedback control provided that the monitors detect all malfunctions that meet the criteria in sections (e)(4.2.5)(A) and (B).

(4.2.8) For purposes of determining the charge air cooling performance malfunction criteria in section (e)(4.2.4) for charge air cooling systems that consist of more than one cooler (e.g., a pre-cooler and a main cooler, two or more coolers in series), the manufacturer shall submit a charge air cooling system aging and monitoring plan to the Executive Officer for review and approval. The plan shall include the description and location of each component, the monitoring strategy for each component and combination of components, and the method for determining the malfunction criteria of section (e)(4.2.4) including the deterioration/aging process. Executive Officer approval of the plan shall be based on the representativeness of the aging to real world charge air cooling system component deterioration under normal and malfunctioning engine operating conditions and the effectiveness of the method used to determine the malfunction criteria of section (e)(4.2.4).

(4.3) Monitoring Conditions:

(4.3.1) Except as provided in section (e)(4.3.4), the OBD system shall monitor continuously for malfunctions identified in sections (e)(4.2.1), (4.2.2), and (4.2.5) (i.e., over and under boost, feedback control). Additionally, for all 2024 and subsequent model year engines, manufacturers shall define monitoring conditions for malfunctions identified in sections (e)(4.2.1), (e)(4.2.2), and (e)(4.2.5) that are continuous and in accordance with section (d)(3.2) (i.e., the minimum ratio requirements), and manufacturers shall track and report the in-use performance of the boost pressure control system monitors under sections (e)(4.2.1), (e)(4.2.2), and (e)(4.2.5) in accordance with section (d)(3.2.1). For purposes of tracking and reporting as required in section (d)(3.2.1), all monitors used to detect malfunctions identified in sections (e)(4.2.1), (e)(4.2.2), and (e)(4.2.5) shall be tracked separately but reported as a single set of values as specified in section (d)(5.2.2).

(4.3.2) Manufacturers shall define the monitoring conditions for malfunctions identified in section (e)(4.2.3) (i.e., slow response) in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements), with the exception that monitoring shall occur every time the monitoring conditions are met during the driving cycle in lieu of once per driving cycle as required in section (d)(3.1.2). Additionally, manufacturers shall track and report the in-use performance of the boost pressure control system monitors under section (e)(4.2.3) in accordance with section (d)(3.2.1). For purposes of tracking and reporting as required in section (d)(3.2.1), all monitors used to detect malfunctions identified in section (e)(4.2.3) shall be tracked separately but reported as a single set of values as specified in section (d)(5.2.2).

(4.3.3) Manufacturers shall define the monitoring conditions for malfunctions identified in section (e)(4.2.4) (i.e., charge air cooler performance) in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements). Additionally, manufacturers shall track and report the in-use performance of the boost pressure control system monitors under section (e)(4.2.4) in accordance with section (d)(3.2.1). For purposes of tracking and reporting as required in section (d)(3.2.1), all monitors used to detect malfunctions identified in section (e)(4.2.4) shall be tracked separately but reported as a single set of values as specified in section (d)(5.2.2).

(4.3.4) Manufacturers may request Executive Officer approval to temporarily disable continuous monitoring under conditions technically necessary to ensure robust detection of malfunctions and to avoid false passes and false indications of malfunctions (e.g., disable monitoring of underboost when commanded or expected boost pressure is very low). The Executive Officer shall approve the request upon determining that the manufacturer has submitted data and/or an engineering evaluation which demonstrate that a properly operating system cannot be distinguished from a malfunctioning system and that the disablement interval is limited only to that which is technically necessary.

(4.4) MIL Illumination and Fault Code Storage:

(4.4.1) General requirements for MIL illumination and fault code storage are set forth in section (d)(2).

(4.4.2) Additionally, for malfunctions identified in sections (e)(4.2.1) and (e)(4.2.2) (i.e., over and under boost) on all 2024 and subsequent model year engines:

(A) A pending fault code shall be stored immediately upon the boost pressure exceeding the malfunction criteria established pursuant to section (e)(4.2.1) or (4.2.2).

(B) Except as provided below, if a pending fault code is stored, the OBD system shall immediately illuminate the MIL and store a confirmed/MIL-on fault code if a malfunction is again detected during either of the following two events: (a) the driving cycle immediately following the storage of the pending fault code, regardless of the conditions encountered during the driving cycle; or (b) on the next driving cycle in which similar conditions (see section (c)) to those that occurred when the pending fault code was stored are encountered.

(C) The pending fault code shall be erased at the end of the next driving cycle in which similar conditions have been encountered without an exceedance of the specified boost pressure control system malfunction criteria. The pending code may also be erased if similar conditions are not encountered during the 80 driving cycles immediately after the initial detection of a malfunction for which the pending code was set.

(D) Storage of boost pressure control system conditions for determining similar conditions of operation.

(i) Upon detection of a boost pressure control system malfunction under section (e)(4.4.2), the OBD system shall store the engine speed, load, and warm-up status of the first boost pressure control system malfunction that resulted in the storage of the pending fault code.

(ii) The manufacturer may request Executive Officer approval to use an alternate definition of similar conditions in lieu of the definition specified in section (c). The Executive Officer shall approve the alternate definition upon the manufacturer providing data or analysis demonstrating that the alternate definition provides for equivalent robustness in detection of boost pressure control system faults that vary in severity depending on engine speed, load, and/or warm-up status.

(E) Extinguishing the MIL. The MIL may be extinguished after three sequential driving cycles in which similar conditions have been encountered without a malfunction of the boost pressure control system.

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

(5.1) Requirement: The OBD system shall monitor the NMHC converting catalyst(s) for proper NMHC conversion capability. For engines equipped with catalyzed PM filters that convert NMHC emissions, the catalyst function of the PM filter shall be monitored in accordance with the PM filter requirements in section (e)(8).

(5.2) Malfunction Criteria:

(5.2.1) For purposes of section (e)(5), each catalyst in a series configuration that converts NMHC shall be monitored either individually or in combination with others.

(5.2.2) Conversion Efficiency:

(A) For 2010 through 2012 model year engines, the OBD system shall detect an NMHC catalyst malfunction when the catalyst conversion capability decreases to the point that NMHC emissions exceed 2.0 times any of the applicable standards.

(B) For 2013 and subsequent model year engines, the OBD system shall detect an NMHC catalyst malfunction when the catalyst conversion capability decreases to the point that NMHC emissions exceed 2.0 times any of the applicable standards or NOx emissions exceed any of the applicable standards by more than 0.2 g/bhp-hr (e.g., cause emissions to exceed 0.4 g/bhp-hr if the exhaust emission standard is 0.2 g/bhp-hr).

(C) If no failure or deterioration of the catalyst conversion capability could result in an engine's NMHC or NOx emissions exceeding the applicable malfunction criteria of section (e)(5.2.2), the OBD system shall detect a malfunction when the catalyst has no detectable amount of NMHC or NOx conversion capability.

(5.2.3) Other Aftertreatment Assistance Functions:

(A) For catalysts used to generate an exotherm to assist PM filter regeneration, the OBD system shall detect a malfunction when the catalyst is unable to generate a sufficient exotherm to achieve regeneration of the PM filter.

(B) For 2015 and subsequent model year engines, except as provided for in sections (e)(5.2.3)(B)(i) through (iii) below, 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 shall detect a malfunction when the catalyst is unable to generate the necessary feedgas constituents for proper SCR system operation. For purposes of this monitoring requirement, the manufacturer shall monitor feedgas constituency generation performance of the NMHC catalyst either by itself or in combination with the catalyzed PM filter described under section (e)(8.2.4)(B).

(i) Catalysts are exempt from this monitoring if both of the following criteria are satisfied: (1) no malfunction of the catalyst's feedgas generation ability can cause emissions to increase by ~~15~~30 percent or more of the applicable NOx standard as measured from an applicable emission test cycle; and (2) no malfunction of the catalyst's feedgas generation ability can cause emissions to exceed the applicable NOx standard as measured from an applicable emission test cycle.

(ii) For purposes of using the monitoring exemption allowance above, the manufacturer shall submit a catalyst deterioration plan to the Executive Officer for review and approval. Executive Officer approval of the plan shall be based on the representativeness of the deterioration method to real world catalyst deterioration replicating a total loss of feedgas constituency generation while still maintaining NMHC conversion capability (e.g., a catalyst loaded only with the production-level specification of palladium).

(iii) For purposes of using the monitoring exemption allowance above, the manufacturer shall conduct the testing using the NMHC catalyst either by itself or in combination with the catalyzed PM filter described under section (e)(8.2.4)(B).

(C) For catalysts located downstream of a PM filter and used to convert NMHC emissions during PM filter regeneration, the OBD system shall detect a malfunction when the catalyst has no detectable amount of NMHC conversion capability.

(D) For catalysts located downstream of an SCR system (e.g., to prevent ammonia slip), the OBD system shall detect a malfunction when the catalyst has no detectable amount of NMHC, CO, NOx, or PM conversion capability. Catalysts are exempt from this monitoring if both of the following criteria are satisfied: (1) the catalyst is part of the SCR catalyst and monitored as part of the SCR system; and (2) the catalyst is aged as part of the SCR system for the purposes of determining the SCR system monitor malfunction criteria under section (e)(6.2.1). For catalysts located outside the SCR system, ~~M~~monitoring of the catalyst is not required if there is no measurable emission impact on the criteria pollutants (i.e., NMHC, CO, NOx, and PM) during any reasonable driving condition ~~in which the catalyst is most likely to affect criteria pollutants (e.g., during conditions most likely to result in ammonia generation or excessive reductant delivery)~~.

(5.2.4) Catalyst System Aging and Monitoring

(A) For purposes of determining the catalyst malfunction criteria in sections (e)(5.2.2) and (5.2.3) for individually monitored catalysts, the manufacturer shall use a catalyst deteriorated to the malfunction criteria using methods established by the manufacturer to represent real world catalyst deterioration under normal and malfunctioning engine operating conditions. If the catalyst system contains catalysts in parallel (e.g., a two bank exhaust system where each bank has its own catalyst), the malfunction criteria shall be determined with the “parallel” catalysts equally deteriorated.

(B) For purposes of determining the catalyst malfunction criteria in sections (e)(5.2.2) and (5.2.3) for catalysts monitored in combination with others, the manufacturer shall submit a catalyst system aging and monitoring plan to the Executive Officer for review and approval. The plan shall include the description, emission control purpose, and location of each component, the monitoring strategy for each component and/or combination of components, and the method for determining the malfunction criteria of sections (e)(5.2.2) and (5.2.3) including the deterioration/aging process. If the catalyst system contains catalysts in parallel (e.g., a two bank exhaust system where each bank has its own catalyst), the malfunction criteria shall be determined with the “parallel” catalysts equally deteriorated. Executive Officer approval of the plan shall be based on the representativeness of the aging to real world catalyst system component deterioration under normal and malfunctioning engine operating conditions, the effectiveness of the method used to determine the malfunction criteria of section (e)(5.2), the ability of the component monitor(s) to pinpoint the likely area of malfunction and ensure the correct components are repaired/replaced in-use, and the ability of the component monitor(s) to accurately verify that each catalyst component is functioning as designed and as required in sections (e)(5.2.2) and (5.2.3).

(5.3) Monitoring Conditions:

(5.3.1) Manufacturers shall define the monitoring conditions for malfunctions identified in sections (e)(5.2.2) and (5.2.3) in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements). <u>Additionally, manufacturers shall track and report the in-use performance of the NMHC converting catalyst monitors under sections (e)(5.2.2) and (e)(5.2.3) in accordance with section (d)(3.2.1).</u> For purposes of tracking and reporting as required in section (d)(3.2.1), all monitors used to detect malfunctions identified in sections (e)(5.2.2) and (5.2.3) shall be tracked separately but reported as a single set of values as specified in section (d)(5.2.2).

(5.4) MIL Illumination and Fault Code Storage:

(5.4.1) General requirements for MIL illumination and fault code storage are set forth in section (d)(2).

(5.4.2) The monitoring method for the catalyst(s) shall be capable of detecting all instances, except diagnostic self-clearing, when a catalyst fault code has been cleared but the catalyst has not been replaced (e.g., catalyst overtemperature histogram approaches are not acceptable).

(6) Oxides of Nitrogen (NOx) Converting Catalyst Monitoring

(6.1) Requirement: The OBD system shall monitor the NOx converting catalyst(s) for proper conversion capability. For engines equipped with selective catalytic reduction (SCR) systems or other catalyst systems that utilize an active/intrusive reductant injection (e.g., active lean NOx catalysts utilizing diesel fuel injection), the OBD system shall monitor the SCR or active/intrusive reductant injection system for proper performance. The individual electronic components (e.g., actuators, valves, sensors, heaters, pumps) in the SCR or active/intrusive reductant injection system shall be monitored in accordance with the comprehensive component requirements in section (g)(3).

(6.2) Malfunction Criteria: For purposes of section (e)(6), each catalyst in a series configuration that converts NOx shall be monitored either individually or in combination with others.

(6.2.1) Conversion Efficiency:

(A) For 2010 through 2012 model year engines:

(i) The OBD system shall detect a catalyst malfunction when the catalyst conversion capability decreases to the point that would cause an engine's NOx emissions to exceed any of the applicable standards by more than 0.4 g/bhp-hr (e.g., cause emissions to exceed 0.6 g/bhp-hr if the exhaust emission standard is 0.2 g/bhp-hr) as measured from an applicable cycle emission test (i.e., FTP or SET).

(ii) If no failure or deterioration of the catalyst NOx conversion capability could result in an engine's NOx emissions exceeding any of the applicable standards by more than 0.4 g/bhp-hr, the OBD system shall detect a malfunction when the catalyst has no detectable amount of NOx conversion capability.

(B) For all 2013 model year engines and 2014 and 2015 model year engines that are not included in the phase-in specified in section (e)(6.2.1)(C):

(i) The OBD system shall detect a catalyst malfunction when the catalyst conversion capability decreases to the point that would cause an engine's emissions to exceed the applicable NOx standard by more than 0.4 g/bhp-hr (e.g., cause emissions to exceed 0.6 g/bhp-hr if the exhaust emission standard is 0.2 g/bhp-hr) as measured from an applicable cycle emission test or 2.0 times the applicable NMHC standard.

(ii) If no failure or deterioration of the catalyst system NOx conversion capability could result in an engine's NOx or NMHC emissions exceeding the applicable malfunction criteria of section (e)(6.2.1)(B)(i), the OBD system shall detect a malfunction when the catalyst has no detectable amount of NOx or NMHC conversion capability.

(C) For at least 20 percent of 2014 model year diesel engines and at least 50 percent of 2015 model year diesel engines (percentage based on the manufacturer's projected California sales volume of all diesel engines subject to this regulation):

(i) The OBD system shall detect a catalyst malfunction when the catalyst conversion capability decreases to the point that would cause an engine's emissions to exceed the applicable NOx standard by more than 0.3 g/bhp-hr (e.g., cause emissions to exceed 0.5 g/bhp-hr if the exhaust emission standard is 0.2 g/bhp-hr) as measured from an applicable cycle emission test or 2.0 times the applicable NMHC standard.

(ii) If no failure or deterioration of the catalyst system NOx conversion capability could result in an engine's NOx or NMHC emissions exceeding the applicable malfunction criteria of section (e)(6.2.1)(C)(i), the OBD system shall detect a malfunction when the catalyst has no detectable amount of NOx or NMHC conversion capability.

(D) Except as provided for below in section (e)(6.2.1)(E), for 2016 and subsequent model year engines:

(i) The OBD system shall detect a catalyst malfunction when the catalyst conversion capability decreases to the point that would cause an engine's emissions to exceed the applicable NOx standard by more than 0.2 g/bhp-hr (e.g., cause emissions to exceed 0.4 g/bhp-hr if the exhaust emission standard is 0.2 g/bhp-hr) as measured from an applicable cycle emission test or 2.0 times the applicable NMHC standard.

(ii) If no failure or deterioration of the catalyst system NOx conversion capability could result in an engine's NOx or NMHC emissions exceeding the applicable malfunction criteria of section (e)(6.2.1)(D)(i), the OBD system shall detect a malfunction when the catalyst has no detectable amount of NOx or NMHC conversion capability.

(E) In lieu of using the malfunction criteria in section (e)(6.2.1)(D), a manufacturer may continue to use the malfunction criteria in section (e)(6.2.1)(C) for any 2016 model year engine that was previously certified in the 2014 or 2015 model year to the malfunction criteria in section (e)(6.2.1)(C) and carried over to the 2016 model year.

(6.2.2) Selective Catalytic Reduction (SCR) or Other Active/Intrusive Reductant Injection System Performance:

(A) Reductant Delivery Performance:

(i) For 2010 through 2012 model year engines, the OBD system shall detect a malfunction prior to any failure or deterioration of the system to properly regulate reductant delivery (e.g., urea injection, separate injector fuel injection, post injection of fuel, air assisted injection/mixing) that would cause an engine's NOx emissions to exceed any of the applicable standards by more than 0.4 g/bhp-hr (e.g., cause emissions to exceed 0.6 g/bhp-hr if the exhaust emission standard is 0.2 g/bhp-hr) as measured from an applicable cycle emission test (i.e., FTP or SET). If no failure or deterioration of the SCR system could result in an engine's NOx emissions exceeding any of the applicable standards by more than 0.4 g/bhp-hr, the OBD system shall 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.

(ii) For all 2013 model year engines and 2014 and 2015 model year engines that are not included in the phase-in specified in section (e)(6.2.2)(A)(iii):

a. The OBD system shall detect a malfunction prior to any failure or deterioration of the system to properly regulate reductant delivery (e.g., urea injection, separate injector fuel injection, post injection of fuel, air assisted injection/mixing) that would cause an engine's emissions to exceed the applicable NOx standard by more than 0.4 g/bhp-hr (e.g., cause emissions to exceed 0.6 g/bhp-hr if the exhaust emission standard is 0.2 g/bhp-hr) as measured from an applicable cycle emission test or 2.0 times the applicable NMHC standard.

b. If no failure or deterioration of the SCR system could result in an engine's NOx or NMHC emissions exceeding the applicable malfunction criteria of section (e)(6.2.2)(A)(ii)a., the OBD system shall 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.

(iii) For at least 20 percent of all 2014 model year diesel engines and at least 50 percent of all 2015 model year diesel engines (percentage based on the manufacturer's projected California sales volume of all diesel engines subject to this regulation):

a. The OBD system shall detect a malfunction prior to any failure or deterioration of the system to properly regulate reductant delivery (e.g., urea injection, separate injector fuel injection, post injection of fuel, air assisted injection/mixing) that would cause an engine's emissions to exceed the applicable NOx standard by more than 0.3 g/bhp-hr (e.g., cause emissions to exceed 0.5 g/bhp-hr if the exhaust emission standard is 0.2 g/bhp-hr) as measured from an applicable cycle emission test or 2.0 times the applicable NMHC standard.

b. If no failure or deterioration of the SCR system could result in an engine's NOx or NMHC emissions exceeding the applicable malfunction criteria of section (e)(6.2.2)(A)(iii)a., the OBD system shall 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.

(iv) Except as provided for below in section (e)(6.2.2)(A)(v), for 2016 and subsequent model year engines, the OBD system shall detect a system malfunction prior to any failure or deterioration of the system to properly regulate reductant delivery (e.g., urea injection, separate injector fuel injection, post injection of fuel, air assisted injection/mixing) that would cause an engine's emissions to exceed the applicable NOx standard by more than 0.2 g/bhp-hr (e.g., cause emissions to exceed 0.4 g/bhp-hr if the exhaust emission standard is 0.2 g/bhp-hr) as measured from an applicable cycle emission test or 2.0 times the applicable NMHC standard. If no failure or deterioration of the SCR system could result in an engine's NOx or NMHC emissions exceeding the applicable malfunction criteria above, the OBD system shall 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.

(v) In lieu of using the malfunction criteria in section (e)(6.2.2)(A)(iv), a manufacturer may continue to use the malfunction criteria in section (e)(6.2.2)(A)(iii) for any 2016 model year engine that was previously certified in the 2014 or 2015 model year to the malfunction criteria in section (e)(6.2.2)(A)(iii) and carried over to the 2016 model year.

(B) Except as provided for in section (e)(6.2.2)(G), ~~I~~if the catalyst 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 shall detect a malfunction when there is no longer sufficient reductant available to properly operate the reductant system (e.g., the reductant tank is empty).

(C) Except as provided for in section (e)(6.2.2)(H), ~~I~~if the catalyst system uses a reservoir/tank for the reductant that is separate from the fuel tank used for the engine, the OBD system shall 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 reductant).

(D) Feedback control: Except as provided for in section (e)(6.2.2)(E), if the engine is equipped with feedback or feed-forward control of the reductant injection (e.g., dosing quantity, pressure control), the OBD system shall detect a malfunction:

(i) If the system fails to begin control within a manufacturer specified time interval;

(ii) If a failure or deterioration causes open loop or default operation; or

(iii) If the control system has used up all of the adjustment allowed by the manufacturer and cannot achieve the target, or reached its maximum authority and cannot achieve the target.

(E) A manufacturer may request Executive Officer approval to temporarily disable monitoring for the malfunction criteria specified in section (e)(6.2.2)(D)(iii) during conditions that a manufacturer cannot robustly distinguish between a malfunctioning system and a properly operating system. The Executive Officer shall approve the disablement upon the manufacturer submitting data and/or analysis 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.

(F) In lieu of detecting the malfunctions specified in sections (e)(6.2.2)(D)(i) and (ii) with a reductant injection system-specific monitor, the OBD system may monitor the individual parameters or components that are used as inputs for reductant injection feedback control provided that the monitors detect all malfunctions that meet the criteria in sections (e)(6.2.2)(D)(i) and (ii).

(G) A manufacturer may request to be exempted from the monitoring requirements specified in section (e)(6.2.2)(B) (i.e., monitoring for insufficient reductant). The Executive Officer shall approve the request upon determining that the engine has an inducement strategy designed to prevent sustained engine operation with no reductant and that the manufacturer is monitoring all inputs to the inducement strategy (e.g., reductant level sensor) in accordance with the comprehensive component requirements in section (g)(3).

(H) A manufacturer may request to be exempted from the monitoring requirements specified in section (e)(6.2.2)(C) (i.e., monitoring for improper reductant). The Executive Officer shall approve the request upon determining that the engine has an inducement strategy designed to prevent sustained engine operation with poor quality reductant and that the manufacturer is monitoring all inputs to the inducement strategy (e.g., reductant quality sensor) in accordance with the comprehensive component requirements in section (g)(3).

(6.2.3) Catalyst System Aging and Monitoring

(A) For purposes of determining the catalyst malfunction criteria in section (e)(6.2.1) for individually monitored catalysts, the manufacturer shall use a catalyst deteriorated to the malfunction criteria using methods established by the manufacturer to represent real world catalyst deterioration under normal and malfunctioning engine operating conditions. If the catalyst system contains more than one catalyst in series, the manufacturer shall use a catalyst system (including all NOx converting catalysts) deteriorated to the malfunction criteria using methods established by the manufacturer to represent real world catalyst deterioration under normal and malfunctioning engine operating conditions. If the catalyst system contains catalysts in parallel (e.g., a two bank exhaust system where each bank has its own catalyst), the malfunction criteria shall be determined with the “parallel” catalysts equally deteriorated.

(B) For purposes of determining the catalyst malfunction criteria in section (e)(6.2.1) for catalysts monitored in combination with others, the manufacturer shall submit a catalyst system aging and monitoring plan to the Executive Officer for review and approval. The plan shall include the description, emission control purpose, and location of each component, the monitoring strategy for each component and/or combination of components, and the method for determining the malfunction criteria of section (e)(6.2.1) including the deterioration/aging process. If the catalyst system contains catalysts in parallel (e.g., a two bank exhaust system where each bank has its own catalyst), the malfunction criteria shall be determined with the “parallel” catalysts equally deteriorated. Executive Officer approval of the plan shall be based on the representativeness of the aging to real world catalyst system component deterioration under normal and malfunctioning engine operating conditions, the effectiveness of the method used to determine the malfunction criteria of section (e)(6.2.1), the ability of the component monitor(s) to pinpoint the likely area of malfunction and ensure the correct components are repaired/replaced in-use, and the ability of the component monitor(s) to accurately verify that each catalyst component is functioning as designed and as required in section (e)(6.2.1).

(6.3) Monitoring Conditions:

(6.3.1) Manufacturers shall define the monitoring conditions for malfunctions identified in sections (e)(6.2.1), (e)(6.2.2)(A), and (e)(6.2.2)(C) (i.e., catalyst efficiency, reductant delivery performance, and improper reductant) in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements). Additionally, manufacturers shall track and report the in-use performance of the NOx converting catalyst monitors under section (e)(6.2.1) in accordance with section (d)(3.2.1). For purposes of tracking and reporting as required in section (d)(3.2.1), all monitors used to detect malfunctions identified in section (e)(6.2.1) shall be tracked separately but reported as a single set of values as specified in section (d)(5.2.2).

(6.3.2) Except as provided in section (e)(6.3.3), the OBD system shall monitor continuously for malfunctions identified in sections (e)(6.2.2)(B) and (D) (i.e., insufficient reductant, feedback control).

(6.3.3) Manufacturers may request Executive Officer approval to temporarily disable continuous monitoring under conditions technically necessary to ensure robust detection of malfunctions and to avoid false passes and false indications of malfunctions. The Executive Officer shall approve the request upon determining that the manufacturer has submitted data and/or an engineering evaluation which demonstrate that a properly operating system cannot be distinguished from a malfunctioning system and that the disablement interval is limited only to that which is technically necessary.

(6.4) MIL Illumination and Fault Code Storage:

(6.4.1) Except as provided below for reductant faults, general requirements for MIL illumination and fault code storage are set forth in section (d)(2).

(6.4.2) If the OBD system is capable of discerning that a system fault is being caused by a empty reductant tank:

(A) The manufacturer may request Executive Officer approval to delay illumination of the MIL if the vehicle is equipped with an alternative indicator for notifying the vehicle operator of the malfunction. The Executive Officer shall approve the request upon determining the alternative indicator is of sufficient illumination and location to be readily visible under all lighting conditions and provides equivalent assurance that a vehicle operator will be promptly notified and that corrective action will be undertaken.

(B) If the vehicle is not equipped with an alternative indicator and the MIL illuminates, the MIL may be immediately extinguished and the corresponding fault codes 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.

(C) The Executive Officer may approve other strategies that provide equivalent assurance that a vehicle operator will be promptly notified and that corrective action will be undertaken.

(6.4.3) The monitoring method for the catalyst(s) shall be capable of detecting all instances, except diagnostic self-clearing, when a catalyst fault code has been cleared but the catalyst has not been replaced (e.g., catalyst overtemperature histogram approaches are not acceptable).

(7) NOx Adsorber Monitoring

(7.1) Requirement: The OBD system shall monitor the NOx adsorber(s) 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 desorption of the NOx adsorber(s), the OBD system shall 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 shall be monitored in accordance with the comprehensive component requirements in section (g)(3).

(7.2) Malfunction Criteria:

(7.2.1) NOx adsorber capability:

(A) For 2010 through 2012 model year engines, the OBD system shall detect a NOx adsorber system malfunction when the NOx adsorber system capability decreases to the point that would cause an engine's NOx emissions to exceed any of the applicable standards by more than 0.3 g/bhp-hr (e.g., cause emissions to exceed 0.5 g/bhp-hr if the exhaust emission standard is 0.2 g/bhp-hr) as measured from an applicable cycle emission test (i.e., FTP or SET). If no failure or deterioration of the NOx adsorber system capability could result in an engine's NOx emissions exceeding any of the applicable standards by more than 0.3 g/bhp-hr, the OBD system shall detect a malfunction when the system has no detectable amount of NOx adsorber capability.

(B) For 2013 and subsequent model year engines, the OBD system shall detect a NOx adsorber system malfunction when the NOx adsorber capability decreases to the point that would cause an engine's emissions to exceed the applicable NOx standards by more than 0.2 g/bhp-hr (e.g., cause emissions to exceed 0.4 g/bhp-hr if the exhaust emission standard is 0.2 g/bhp-hr) as measured from an applicable cycle emission test (i.e., FTP or SET) or 2.0 times the applicable NMHC standard. If no failure or deterioration of the NOx adsorber capability could result in an engine's NOx or NMHC emissions exceeding the applicable malfunction criteria above, the OBD system shall detect a malfunction when the system has no detectable amount of NOx adsorber capability.

(7.2.2) For systems that utilize active/intrusive injection (e.g., in-cylinder post fuel injection, in-exhaust air-assisted fuel injection) to achieve desorption of the NOx adsorber, the OBD system shall 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 NOx adsorber.

(7.2.3) Feedback control: Except as provided for in section (e)(7.2.4), if the engine is equipped with feedback or feed-forward control of the NOx adsorber or active/intrusive injection system (e.g., feedback control of injection quantity, time), the OBD system shall detect a malfunction:

(A) If the system fails to begin control within a manufacturer specified time interval;

(B) If a failure or deterioration causes open loop or default operation; or

(C) If the control system has used up all of the adjustment allowed by the manufacturer <u>and cannot achieve the target,</u> or reached its maximum authority and cannot achieve the target.

(7.2.4) A manufacturer may request Executive Officer approval to temporarily disable monitoring for the malfunction criteria specified in section (e)(7.2.3)(C) during conditions that a manufacturer cannot robustly distinguish between a malfunctioning system and a properly operating system. The Executive Officer shall approve the disablement upon the manufacturer submitting data and/or analysis 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.

(7.2.5) In lieu of detecting the malfunctions specified in sections (e)(7.2.3)(A) and (B) with a NOx adsorber-specific monitor, the OBD system may monitor the individual parameters or components that are used as inputs for NOx adsorber or active/intrusive injection system feedback control provided that the monitors detect all malfunctions that meet the criteria in sections (e)(7.2.3)(A) and (B).

(7.2.6) For purposes of determining the NOx adsorber system malfunction criteria in section (e)(7.2.1), the manufacturer shall meet the following requirements:

(A) For individually monitored NOx adsorbers, the manufacturer shall use a NOx adsorber deteriorated to the malfunction criteria using methods established by the manufacturer to represent real world NOx adsorber deterioration under normal and malfunctioning engine operating conditions. If the NOx adsorber system contains NOx adsorbers in parallel (e.g., a two bank exhaust system where each bank has its own NOx adsorber), the malfunction criteria shall be determined with the "parallel" NOx adsorbers equally deteriorated.

(B) ~~f~~For NOx adsorber systems that consist of more than one NOx adsorber (e.g., two or more adsorbers in series), the manufacturer shall submit a system aging and monitoring plan to the Executive Officer for review and approval. The plan shall include the description and location of each component, the monitoring strategy for each component and/or combination of components, and the method for determining the malfunction criteria of section (e)(7.2.1) including the deterioration/aging process. Executive Officer approval of the plan shall be based on the representativeness of the aging to real world NOx adsorber system component deterioration under normal and malfunctioning engine operating conditions, the effectiveness of the method used to determine the malfunction criteria of section (e)(7.2.1), the ability of the component monitor(s) to pinpoint the likely area of malfunction and ensure the correct components are repaired/replaced in-use, and the ability of the component monitor(s) to accurately verify that each NOx adsorber system component is functioning as designed and as required in section (e)(7.2.1).

(7.3) Monitoring Conditions:

(7.3.1) Manufacturers shall define the monitoring conditions for malfunctions identified in sections (e)(7.2.1) (i.e., adsorber capability) in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements). Additionally, manufacturers shall track and report the in-use performance of the NOx adsorber monitors under section (e)(7.2.1) in accordance with section (d)(3.2.1). For purposes of tracking and reporting as required in section (d)(3.2.1), all monitors used to detect malfunctions identified in sections (e)(7.2.1) shall be tracked separately but reported as a single set of values as specified in section (d)(5.2.2).

(7.3.2) Except as provided in section (e)(7.3.3), the OBD system shall monitor continuously for malfunctions identified in sections (e)(7.2.2) and (7.2.3) (e.g., injection function, feedback control).

(7.3.3) Manufacturers may request Executive Officer approval to temporarily disable continuous monitoring under conditions technically necessary to ensure robust detection of malfunctions and to avoid false passes and false indications of malfunctions. The Executive Officer shall approve the request upon determining that the manufacturer has submitted data and/or an engineering evaluation which demonstrate that a properly operating system cannot be distinguished from a malfunctioning system and that the disablement interval is limited only to that which is technically necessary.

(7.4) MIL Illumination and Fault Code Storage: General requirements for MIL illumination and fault code storage are set forth in section (d)(2).

(8) Particulate Matter (PM) Filter Monitoring

(8.1) Requirement: The OBD system shall monitor the PM filter on engines so-equipped for proper performance. 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 shall 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 shall be monitored in accordance with the comprehensive component requirements in section (g)(3).

(8.2) Malfunction Criteria:

(8.2.1) Filtering Performance:

(A) For 2010 through 2012 model year engines, the OBD system shall detect a malfunction prior to a decrease in the filtering capability of the PM filter (e.g., cracking) that would cause an engine's PM emissions to exceed either of the following thresholds, whichever is higher: 0.07 g/bhp-hr as measured from an applicable emission test cycle (i.e., FTP or SET); or the applicable standard plus 0.06 g/bhp-hr (e.g., 0.07 g/bhp-hr if the exhaust emission standard is 0.01 g/bhp-hr). If no failure or deterioration of the PM filtering performance could result in an engine's PM emissions exceeding these levels, the OBD system shall detect a malfunction when no detectable amount of PM filtering occurs.

(B) For all 2013 model year engines and 2014 and 2015 model year engines that are not included in the phase-in specified in section (e)(8.2.1)(C) the OBD system shall detect a malfunction prior to a decrease in the filtering capability of the PM filter that would cause an engine's PM emissions to exceed either of the following thresholds, whichever is higher: 0.05 g/bhp-hr as measured from an applicable emission test cycle (i.e., FTP or SET); or the applicable standard plus 0.04 g/bhp-hr (e.g., 0.05 g/bhp-hr if the exhaust emission standard is 0.01 g/bhp-hr). If no failure or deterioration of the PM filtering performance could result in an engine's PM emissions exceeding these levels, the OBD system shall detect a malfunction when no detectable amount of PM filtering occurs.

(C) For 2014 through 2015 model year engines, the manufacturer shall meet one of the following two options below:

(i) For at least 20 percent of 2014 model year diesel engines and at least 20 percent of 2015 model year diesel engines (percentage based on the manufacturer's projected California sales volume of all diesel engines subject to this regulation), the OBD system shall use the malfunction criteria of section (e)(8.2.1)(B) without using the provisions of section (g)(5.1) to exclude specific failure modes.

(ii) For at least 50 percent of 2015 model year diesel engines (percentage based on the manufacturer's projected California sales volume of all diesel engines subject to this regulation), the OBD system shall detect a malfunction prior to a decrease in the filtering capability of the PM filter that would cause an engine's PM emissions to exceed either of the following thresholds, whichever is higher, without using the provisions of section (g)(5.1) to exclude specific failure modes: 0.03 g/bhp-hr as measured from an applicable emission test cycle (i.e., FTP or SET); or the applicable standard plus 0.02 g/bhp-hr (e.g., 0.03 g/bhp-hr if the exhaust emission standard is 0.01 g/bhp-hr). If no failure or deterioration of the PM filtering performance could result in an engine's PM emissions exceeding these levels, the OBD system shall detect a malfunction when no detectable amount of PM filtering occurs.

(D) Except as provided in section (e)(8.2.1)(~~E~~F), for ~~all~~ 2016 ~~and subsequent~~through 2023 model year engines, the OBD system shall detect a malfunction prior to a decrease in the filtering capability of the PM filter that would cause an engine's PM emissions to exceed either of the following thresholds, whichever is higher: 0.03 g/bhp-hr as measured from an applicable emission test cycle (i.e., FTP or SET); or the applicable standard plus 0.02 g/bhp-hr (e.g., 0.03 g/bhp-hr if the exhaust emission standard is 0.01 g/bhp-hr). If no failure or deterioration of the PM filtering performance could result in an engine's PM emissions exceeding these levels, the OBD system shall detect a malfunction when no detectable amount of PM filtering occurs.

(E) For all 2024 and subsequent model year engines, the OBD system shall detect a malfunction prior to a decrease in the filtering capability of the PM filter that would cause an engine's emissions to exceed the applicable NOx standard by more than 0.2 g/bhp-hr (e.g., exceed 0.4 g/bhp-hr if the exhaust emission standard is 0.2 g/bhp-hr) as measured from an applicable cycle emission test, or either of the following thresholds for PM emissions, whichever is higher: 0.03 g/bhp-hr as measured from an applicable emission test cycle (i.e., FTP or SET); or the applicable standard plus 0.02 g/bhp-hr (e.g., 0.03 g/bhp-hr if the exhaust emission standard is 0.01 g/bhp-hr). If no failure or deterioration of the PM filtering performance could result in an engine's emissions exceeding these levels, the OBD system shall detect a malfunction when no detectable amount of PM filtering occurs.

(~~E~~F) In lieu of the malfunction criteria in section (e)(8.2.1)(D), a manufacturer may continue to use the malfunction criteria in section (e)(8.2.1)(C)(i) for any 2016 model year engine that was previously certified in the 2014 or 2015 model year to the malfunction criteria in section (e)(8.2.1)(C)(i) and carried over to the 2016 model year.

(~~F~~G) For the phase-in schedules described in section (e)(8.2.1)(C) above, the manufacturer may not use an alternate phase-in schedule as defined in section (c) in lieu of the required phase-in schedules.

(8.2.2) Frequent Regeneration: The OBD system shall detect a malfunction when the PM filter regeneration occurs more frequently than (i.e., occurs more often than) the manufacturer's specified regeneration frequency to a level such that it would cause an engine's emissions to exceed the following:

(A) For 2010 through 2012 model year engines, 2.0 times the applicable NMHC standards.

(B) For 2013 and subsequent model year engines, 2.0 times the applicable NMHC standards or the applicable NOx standard by more than 0.2 g/bhp-hr (e.g., cause NOx emissions to exceed 0.4 g/bhp-hr if the exhaust emission standard is 0.2 g/bhp-hr).

(C) If no failure or deterioration causes an increase in the PM filter regeneration frequency that could result in an engine's emissions exceeding the emission levels specified above, the OBD system shall detect a malfunction when the PM filter regeneration frequency exceeds the manufacturer's specified design limits for allowable regeneration frequency.

(8.2.3) Incomplete regeneration: The OBD system shall detect a regeneration malfunction when the PM filter does not properly regenerate under manufacturer-defined conditions where regeneration is designed to occur.

(8.2.4) Catalyzed PM Filter:

(A) NMHC conversion: For 2015 and subsequent model year engines with catalyzed PM filters that convert NMHC emissions:

(i) The OBD system shall monitor the catalyst function of the PM filter and detect a malfunction when the NMHC conversion capability decreases to the point that ~~NMHC~~ emissions exceed the following:

a. For 2015 through 2023 model year engines, 2.0 times the applicable NMHC standards.

b. For 2024 and subsequent model year engines, 2.0 times the applicable NMHC emissions or the applicable NOx standard by more than 0.2 g/bhp-hr (e.g., exceed 0.4 g/bhp-hr if the exhaust emission standard is 0.2 g/bhp-hr) as measured from an applicable cycle emission test.

(ii) If no failure or deterioration of the NMHC conversion capability could result in an engine's NMHC emissions exceeding ~~2.0 times the applicable standards~~the emission levels specified in section (e)(8.2.4)(A)(i) above, the OBD system shall detect a malfunction when the system has no detectable amount of NMHC conversion capability.

(iii) Catalyzed PM filters are exempt from this monitoring if both of the following criteria are satisfied: (1) no malfunction of the catalyzed PM filter's NMHC conversion capability can cause emissions to increase by 15 percent or more of the applicable NMHC, NOx, CO, or PM standard as measured from an applicable emission test cycle; and (2) no malfunction of the catalyzed PM filter's NMHC conversion capability can cause emissions to exceed the applicable NMHC, NOx, CO, or PM standard as measured from an applicable emission test cycle.

(B) Feedgas generation: For 2016 and subsequent model year engines with catalyzed PM filters used to generate a feedgas constituency to assist SCR systems (e.g., to increase NO_2 concentration upstream of an SCR system), except as provided below in sections (e)(8.2.4)(B)(i) through (iii) below, the OBD system shall detect a malfunction when the system is unable to generate the necessary feedgas constituents for proper SCR system operation. For purposes of this monitoring requirement, the manufacturer shall monitor feedgas generation performance of the catalyzed PM filter either by itself or in combination with the NMHC catalyst described under section (e)(5.2.3)(B).

(i) Catalyzed PM filters are exempt from this monitoring if both of the following criteria are satisfied: (1) no malfunction of the catalyzed PM filter's feedgas generation ability can cause emissions to increase by 30~~15~~ percent or more of the applicable NOx standard as measured from an applicable emission test cycle; and (2) no malfunction of the catalyzed PM filter's feedgas generation ability can cause emissions to exceed the applicable NOx standard as measured from an applicable emission test cycle.

(ii) For purposes of using the monitoring exemption allowance above, the manufacturer shall submit a catalyzed PM filter deterioration plan to the Executive Officer for review and approval. Executive Officer approval of the plan shall be based on the representativeness of the deterioration method to real world catalyzed PM filter deterioration replicating a total loss of feedgas generation while still maintaining NMHC conversion capability (e.g., a catalyzed PM filter loaded only with the production-level specification of palladium).

(iii) For purposes of using the monitoring exemption allowance above, the manufacturer shall conduct the testing using the catalyzed PM filter either by itself or in combination with the NMHC catalyst described under section (e)(5.2.3)(B).

(8.2.5) Missing substrate: The OBD system shall detect a malfunction if ~~either~~ the PM filter substrate is completely destroyed, removed, or missing, or if the PM filter assembly is replaced with a muffler or straight pipe.

(8.2.6) Active/Intrusive Injection: For systems that utilize active/intrusive injection (e.g., in-cylinder post fuel injection, in-exhaust air-assisted fuel injection) to achieve regeneration of the PM filter, the OBD system shall 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 regeneration of the PM filter.

(8.2.7) Feedback Control: Except as provided for in section (e)(8.2.8), if the engine is equipped with feedback or feed-forward control of the PM filter 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 shall detect a malfunction:

(A) If the system fails to begin control within a manufacturer specified time interval;

(B) If a failure or deterioration causes open loop or default operation; or

(C) If the control system has used up all of the adjustment allowed by the manufacturer and cannot achieve the target, or reached its maximum authority and cannot achieve the target.

(8.2.8) A manufacturer may request Executive Officer approval to temporarily disable monitoring for the malfunction criteria specified in section (e)(8.2.7)(C) during conditions that a manufacturer cannot robustly distinguish between a malfunctioning system and a properly operating system. The Executive Officer shall approve the disablement upon the manufacturer submitting data and/or analysis 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.

(8.2.9) In lieu of detecting the malfunctions specified in sections (e)(8.2.7)(A) and (B) with a PM filter-specific monitor, the OBD system may monitor the individual parameters or components that are used as inputs for PM filter regeneration feedback control provided that the monitors detect all malfunctions that meet the criteria in sections (e)(8.2.7)(A) and (B).

(8.3) Monitoring Conditions:

(8.3.1) Manufacturers shall define the monitoring conditions for malfunctions identified in sections (e)(8.2.1) ~~through (8.2.6)~~ in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements)~~, with the exception that monitoring shall occur every time the monitoring conditions are met during the driving cycle in lieu of once per driving cycle as required in section (d)(3.1.2)~~. Additionally, manufacturers shall track and report the in-use performance of the PM filter monitors under section (e)(8.2.1) in accordance with section (d)(3.2.1). For purposes of tracking and reporting as required in section (d)(3.2.1), all monitors used to detect malfunctions identified in sections (e)(8.2.1) shall be tracked separately but reported as a single set of values as specified in section (d)(5.2.2).

(8.3.2) Manufacturers shall define the monitoring conditions for malfunctions identified in sections (e)(8.2.2) through (8.2.6) in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements), with the exception that monitoring shall occur every time the monitoring conditions are met during the driving cycle in lieu of once per driving cycle as required in section (d)(3.1.2). Additionally, for all 2024 and subsequent model year engines, manufacturers shall track and report the in-use performance of the PM filter monitors under sections (e)(8.2.2), (e)(8.2.5), and (e)(8.2.6) in accordance with section (d)(3.2.1). For purposes of tracking and reporting as required in section (d)(3.2.1), all monitors used to detect malfunctions identified in sections (e)(8.2.2), (e)(8.2.5), and (e)(8.2.6) shall be tracked separately but reported as a single set of values as specified in section (d)(5.2.2).

(8.3.~~2~~3) Except as provided in section (e)(8.3.~~3~~4), the OBD ~~II~~ system shall monitor continuously for malfunctions identified in section (e)(8.2.7) (i.e., PM filter feedback control).

(8.3.~~3~~4) Manufacturers may request Executive Officer approval to temporarily disable continuous monitoring under conditions technically necessary to ensure robust detection of malfunctions and to avoid false passes and false indications of malfunctions. The Executive Officer shall approve the request upon determining that the manufacturer has submitted data and/or an engineering evaluation which demonstrate that a properly operating system cannot be distinguished from a malfunctioning system and that the disablement interval is limited only to that which is technically necessary.

(8.4) MIL Illumination and Fault Code Storage: General requirements for MIL illumination and fault code storage are set forth in section (d)(2).

(9) Exhaust Gas Sensor Monitoring

(9.1) Requirement:

(9.1.1) The OBD system shall monitor all exhaust gas sensors (e.g., oxygen, air-fuel ratio, NOx) used for emission control system feedback (e.g., EGR control/feedback, SCR control/feedback, NOx adsorber control/feedback) or as a monitoring device for proper output signal, activity, response rate, and any other parameter that can affect emissions.

(9.1.2) For engines equipped with heated exhaust gas sensors, the OBD system shall monitor the heater for proper performance.

(9.2) Malfunction Criteria:

(9.2.1) Air-Fuel Ratio Sensors:

(A) For sensors located upstream of the exhaust aftertreatment:

(i) Sensor performance faults: The OBD system shall 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 NMHC, CO, or NOx emissions to exceed 2.0 times any of the applicable standards or the engine's PM emissions to exceed any of the applicable standards plus 0.02 g/bhp-hr.

(ii) Circuit faults: The OBD system shall detect malfunctions of the sensor caused by ~~either~~ a lack of circuit continuity or out-of-range values.

(iii) Feedback faults: The OBD system shall detect a malfunction of the sensor when a sensor failure or deterioration causes an emission control system (e.g., EGR, SCR, or NOx adsorber) to stop using that sensor as a feedback or feed-forward input (e.g., causes default or open-loop operation).

(iv) Monitoring capability: To the extent feasible, the OBD system shall 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 NOx adsorber monitoring).

(B) For sensors located downstream of the exhaust aftertreatment:

(i) Sensor performance faults:

a. For 2010 through 2012 model year engines, the OBD system shall 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 NMHC emissions to exceed 2.5 times any of the applicable standards, cause an engine's NOx emissions to exceed any of the applicable standards by more than 0.3 g/bhp-hr (e.g., cause emissions to exceed 0.5 g/bhp-hr if the exhaust emission standard is 0.2 g/bhp-hr) as measured from an applicable cycle emission test (i.e., FTP or SET), or cause an engine's PM emissions to exceed (whichever is higher): 0.05 g/bhp-hr as measured from an applicable cycle emission test (i.e., FTP or SET); or any of the applicable standards by more than 0.04 g/bhp-hr (e.g., cause emissions to exceed 0.05 g/bhp-hr if the exhaust emission standard is 0.01 g/bhp-hr).

b. For 2013 and subsequent model year engines, the OBD system shall 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 NMHC emissions to exceed 2.0 times any of the applicable standards, cause an engine's NOx emissions to exceed any of the applicable standards by more than 0.2 g/bhp-hr (e.g., cause emissions to exceed 0.4 g/bhp-hr if the exhaust emission standard is 0.2 g/bhp-hr) as measured from an applicable cycle emission test (i.e., FTP or SET), or cause an engine's PM emissions to exceed (whichever is higher): 0.03 g/bhp-hr as measured from an applicable cycle emission test (i.e., FTP or SET); or any of the applicable standards by more than 0.02 g/bhp-hr (e.g., cause emissions to exceed 0.03 g/bhp-hr if the exhaust emission standard is 0.01 g/bhp-hr).

(ii) Circuit faults: The OBD system shall detect malfunctions of the sensor caused by ~~either~~ a lack of circuit continuity or out-of-range values.

(iii) Feedback faults: The OBD system shall detect a malfunction of the sensor when a sensor failure or deterioration causes an emission control system (e.g., EGR, SCR, or NOx adsorber) to stop using that sensor as a feedback or feed-forward input (e.g., causes default or open-loop operation).

(iv) Monitoring capability: To the extent feasible, the OBD system shall 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 NOx adsorber monitoring).

(9.2.2) NOx and PM sensors:

(A) Sensor performance faults:

(i) For 2010 through 2012 model year engines, the OBD system shall 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 NOx emissions to exceed any of the applicable standards by more than 0.4

g/bhp-hr (e.g., cause emissions to exceed 0.6 g/bhp-hr if the exhaust emission standard is 0.2 g/bhp-hr) as measured from an applicable cycle emission test (i.e., FTP or SET), or cause an engine's PM emissions to exceed (whichever is higher): 0.05 g/bhp-hr as measured from an applicable cycle emission test (i.e., FTP or SET); or any of the applicable standards by more than 0.04 g/bhp-hr (e.g., cause emissions to exceed 0.05 g/bhp-hr if the exhaust emission standard is 0.01 g/bhp-hr).

(ii) For all 2013 model year engines and 2014 and 2015 model year engines that are not included in the phase-in specified in section (e)(9.2.2)(A)(iii), the OBD system shall 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 NOx emissions to exceed the applicable NOx standard by more than 0.4 g/bhp-hr (e.g., cause emissions to exceed 0.6 g/bhp-hr if the exhaust emission standard is 0.2 g/bhp-hr) as measured from an applicable cycle emission test or cause an engine's PM emissions to exceed (whichever is higher): 0.03 g/bhp-hr as measured from an applicable cycle emission test (i.e., FTP or SET); or any of the applicable standards by more than 0.02 g/bhp-hr (e.g., cause emissions to exceed 0.03 g/bhp-hr if the exhaust emission standard is 0.01 g/bhp-hr).

(iii) For at least 20 percent of 2014 model year diesel engines and at least 50 percent of 2015 model year diesel engines (percentage based on the manufacturer’s projected California sales volume of all diesel engines subject to this regulation), the OBD system shall 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 NOx emissions to exceed the applicable NOx standard by more than 0.3 g/bhp-hr (e.g., cause emissions to exceed 0.5 g/bhp-hr if the exhaust emission standard is 0.2 g/bhp-hr) as measured from an applicable cycle emission test or cause an engine's PM emissions to exceed (whichever is higher): 0.03 g/bhp-hr as measured from an applicable cycle emission test (i.e., FTP or SET); or any of the applicable standards by more than 0.02 g/bhp-hr (e.g., cause emissions to exceed 0.03 g/bhp-hr if the exhaust emission standard is 0.01 g/bhp-hr).

(iv) Except as provided for below in section (e)(9.2.2)(A)(v), for 2016 and subsequent model year engines, the OBD system shall 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 NOx emissions to exceed the applicable NOx standards by more than 0.2 g/bhp-hr (e.g., cause emissions to exceed 0.4 g/bhp-hr if the exhaust emission standard is 0.2 g/bhp-hr) as measured from an applicable cycle emission test (i.e., FTP or SET), cause an engine’s NMHC emissions to exceed 2.0 times the applicable NMHC standard, or cause an engine's PM emissions to exceed (whichever is higher): 0.03 g/bhp-hr as measured from an applicable cycle emission test (i.e., FTP or SET); or any of the applicable standards by more than 0.02 g/bhp-hr (e.g., cause emissions to exceed 0.03 g/bhp-hr if the exhaust emission standard is 0.01 g/bhp-hr).

(v) In lieu of using the malfunction criteria in section (e)(9.2.2)(A)(iv), a manufacturer may continue to use the malfunction criteria in section (e)(9.2.2)(A)(iii) for any 2016 model year engine that was previously certified in the 2014 or 2015 model year to the malfunction criteria in section (e)(9.2.2)(A)(iii) and carried over to the 2016 model year.

(B) Circuit faults: The OBD system shall detect malfunctions of the sensor caused by ~~either~~ a lack of circuit continuity or out-of-range values.

(C) Feedback faults: The OBD system shall detect a malfunction of the sensor when a sensor failure or deterioration causes an emission control system (e.g., EGR, SCR, or NOx adsorber) to stop using that sensor as a feedback or feed-forward input (e.g., causes default or open-loop operation).

(D) Monitoring capability: To the extent feasible, the OBD system shall 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, PM filter, SCR, or NOx adsorber monitoring).

(E) NOx sensor activity faults: For 2022 and subsequent model year engines, the OBD system shall detect a malfunction of the NOx sensor (e.g., internal sensor temperature not properly achieved/maintained, stabilization criteria not properly achieved/maintained) when the NOx sensor is not actively reporting NOx concentration data (i.e., the NOx sensor is not “active”) under conditions when it is technically feasible for a properly-working NOx sensor to be actively reporting NOx concentration data. The malfunctions include, at a minimum, faults that delay the time it takes for the NOx sensor to become “active” after start (e.g., time after start to satisfy NOx sensor stabilization criteria takes longer than normal) and faults that cause the NOx sensor to not be “active” for longer periods of time than normal (e.g., ratio of sensor “inactive” time to “active” time is higher than normal). If the NOx sensor activity fault is caused by a malfunction of a component other than the NOx sensor (e.g., a component that is used as an input necessary to make the NOx sensor become “active”), the OBD system shall monitor the component and detect a malfunction that prevents the NOx sensor from being “active”.

(9.2.3) Other exhaust gas sensors:

(A) For other exhaust gas sensors, the manufacturer shall submit a monitoring plan to the Executive Officer for approval. The Executive Officer shall approve the request upon determining that the manufacturer has submitted data and an engineering evaluation that demonstrate that the monitoring plan is as reliable and effective as the monitoring plan required for air-fuel ratio sensors, NOx sensors, and PM sensors under sections (e)(9.2.1) and (e)(9.2.2).

(9.2.4) Sensor Heaters:

(A) The OBD system shall 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). Subject to Executive Officer approval, other malfunction criteria for heater performance malfunctions may be used upon the Executive Officer determining that the manufacturer has submitted data and/or an engineering evaluation that demonstrate the monitoring reliability and timeliness to be equivalent to the stated criteria in section (e)(9.2.4)(A).

(B) The OBD system shall 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)).

(9.3) Monitoring Conditions:

(9.3.1) Exhaust Gas Sensors

(A) Manufacturers shall define the monitoring conditions for malfunctions identified in sections (e)(9.2.1)(A)(i), (9.2.1)(B)(i), (9.2.2)(A), and (9.2.2)(D) (e.g., sensor performance faults) in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements). Additionally, manufacturers shall track and report the in-use performance of the exhaust gas sensor monitors under sections (e)(9.2.1)(A)(i), (9.2.1)(B)(i), and (9.2.2)(A) in accordance with section (d)(3.2.1). Further, for all 2016 and subsequent model year engines, manufacturers shall track and report the in-use performance of the exhaust gas sensor monitors under section (e)(9.2.2)(D) in accordance with section (d)(3.2.1). For purposes of tracking and reporting as required in section (d)(3.2.1), all monitors used to detect malfunctions identified in sections (e)(9.2.1)(A)(i), (9.2.1)(B)(i), (9.2.2)(A), and ~~for 2016 and subsequent model year engines, section (e)~~(9.2.2)(D)~~,~~ shall be tracked separately but reported as a single set of values as specified in section (d)(5.2.2).

(B) Manufacturers shall define the monitoring conditions for malfunctions identified in sections (e)(9.2.1)(A)(iv) and (9.2.1)(B)(iv), (e.g., monitoring capability) in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements).

(C) Except as provided in section (e)(9.3.1)(D), monitoring for malfunctions identified in sections (e)(9.2.1)(A)(ii), (9.2.1)(A)(iii), (9.2.1)(B)(ii), (9.2.1)(B)(iii), (9.2.2)(B), ~~and~~ (9.2.2)(C), and (9.2.2)(E) (i.e., circuit continuity, ~~and~~ open-loop malfunctions, and NOx sensor activity malfunctions) shall be conducted continuously.

(D) A manufacturer may request Executive Officer approval to 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). The Executive Officer shall approve the disablement upon determining that the manufacturer has submitted test data and/or documentation that demonstrate 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.

(9.3.2) Sensor Heaters

(A) Manufacturers shall define monitoring conditions for malfunctions identified in section (e)(9.2.4)(A) (i.e., sensor heater performance) in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements).

(B) Monitoring for malfunctions identified in section (e)(9.2.4)(B) (i.e., circuit malfunctions) shall be conducted continuously.

(9.4) MIL Illumination and Fault Code Storage: General requirements for MIL illumination and fault code storage are set forth in section (d)(2). To the extent feasible, the OBD system shall separately detect lack of circuit continuity and out-of-range faults as required under sections (e)(9.2.1)(A)(ii), (e)(9.2.1)(B)(ii), and (e)(9.2.2)(B) and store different fault codes for each distinct malfunction (e.g., out-of-range low, out-of-range high, open circuit). For sensors with sensing elements externally connected to a sensor control module, manufacturers are not required to store different fault codes for lack of circuit continuity and out-of-range faults if: (1) the sensing element (i.e., probe or sensor externally connected to the sensor control module) is a subcomponent integral to the function of the complete sensor unit; (2) the sensing element is permanently attached to the sensor control module with wires or one-time connectors; (3) the complete sensor unit is designed, manufactured, installed, and serviced per manufacturer published procedures as a single component; and (4) the sensor control module and sensing element are calibrated together during the manufacturing process such that neither can be individually replaced in a repair scenario. Additionally, ~~M~~manufacturers are not required to store separate fault codes for lack of circuit continuity faults that cannot be distinguished from other out-of-range circuit faults.

(10) Variable Valve Timing, Lift, and/or Control (VVT) System Monitoring

(10.1) Requirement: The OBD system shall monitor the VVT system on engines so-equipped for target error and slow response malfunctions. Manufacturers must submit data and/or an analysis identifying all possible failure modes of the VVT system (e.g., partial or complete blockage of hydraulic passages, broken return springs, a failure of a single cylinder-specific pin to move into the desired position on a lift mechanism) and the effect each has (e.g., failure modes and effects analysis) across the entire range of operating conditions. The individual electronic components (e.g., actuators, valves, sensors) that are used in the VVT system shall be monitored in accordance with the comprehensive components requirements in section (g)(3).

(10.2) Malfunction Criteria:

(10.2.1) Target Error: The OBD system shall 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 NHMC, NOx, or CO emissions to exceed 2.0 times any of the applicable standards or an engine’s PM emissions to exceed a threshold of the applicable standard plus 0.02

g/bhp-hr. Systems with discrete operating states (e.g., two step valve train systems) are not required to detect a malfunction prior to exceeding the threshold but are required to detect all failures that exceed the threshold.

(10.2.2) Slow Response: The OBD system shall 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 NHMC, NOx, or CO emissions to exceed 2.0 times any of the applicable standards or an engine's PM emissions to exceed a threshold of the applicable standard plus 0.02 g/bhp-hr. Systems with discrete operating states are not required to detect a malfunction prior to exceeding the threshold but are required to detect all failures that exceed the threshold.

(10.2.3) For engines in which no failure or deterioration of the VVT system could result in an engine's emissions exceeding the thresholds of sections (e)(10.2.1) or (10.2.2), the OBD system shall detect a malfunction of the VVT system when proper functional response of the ~~system~~ electronic components to computer commands does not occur.

(10.3) Monitoring Conditions: Manufacturers shall define the monitoring conditions for VVT system malfunctions identified in section (e)(10.2) in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements), with the exception that monitoring shall occur every time the monitoring conditions are met during the driving cycle in lieu of once per driving cycle as required in section (d)(3.1.2). Additionally, manufacturers shall track and report the in-use performance of the VVT system monitors under section (e)(10.2) in accordance with section (d)(3.2.1). For purposes of tracking and reporting as required in section (d)(3.2.1), all monitors used to detect malfunctions identified in section (e)(10.2) shall be tracked separately but reported as a single set of values as specified in section (d)(5.2.2).

(10.4) MIL Illumination and Fault Code Storage: General requirements for MIL illumination and fault code storage are set forth in section (d)(2).

(11) Cold Start Emission Reduction Strategy Monitoring

(11.1) Requirement:

(11.1.1) For all 2013 and subsequent model year engines that incorporate a specific engine control strategy to reduce cold start emissions, the OBD system shall monitor the strategy to verify that it achieves the desired effect (e.g., to achieve accelerated catalyst light-off temperature) and monitor the commanded elements/components for proper function (e.g., injection timing, increased engine idle speed, increased engine load via intake or exhaust throttle activation) while the control strategy is active to ensure proper operation of the control strategy.

(11.1.2) For an element/component associated with the cold start emission reduction control strategy under section (e)(11) that is also required to be monitored elsewhere in section (e) or (g) (e.g., fuel injection timing), the manufacturer shall use different diagnostics to distinguish faults detected under section (e)(11) (i.e., faults associated with the cold start strategy) from faults detected under sections other than section (e)(11) (i.e., faults not associated with the cold start strategy).

(11.2) Malfunction Criteria: The OBD system shall, to the extent feasible, detect a malfunction if ~~either~~ any of the following occurs:

(11.2.1) Any single commanded element/component does not properly respond to the commanded action while the cold start strategy is active. For purposes of this section, “properly respond” is defined as when the element responds:

(A) by a robustly detectable amount by the monitor; and

(B) in the direction of the desired command; and

(C) above and beyond what the element/component would achieve on start-up without the cold start strategy active (e.g., if the cold start strategy commands a higher idle engine speed, a fault must be detected if there is no detectable amount of engine speed increase above what the system would achieve without the cold start strategy active);

(11.2.2) Any failure or deterioration of the cold start emission reduction control strategy that would cause an engine’s NMHC, NOx, or CO emissions to exceed 2.0 times the applicable standards or the engine’s PM emissions to exceed the applicable standard plus 0.02 g/bhp-hr.

(11.2.3) For section (e)(11.2.2), to the extent feasible (without adding hardware for this purpose), the OBD system shall monitor the ability of the system to achieve the desired effect (e.g., strategies used to accelerate catalyst light-off by increasing catalyst inlet temperature shall verify the catalyst inlet temperature actually achieves the desired temperatures within an Executive Officer approved time interval after starting the engine) for failures that cause emissions to exceed the applicable emission levels specified in section (e)(11.2.2). For strategies where it is not feasible to be monitored as a system, the OBD system shall monitor the individual elements/components (e.g., increased engine speed, increased engine load from restricting an exhaust throttle) for failures that cause emissions to exceed the applicable emission levels specified in section (e)(11.2.2).

(11.3) Monitoring Conditions: Manufacturers shall define the monitoring conditions for malfunctions identified in section (e)(11.2) in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements).

(11.4) MIL Illumination and Fault Code Storage: General requirements for MIL illumination and fault code storage are set forth in section (d)(2).

(f) *Monitoring Requirements for Gasoline/Spark-Ignited Engines*.

(1) Fuel System Monitoring

(1.1) Requirement: The OBD system shall monitor the fuel delivery system to determine its ability to provide compliance with applicable standards.

(1.2) Malfunction Criteria:

(1.2.1) The OBD system shall detect a malfunction of the fuel delivery system when any of the following occurs:

(A) The fuel delivery system is unable to maintain an engine's emissions at or below 1.5 times the applicable standards; or

(B) If equipped, the feedback control based on a secondary oxygen or exhaust gas sensor is unable to maintain an engine’s emissions (except as a result of a malfunction specified in section (f)(1.2.1)(C)) at or below 1.5 times any of the applicable standards; or

(C) For 2014 and subsequent model year engines, an air-fuel ratio cylinder imbalance (e.g., the air-fuel ratio in one or more cylinders is different than the other cylinders due to a cylinder specific malfunction such as an intake manifold leak at a particular cylinder, fuel injector problem, an individual cylinder EGR runner flow delivery problem, an individual variable cam lift malfunction such that an individual cylinder is operating on the wrong cam lift profile, or other similar problems) occurs in one or more cylinders such that the fuel delivery system is unable to maintain an engine's emissions at or below: 3.0 times the applicable standards for the 2014 through 2016 model years; and 1.5 times the applicable FTP standards for all 2017 and subsequent model year engines.

(1.2.2) Except as provided for in section (f)(1.2.3) below, if the engine is equipped with adaptive feedback control, the OBD system shall detect a malfunction when the adaptive feedback control has used up all of the adjustment allowed by the manufacturer.

(1.2.3) If the engine is equipped with feedback control that is based on a secondary oxygen (or equivalent) sensor, the OBD system is not required to detect a malfunction of the fuel system solely when the feedback control based on a secondary oxygen sensor has used up all of the adjustment allowed by the manufacturer. However, if a failure or deterioration results in engine emissions that exceed the malfunction criteria in section (f)(1.2.1)(B), the OBD system is required to detect a malfunction.

(1.2.4) <u>Except as provided in section (f)(1.2.4)(D) below, </u>~~T~~<u>t</u>he OBD system shall detect a malfunction whenever the fuel control system fails to enter closed-loop operation within an Executive Officer-approved time interval after engine start. Executive Officer approval of the time interval shall be granted upon determining that the data and/or engineering evaluation submitted by the manufacturer supports the specified times.

<u>(A) For 2010 through 2023 model year engines, "closed-loop operation" as specified in section (f)(1.2.4) above shall mean either stoichiometric or non-stoichiometric closed-loop operation, whichever one the manufacturer chooses.</u>

<u>(B) For 2024 and subsequent model year engines, "closed-loop operation" as specified in section (f)(1.2.4) above shall mean stoichiometric closed-loop operation.</u>

(~~1.2.5~~<u>C</u>) For engines that employ engine shutoff strategies that do not require the vehicle operator to restart the engine to continue driving (e.g., hybrid bus with engine shutoff at idle), the OBD system shall detect whenever the fuel control system fails to enter closed-loop operation within an Executive Officer-approved time interval after an engine restart. Executive Officer approval of the time interval shall be granted upon determining that the data and/or engineering evaluation submitted by the manufacturer supports the specified times.

<u>(D) In lieu of detecting the malfunctions specified section (f)(1.2.4) above with a fuel system-specific monitor, the OBD system may monitor the</u>

individual parameters or components that are used as inputs for fuel system closed-loop operation if the manufacturer demonstrates that the monitor(s) detect all malfunctions and is equally as effective and timely in detecting faults that prevent achieving closed-loop operation in the time interval approved by the Executive Officer.

(1.3) Monitoring Conditions:

(1.3.1) Except as provided in section (f)(1.3.5), the OBD system shall monitor continuously for malfunctions identified in sections (f)(1.2.1)(A), (f)(1.2.1)(B), and (f)(1.2.2) (i.e., fuel delivery system, secondary feedback control, adaptive feedback control).

(1.3.2) Manufacturers shall define monitoring conditions for malfunctions identified in section (f)(1.2.1)(C) (i.e., air-fuel ratio cylinder imbalance malfunctions) in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements). Additionally, for 2024 and subsequent model year engines, manufacturers shall track and report the in-use performance of the fuel system monitors under section (f)(1.2.1)(C) in accordance with section (d)(3.2.1). For purposes of tracking and reporting as required in section (d)(3.2.1), all dedicated monitors used to detect malfunctions identified in section (f)(1.2.1)(C) shall be tracked separately but reported as a single set of values as specified in section (d)(5.2.2). Manufacturers that use other existing monitors (e.g., misfire monitor under section (f)(2), fuel system monitor under section (f)(1.2.1)(A)) to detect malfunctions identified in section (f)(1.2.1)(C) are subject to the tracking and reporting requirements of the other monitors.

(1.3.3) Manufacturers shall define monitoring conditions for malfunctions identified in section (f)(1.2.4) (except malfunctions identified in section (f)(1.2.4)(C), which is provided for per section (f)(1.3.4) below) in accordance with section~~s~~ (d)(3.1).

(1.3.4) Manufacturers shall define monitoring conditions for malfunctions identified in section (f)(1.2.~~5~~4)(C) in accordance with section~~s~~ (d)(3.1) with the exception that monitoring shall occur every time the monitoring conditions are met during the driving cycle in lieu of once per driving cycle as required in section (d)(3.1.2).

(1.3.5) Manufacturers may request Executive Officer approval to temporarily disable continuous monitoring under conditions technically necessary to ensure robust detection of malfunctions and to avoid false passes and false indications of malfunctions (e.g., for temporary introduction of large amounts of purge vapor). The Executive Officer shall approve the request upon determining that the manufacturer has submitted data and/or an engineering evaluation which demonstrate that a properly operating system cannot be distinguished from a malfunctioning system and that the disablement interval is limited only to that which is technically necessary.

(1.4) MIL Illumination and Fault Code Storage: For malfunctions described under section (f)(1.2.1)(C) (i.e., air-fuel ratio cylinder imbalance malfunctions), general requirements for MIL illumination and fault code storage are set forth in section (d)(2). The stored fault code shall pinpoint the likely cause of the malfunction to the fullest extent that is inherently possible based on the monitoring strategy used. Further, the stored fault code is not required to specifically identify the air-fuel ratio cylinder imbalance malfunction (e.g., a fault code for misfire monitoring can be stored) if the manufacturer demonstrates that additional monitoring hardware would be necessary to make this identification and that the other monitor(s) robustly detects the malfunction. For all other fuel system malfunctions, the MIL illumination and fault code storage requirements are set forth in sections (f)(1.4.1) through (1.4.6) below.

(1.4.1) A pending fault code shall be stored immediately upon the fuel system exceeding the malfunction criteria established pursuant to section (f)(1.2).

(1.4.2) Except as provided below, if a pending fault code is stored, the OBD system shall immediately illuminate the MIL and store a confirmed/MIL-on fault code if a malfunction is again detected during ~~either~~ any of the following two events: (a) the driving cycle immediately following the storage of the pending fault code, regardless of the conditions encountered during the driving cycle; or (b) on the next driving cycle in which similar conditions (see section (c)) to those that occurred when the pending fault code was stored are encountered.

(1.4.3) The pending fault code ~~may~~ shall be erased at the end of the next driving cycle in which similar conditions have been encountered without an exceedance of the specified fuel system malfunction criteria. The pending code may also be erased if similar conditions are not encountered during the 80 driving cycles immediately after the initial detection of a malfunction for which the pending code was set.

(1.4.4) Storage of freeze frame conditions.

(A) For 2010 through 2023 model year engines using the ISO 15765-4 protocol for the standardized functions in section (h), ~~T~~the OBD system shall store and erase freeze frame conditions either in conjunction with storing and erasing a pending fault code or in conjunction with storing and erasing a confirmed fault code. For 2024 and subsequent model year engines using the ISO 15765-4 protocol for the standardized functions in section (h), the OBD system shall store and erase freeze frame conditions in accordance with section (d)(2.2.1)(D)(iii). For engines using the SAE J1939 protocol for the standardized functions in section (h), the OBD system shall store and erase freeze frame conditions in accordance with section (d)(2.2.2)(D).

(B) If freeze frame conditions are stored for a malfunction other than a misfire (see section (f)(2)) or fuel system malfunction when a fuel system fault code is stored as specified in section (f)(1.4.1) or (f)(1.4.2) above, the stored freeze frame information shall be replaced with freeze frame information regarding the fuel system malfunction.

(1.4.5) Storage of fuel system conditions for determining similar conditions of operation.

(A) Upon detection of a fuel system malfunction under section (f)(1.2), the OBD system shall store the engine speed, load, and warm-up status of the first fuel system malfunction that resulted in the storage of the pending fault code.

(B) For fuel system faults detected using feedback control that is based on a secondary oxygen (or equivalent) sensor, the manufacturer may request

Executive Officer approval to use an alternate definition of similar conditions in lieu of the definition specified in section (c). The Executive Officer shall approve the alternate definition upon the manufacturer providing data or analysis demonstrating that the alternate definition provides for equivalent robustness in detection of fuel system faults that vary in severity depending on engine speed, load, and/or warm-up status.

(1.4.6) Extinguishing the MIL. The MIL may be extinguished after three sequential driving cycles in which similar conditions have been encountered without a malfunction of the fuel system.

(2) Misfire Monitoring

(2.1) Requirement:

(2.1.1) The OBD system shall monitor the engine for misfire~~ causing catalyst damage and misfire causing excess emissions~~.

(2.1.2) The OBD system shall identify the specific cylinder that is experiencing misfire. Manufacturers may request Executive Officer approval to store a general misfire fault code instead of a cylinder specific fault code under certain operating conditions. The Executive Officer shall approve the request upon determining that the manufacturer has submitted data and/or an engineering evaluation that demonstrate that the misfiring cylinder cannot be reliably identified when the conditions occur.

(2.1.3) If more than one cylinder is misfiring, a separate fault code shall be stored indicating that multiple cylinders are misfiring except as allowed below. When identifying multiple cylinder misfire, the OBD system is not required to also identify each of the misfiring cylinders individually through separate fault codes. If more than 90 percent of the detected misfires occur in a single cylinder, the OBD system may elect to store the appropriate fault code indicating the specific misfiring cylinder in lieu of the multiple cylinder misfire fault code. If, however, two or more cylinders individually have more than 10 percent of the total number of detected misfires, a multiple cylinder fault code must be stored.

(2.2) Malfunction Criteria: The OBD system shall detect a misfire malfunction pursuant to the following:

(2.2.1) Misfire causing catalyst damage:

(A) Manufacturers shall determine the percentage of misfire evaluated in 200 revolution increments for each engine speed and load condition that would result in a temperature that causes catalyst damage. The manufacturer shall submit documentation to support this percentage of misfire as required in section (j)(2.5). For every engine speed and load condition that this percentage of misfire is determined to be lower than five percent, the manufacturer may set the malfunction criteria at five percent.

(B) Subject to Executive Officer approval, a manufacturer may employ a longer interval than 200 revolutions but only for determining, on a given driving cycle, the first misfire exceedance as provided in section (f)(2.4.1)(A) below. Executive Officer approval shall be granted upon determining that the manufacturer has submitted data and/or an engineering evaluation that demonstrate that catalyst damage would not occur due to unacceptably high catalyst temperatures before the interval has elapsed.

(C) A misfire malfunction shall be detected if the percentage of misfire established in section (f)(2.2.1)(A) is exceeded. For multiple cylinder misfire situations that result in a misfire rate greater than or equal to 50 percent, the OBD system shall only be required to detect a misfire malfunction for situations that are caused by a single component failure.

(D) For purposes of establishing the temperature at which catalyst damage occurs as required in section (f)(2.2.1)(A), manufacturers may not define catalyst damage at a temperature more severe than what the catalyst system could be operated at for 10 consecutive hours and still meet the applicable standards.

(2.2.2) Misfire causing emissions to exceed 1.5 times the applicable standards:

(A) Manufacturers shall determine the percentage of misfire evaluated in 1000 revolution increments that would cause emissions from an emission durability demonstration engine to exceed 1.5 times any of the applicable standards if the percentage of misfire were present from the beginning of the test. To establish this percentage of misfire, the manufacturer shall 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.

(B) Subject to Executive Officer approval, a manufacturer may employ other revolution increments. The Executive Officer shall grant approval upon determining that the manufacturer has demonstrated that the strategy would be equally effective and timely in detecting misfire.

(C) A malfunction shall be detected if the percentage of misfire established in section (f)(2.2.2)(A) is exceeded regardless of the pattern of misfire events (e.g., random, equally spaced, continuous). <u>For multiple cylinder misfire situations that result in a misfire rate greater than or equal to 50 percent of all engine firings, the OBD system shall only be required to detect a misfire malfunction for situations that are caused by a single component failure.</u>

(2.3) Monitoring Conditions:

(2.3.1) The OBD system shall continuously monitor for misfire under the following conditions:

(A) Except as provided for in section (f)(2.3.6) below, from no later than the end of the second crankshaft revolution after engine start,

(B) While under positive torque conditions during the rise time and settling time for engine speed to reach the desired idle engine speed at engine start-up (i.e., “flare-up” and “flare-down”), and

(C) Under all positive torque engine speeds and load conditions except within the following range: the engine operating region bound by the positive torque line (i.e., engine load with the transmission in neutral), and the two following engine operating points: an engine speed of 3000 rpm with the engine load at the positive torque line, and the redline engine speed (defined in section (c)) with the engine's manifold vacuum at four inches of mercury lower than that at the positive torque line.

(2.3.2) If a monitoring system cannot detect all misfire patterns under all required engine speed and load conditions as required in section (f)(2.3.1) above, the manufacturer may request Executive Officer approval to accept the monitoring system. In evaluating the manufacturer's request, the Executive Officer shall 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 shall 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.

(2.3.3) A manufacturer may request Executive Officer approval of a monitoring system that has reduced misfire detection capability during the portion of the first 1000 revolutions after engine start that a cold start emission reduction strategy that reduces engine torque (e.g., spark retard strategies) is active. The Executive Officer shall approve the request upon determining that the manufacturer has demonstrated 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 <u>(or 10-30 degrees Celsius)</u> and that the technology cannot reliably detect a higher percentage of the misfire events during the conditions.

(2.3.4) A manufacturer may request Executive Officer approval to disable misfire monitoring or employ an alternate malfunction criterion when misfire cannot be distinguished from other effects.

(A) Upon determining that the manufacturer has presented documentation that demonstrates the disablement interval or period of use of an alternate malfunction criterion is limited only to that necessary for avoiding false detection, the Executive Officer shall approve the disablement or use of the alternate malfunction criterion for conditions involving:
- (i) rough road,
- (ii) fuel cut,
- (iii) gear changes for manual transmission vehicles,
- (iv) traction control or other vehicle stability control activation such as anti-lock braking or other engine torque modifications to enhance vehicle stability,
- (v) off-board control or intrusive activation of vehicle components or diagnostics during service or assembly plant testing,
- (vi) 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

(vii) 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.

(B) Additionally, the Executive Officer will approve a manufacturer's request in accordance with sections (g)(5.3), (g)(5.4), and (g)(5.6) to 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 (or -6.7 degrees Celsius). The Executive Officer will approve a request to continue disablement on engine starts when engine coolant temperature is below 20 degrees Fahrenheit (or -6.7 degrees Celsius) at engine start until engine coolant temperature exceeds 70 degrees Fahrenheit (or 21.1 degrees Celsius).

(C) In general, the Executive Officer shall not approve 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).

(D) The Executive Officer may approve misfire monitoring disablement or use of an alternate malfunction criterion for any other condition on a case by case basis upon determining that 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.

(2.3.5) For engines with more than eight cylinders that cannot meet the requirements of section (f)(2.3.1), a manufacturer may request Executive Officer approval to use alternative misfire monitoring conditions. The Executive Officer shall approve the request upon determining that the manufacturer has submitted data and/or an engineering evaluation that demonstrate that misfire detection throughout the required operating region cannot be achieved when employing 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 Executive Officer may not grant the request if the misfire detection system is unable to monitor during all positive torque operating conditions encountered during an FTP cycle.

(2.3.6) For engines that employ engine shutoff strategies that do not require the vehicle operator to restart the engine to continue driving (e.g., hybrid bus with engine shutoff at idle), the OBD system shall monitor for misfire from no later than the end of the second crankshaft revolution after engine fueling begins for the initial start and after each time fueling resumes.

(2.4) MIL Illumination and Fault Code Storage:

(2.4.1) Misfire causing catalyst damage. Upon detection of the percentage of misfire specified in section (f)(2.2.1) above, the following criteria shall apply for MIL illumination and fault code storage:

(A) Pending fault codes

(i) A pending fault code shall be stored immediately if, during a single driving cycle, the specified percentage of misfire is exceeded three times when operating in the positive torque region encountered during an FTP cycle or is exceeded on a single occasion when operating at any other engine speed and load condition in the positive torque region defined in section (f)(2.3.1).

(ii) Immediately after a pending fault code is stored as specified in section (f)(2.4.1)(A)(i) above, the MIL shall blink once per second at all times while misfire is occurring during the driving cycle.

a. The MIL may be extinguished during those times when misfire is not occurring during the driving cycle.

b. If, at the time a misfire malfunction occurs, the MIL is already illuminated for a malfunction other than misfire, the MIL shall blink as previously specified in section (f)(2.4.1)(A)(ii) while misfire is occurring. If misfiring ceases, the MIL shall stop blinking but remain illuminated as required by the other malfunction.

(B) Confirmed/MIL-on fault codes

(i) If a pending fault code for exceeding the percentage of misfire set forth in section (f)(2.2.1) is stored, the OBD system shall immediately store a confirmed/MIL-on fault code if the percentage of misfire specified in section (f)(2.2.1) is again exceeded one or more times during ~~either~~any of the two following events: (a) the driving cycle immediately following the storage of the pending fault code, regardless of the conditions encountered during the driving cycle; or (b) on the next driving cycle in which similar conditions (see section (c)) to the engine conditions that occurred when the pending fault code was stored are encountered.

(ii) If a pending fault code for exceeding the percentage of misfire set forth in section (f)(2.2.2) is stored from a previous driving cycle, the OBD system shall immediately store a confirmed/MIL-on fault code if the percentage of misfire specified in section (f)(2.2.1) is exceeded one or more times regardless of the conditions encountered.

(iii) Upon storage of a confirmed/MIL-on fault code, the MIL shall blink as specified in ~~subparagraph~~ section (f)(2.4.1)(A)(ii) above as long as misfire is occurring and the MIL shall remain continuously illuminated if the misfiring ceases.

(C) Erasure of pending fault codes

Pending fault codes shall be erased at the end of the next driving cycle in which similar conditions to the engine conditions that occurred when the pending fault code was stored have been encountered without any exceedance of the specified percentage of misfire. The pending code may also be erased if similar driving conditions are not encountered during the next 80 driving cycles subsequent to the initial detection of a malfunction.

(D) Exemptions for engines with fuel shutoff and default fuel control. Notwithstanding sections (f)(2.4.1)(A) and (B) above, in engines that provide for fuel shutoff and default fuel control to prevent over fueling during catalyst damage misfire conditions, the MIL is not required to blink. Instead, the MIL may illuminate continuously in accordance with the requirements for continuous MIL illumination in sections (f)(2.4.1)(B)(iii) above upon detection of misfire, provided that the fuel shutoff and default control are activated as soon as misfire is detected. Fuel shutoff and default fuel control may be deactivated only to permit fueling outside of the misfire range. Manufacturers may also periodically, but not more than once every 30 seconds, deactivate fuel shutoff and default fuel control to determine if the specified catalyst damage percentage of misfire is still being exceeded. Normal fueling and fuel control may be resumed if the specified catalyst damage percentage of misfire is no longer being exceeded.

(E) Manufacturers may request Executive Officer approval of strategies that continuously illuminate the MIL in lieu of blinking the MIL during extreme catalyst damage misfire conditions (i.e., catalyst damage misfire occurring at all engine speeds and loads). Executive Officer approval shall be granted upon determining that the manufacturer employs the strategy only when catalyst damage misfire levels cannot be avoided during reasonable driving conditions and the manufacturer has demonstrated that the strategy will encourage operation of the vehicle in conditions that will minimize catalyst damage (e.g., at low engine speeds and loads).

(2.4.2) Misfire causing emissions to exceed 1.5 times the FTP standards. Upon detection of the percentage of misfire specified in section (f)(2.2.2), the following criteria shall apply for MIL illumination and fault code storage:

(A) Misfire within the first 1000 revolutions after engine start.

(i) A pending fault code shall be stored no later than after the first exceedance of the specified percentage of misfire during a single driving cycle if the exceedance occurs within the first 1000 revolutions after engine start (defined in section (c)) during which misfire detection is active.

(ii) If a pending fault code is stored, the OBD system shall illuminate the MIL and store a confirmed/MIL-on fault code within 10 seconds if an exceedance of the specified percentage of misfire is again detected in the first 1000 revolutions during any subsequent driving cycle, regardless of the conditions encountered during the driving cycle.

(iii) The pending fault code shall be erased at the end of the next driving cycle in which similar conditions to the engine conditions that occurred when the pending fault code was stored have been encountered without an exceedance of the specified percentage of misfire. The pending code may also be erased if similar conditions are not encountered during the next 80 driving cycles immediately following the initial detection of the malfunction.

(B) Exceedances after the first 1000 revolutions after engine start.

(i) A pending fault code shall be stored no later than after the fourth exceedance of the percentage of misfire specified in section (f)(2.2.2) during a single driving cycle.

(ii) If a pending fault code is stored, the OBD system shall illuminate the MIL and store a confirmed/MIL-on fault code within 10 seconds if the percentage of misfire specified in section (f)(2.2.2) is again exceeded four times during: (a) the driving cycle immediately following the storage of the pending fault code, regardless of the conditions encountered during the driving cycle; or (b) on the next driving cycle in which similar conditions (see section (c)) to the engine conditions that occurred when the pending fault code was stored are encountered.

(iii) The pending fault code ~~may~~ shall be erased at the end of the next driving cycle in which similar conditions to the engine conditions that occurred when the pending fault code was stored have been encountered without an exceedance of the specified percentage of misfire. The pending code may also be erased if similar conditions are not encountered during the next 80 driving cycles immediately following initial detection of the malfunction.

(2.4.3) Storage of freeze frame conditions.

(A) For 2010 through 2023 model year engines using the ISO 15765-4 protocol for the standardized functions in section (h), ~~T~~the OBD system shall store and erase freeze frame conditions either in conjunction with storing and erasing a pending fault code or in conjunction with storing and erasing a confirmed fault code. For 2024 and subsequent model year engines using the ISO 15765-4 protocol for the standardized functions in section (h), the OBD system shall store and erase freeze frame conditions in accordance with section (d)(2.2.1)(D)(iii). For engines using the SAE J1939 protocol for the standardized functions in section (h), the OBD system shall store and erase freeze frame conditions in accordance with section (d)(2.2.2)(D).

(B) If freeze frame conditions are stored for a malfunction other than a misfire or fuel system malfunction (see section (f)(1)) when a misfire fault code is stored as specified in section (f)(2.4) above, the stored freeze frame information shall be replaced with freeze frame information regarding the misfire malfunction.

(2.4.4) Storage of misfire conditions for similar conditions determination. Upon detection of misfire under sections (f)(2.4.1) or (2.4.2), the OBD system shall 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 fault code.

(2.4.5) Extinguishing the MIL. 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

(3.1) Requirement: The OBD system shall 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 shall be monitored in accordance with the comprehensive component requirements in section (g)(3).

(3.2) Malfunction Criteria:

(3.2.1) The OBD system shall detect a malfunction of the EGR system prior to a decrease from the manufacturer's specified EGR flow rate that would cause an engine's emissions to exceed 1.5 times any of the applicable standards. 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 1.5 times any of the applicable standards, the OBD system shall detect a malfunction when either the EGR system has reaches its control limits such that it cannot increase EGR flow to achieve the commanded flow rate, or, for non-feedback controlled systems, the system has no detectable amount of EGR flow when EGR flow is expected.

(3.2.2) The OBD system shall detect a malfunction of the EGR system prior to an increase from the manufacturer's specified EGR flow rate that would cause an engine's emissions to exceed 1.5 times any of the applicable standards. 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 1.5 times any of the applicable standards, the OBD system shall detect a malfunction when the system has reached its control limits such that it cannot reduce EGR flow or, for non-feedback controlled EGR systems, the EGR system has maximum detectable EGR flow when little or no EGR flow is expected. Manufacturers may request Executive Officer approval to be exempt from monitoring for this failure or deterioration. The Executive Officer shall approve the request upon determining that the manufacturer has submitted data and/or engineering evaluation that demonstrate that (1) the failure or deterioration cannot be detected during off-idle conditions, and (2) the failure or deterioration causes the vehicle to immediately stall during idle conditions.

(3.3) Monitoring Conditions:

(3.3.1) Manufacturers shall define the monitoring conditions for malfunctions identified in section (f)(3.2) (i.e., flow rate) in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements). Additionally, manufacturers shall track and report the in-use performance of the EGR system monitors under section (f)(3.2) in accordance with section (d)(3.2.1). For purposes of tracking and reporting as required in section (d)(3.2.1), all monitors used to detect malfunctions identified in section (f)(3.2) shall be tracked separately but reported as a single set of values as specified in section (d)(5.2.2).

(3.3.2) Manufacturers may request Executive Officer approval to temporarily disable the EGR system check under conditions when monitoring may not be reliable (e.g., when freezing may affect performance of the system). The Executive Officer shall approve the request upon determining that the manufacturer has submitted data and/or an engineering evaluation which demonstrate that a reliable check cannot be made when these conditions exist.

(3.4) MIL Illumination and Fault Code Storage: General requirements for MIL illumination and fault code storage are set forth in section (d)(2).

(4) Cold Start Emission Reduction Strategy Monitoring

(4.1) Requirement:

(4.1.1) If an engine incorporates a specific engine control strategy to reduce cold start emissions, the OBD system shall monitor the commanded elements/components for proper function (e.g., increased engine idle speed, mass air flow, commanded ignition timing retard), other than secondary air, while the control strategy is active to ensure proper operation of the control strategy. Secondary air systems shall be monitored under the provisions of section (f)(5).

(4.1.2) For an element/component associated with the cold start emission reduction control strategy under section (f)(4) that is also required to be monitored elsewhere in section (f) or (g) (e.g., ~~fuel injection timing~~ idle control system), the manufacturer shall use different diagnostics to distinguish faults detected under section (f)(4) (i.e., faults associated with the cold start strategy) from faults detected under sections other than section (f)(4) (i.e., faults not associated with the cold start strategy).

(4.2) Malfunction Criteria:

(4.2.1) For 2010 through 2012 model year engines:

(A) The OBD system shall detect a malfunction prior to any failure or deterioration of the individual elements/components associated with the cold start emission reduction control strategy that would cause an engine's emissions to exceed 1.5 times the applicable standards. Manufacturers shall:

(i) Establish the malfunction criteria based on data from one or more representative engine(s).

(ii) Provide an engineering evaluation for establishing the malfunction criteria for the remainder of the manufacturer's product line. The Executive Officer shall waive the evaluation requirement each year if, in the judgment of the Executive Officer, technological changes do not affect the previously determined malfunction criteria.

(B) For elements/components where no failure or deterioration of the element/component used for the cold start emission reduction strategy could result in an engine's emissions exceeding 1.5 times the applicable standards, the individual element/component shall be monitored for proper functional response in accordance with the malfunction criteria in section (g)(3.2) while the control strategy is active.

(4.2.2) For 2013 and subsequent model year engines, the OBD system shall, to the extent feasible, detect a malfunction if ~~either~~ any of the following occurs:

(A) Any single commanded element/component does not properly respond to the commanded action while the cold start strategy is active. For elements/components involving spark timing (e.g., retarded spark timing), the monitor may verify final commanded spark timing in lieu of verifying actual delivered spark timing. For purposes of this section, “properly respond” is defined as when the element/component responds:

(i) by a robustly detectable amount; and

(ii) in the direction of the desired command; and

(iii) above and beyond what the element/component would achieve on start-up without the cold start strategy active (e.g., if the cold start strategy commands a higher idle engine speed, a fault must be detected if there is no detectable amount of engine speed increase above what the system would achieve without the cold start strategy active);

(B) Any failure or deterioration of the cold start emission reduction control strategy that would cause an engine’s emissions to be equal to or above 1.5 times the applicable standards. For this requirement, the OBD system shall either monitor the combined effect of the elements/components of the system as a whole (e.g., measuring air flow and modeling overall heat into the exhaust) or the individual elements/components (e.g., increased engine speed, commanded final spark timing) for failures that cause engine emissions to exceed 1.5 times the applicable standards.

(4.3) Monitoring Conditions: Manufacturers shall define the monitoring conditions for malfunctions identified in section (f)(4.2) in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements).

(4.4) MIL Illumination and Fault Code Storage: General requirements for MIL illumination and fault code storage are set forth in section (d)(2).

(5) Secondary Air System Monitoring

(5.1) Requirement:

(5.1.1) The OBD system on engines equipped with any form of secondary air delivery system shall 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 shall be monitored in accordance with the comprehensive component requirements in section (g)(3).

(5.1.2) For purposes of section (f)(5), “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) shall be monitored in accordance with the malfunction criteria in section (f)(5.2) unless complete blocking of air delivery to one bank does not cause a measurable increase in emissions.

(5.1.3) For purposes of section (f)(5), “normal operation” is defined as the condition when the secondary air system is activated during catalyst and/or engine warm-up following engine start. “Normal operation” does not include the condition when the secondary air system is intrusively turned on solely for the purpose of monitoring.

(5.2) Malfunction Criteria:

(5.2.1) Except as provided in section (f)(5.2.3), the OBD system shall 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 1.5 times any of the applicable standards.

(5.2.2) Except as provided in section (f)(5.2.4), the OBD system shall 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 1.5 times any of the applicable standards.

(5.2.3) For engines in which no deterioration or failure of the secondary air system that causes a decrease in air flow would result in an engine’s emissions exceeding 1.5 times any of the applicable standards, the OBD system shall detect a malfunction when no detectable amount of air flow is delivered during normal operation.

(5.2.4) For 2016 and subsequent model year engines in which no deterioration or failure of the secondary air system that causes an increase in air flow would result in an engine’s emissions exceeding 1.5 times any of the applicable standards, the OBD system shall detect a malfunction when the secondary air system has reached its control limits such that it cannot reduce air flow during normal operation.

(5.3) Monitoring Conditions:

(5.3.1) Manufacturers shall define the monitoring conditions in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements). <u>Additionally, manufacturers shall track and report the in-use performance of the secondary air system monitors under section (f)(5.2) in accordance with section (d)(3.2.1).</u> For purposes of tracking and reporting as required in section (d)(3.2.1), all monitors used to detect malfunctions identified in section (f)(5.2) during normal operation of the secondary air system shall be tracked separately but reported as a single set of values as specified in section (d)(5.2.2).

(5.4) MIL Illumination and Fault Code Storage: General requirements for MIL illumination and fault code storage are set forth in section (d)(2).

(6) Catalyst Monitoring

(6.1) Requirement: The OBD system shall monitor the catalyst system for proper conversion capability.

(6.2) Malfunction Criteria:

(6.2.1) The OBD system shall detect a catalyst system malfunction when the catalyst system’s conversion capability decreases to the point that any of the following occurs:

(A) Non-Methane Hydrocarbon (NMHC) emissions exceed 1.75 times the applicable standards to which the engine has been certified.

(B) The average FTP test NMHC conversion efficiency of the monitored portion of the catalyst system falls below 50 percent (i.e., the cumulative NMHC emissions measured at the outlet of the monitored catalyst(s) are more than 50 percent of the cumulative engine-out emissions measured at the inlet of the catalyst(s)). With Executive Officer approval, manufacturers may use a conversion efficiency malfunction criteria of less than 50 percent if the catalyst system is designed such that the monitored portion of the catalyst system must be replaced along with an adjacent portion of the catalyst system sufficient to ensure that the total portion replaced will meet the 50 percent conversion efficiency criteria. Executive Officer approval shall be based on data and/or engineering evaluation demonstrating the conversion efficiency of the monitored portion and the total portion designed to be replaced, and the likelihood of the catalyst system design to ensure replacement of the monitored and adjacent portions of the catalyst system.

(C) Oxides of nitrogen (NOx) emissions exceed 1.75 times the applicable NOx standard to which the engine has been certified.

(6.2.2) For purposes of determining the catalyst system malfunction criteria in section (f)(6.2.1):

(A) The manufacturer shall use a catalyst system deteriorated to the malfunction criteria using methods established by the manufacturer to represent real world catalyst deterioration under normal and malfunctioning operating conditions.

(B) Except as provided below in section (f)(6.2.2)(C), the malfunction criteria shall be established by using a catalyst system with all monitored and unmonitored (downstream of the sensor utilized for catalyst monitoring) catalysts simultaneously deteriorated to the malfunction criteria.

(C) For engines using fuel shutoff to prevent over-fueling during misfire conditions (see section (f)(2.4.1)(D)), the malfunction criteria shall be established by using a catalyst system with all monitored catalysts simultaneously deteriorated to the malfunction criteria while unmonitored catalysts shall be deteriorated to the end of the engine's useful life.

(6.3) Monitoring Conditions: Manufacturers shall define the monitoring conditions for malfunctions identified in section (f)(6.2) in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements). <u>Additionally, manufacturers shall track and report the in-use performance of the catalyst monitors under section (f)(6.2) in accordance with section (d)(3.2.1).</u> For purposes of tracking and reporting as required in section (d)(3.2.1), all monitors used to detect malfunctions identified in section (f)(6.2) shall be tracked separately but reported as a single set of values as specified in section (d)(5.2.2).

(6.4) MIL Illumination and Fault Code Storage:

(6.4.1) General requirements for MIL illumination and fault code storage are set forth in section (d)(2).

(6.4.2) The monitoring method for the catalyst(s) shall be capable of detecting when a catalyst fault code has been cleared (except OBD system self-clearing), but the catalyst has not been replaced (e.g., catalyst overtemperature histogram approaches are not acceptable).

(7) Evaporative System Monitoring

(7.1) Requirement: The OBD system shall verify purge flow from the evaporative system and shall monitor the complete evaporative system, excluding the tubing and connections between the purge valve and the intake manifold, for vapor leaks to the atmosphere. Individual components of the evaporative system (e.g. valves, sensors) shall be monitored in accordance with the comprehensive components requirements in section (g)(3) (e.g., for circuit continuity, out of range values, rationality, proper functional response). Vehicles not subject to evaporative emission standards shall be exempt from monitoring of the evaporative system. For alternate-fueled engines subject to evaporative emission standards, manufacturers shall submit a monitoring plan to the Executive Officer for approval. The Executive Officer shall approve the request upon determining that the manufacturer has submitted data and an engineering evaluation that demonstrate that the monitoring plan is as reliable and effective as the monitoring plan required for gasoline engines under section (f)(7).

(7.2) Malfunction Criteria:

(7.2.1) For purposes of section (f)(7), an "orifice" is defined 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).

(7.2.2) The OBD system shall detect an evaporative system malfunction when any of the following conditions exist:

(A) Except as specified in section (f)(7.2.2)(C), ~~N~~no purge flow from the evaporative system to the engine (i.e., to the enclosed area of the air intake system) can be detected by the OBD system; ~~or~~

(B) 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~~.~~; or

(C) For high-load purge lines (i.e., lines for purging the evaporative system canister under conditions where the intake manifold pressure is greater than ambient pressure) on vehicles with forced induction engines, no purge flow from the evaporative system to the engine (i.e., to the enclosed area of the air intake system) can be detected by the OBD system.

(7.2.3) A manufacturer may request the Executive Officer to revise the orifice size in section (f)(7.2.2)(B) if the most reliable monitoring method available cannot reliably detect a system leak of the magnitudes specified. The Executive Officer shall approve the request upon determining that the manufacturer has provided data and/or engineering analysis that demonstrate the need for the request.

(7.2.4) Upon request by the manufacturer and upon determining that the manufacturer has submitted data and/or engineering evaluation which support the request, the Executive Officer shall revise the orifice size in section (f)(7.2.2)(B) upward to exclude detection of leaks that cannot cause evaporative or running loss emissions to exceed 1.5 times the applicable evaporative emission standards.

(7.2.5) For engines with multiple fuel tanks, canisters, and/or purge valves, a manufacturer may request the Executive Officer to approve multiple "complete evaporative systems" on the engine with regards to the requirements of section (f)(7.2.2)(B) if the most reliable monitoring method available cannot reliably detect a system leak of the magnitude specified.

The Executive Officer shall approve the request upon determining that the manufacturer has provided data and/or engineering analysis that demonstrate the need for the request and that show the “complete evaporative system” does not have any shared vapor lines or paths with any other “complete evaporative system” in the engine. The manufacturer is required to meet the requirements of section (f)(7.2.2)(B) for each “complete evaporative system.”

(7.2.~~5~~6) For engines that utilize more than one purge flow path (e.g., a turbo-charged engine with a low-load ~~pressure~~ purge line and a high-load ~~pressure~~ purge line), except as provided for in sections (f)(7.2.6)(B) and (C) below, the OBD system shall verify the criteria of (f)(7.2.2)(A) and (f)(7.2.2)(C) (i.e., purge flow to the engine) for all purge flow paths (i.e., detect disconnections, broken lines, blockages, or any other malfunctions that prevent purge flow delivery to the engine).

(A) A manufacturer may request Executive Officer approval to detect the malfunctions using monitoring strategies that do not directly confirm evaporative purge delivery to the engine but infer it through other sensed parameters or conditions. The Executive Officer shall approve the monitoring strategy upon determining that data and/or engineering analysis submitted by the manufacturer demonstrate equivalent effectiveness in detecting malfunctions.

(B) If a manufacturer demonstrates that blockage, leakage, or disconnection of one of the purge flow paths cannot cause a measurable emission increase during any reasonable in-use driving conditions, monitoring of that flow path is not required.

(C) For 2010 through 2023 model year engines subject to the requirements of section (f)(7.2.2)(C), a manufacturer may request Executive Officer approval of a monitoring strategy that cannot detect all disconnections, broken lines, blockages, or any other malfunctions that can impact purge flow delivery to the engine as required in section (f)(7.2.2)(C). The Executive Officer shall approve the request upon determining that the manufacturer has submitted data and/or engineering evaluation demonstrating the following: the degree to which purge flow monitoring is limited is small relative to the fully monitored purge lines (e.g., blocked high-load purge lines can be detected but disconnections or broken lines cannot be detected, or high-load purge lines are fully monitored for purge flow delivery except for a one-inch portion after the venturi where a disconnection or broken fitting cannot be detected), the monitoring of the high-load purge lines cannot be fully achieved when employing proven monitoring technology (i.e., a technology that provides for compliance with these requirements on other engines), and the high-load purge system design is inherently resistant to deterioration (e.g., breakage, disconnections, blockage) of the unmonitored portions of the purge lines.

(7.3) Monitoring Conditions:

(7.3.1) Manufacturers shall define the monitoring conditions for malfunctions identified in section (f)(7.2.2)(A) and (C) (i.e., purge flow) in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements).

(7.3.2) Manufacturers shall define the monitoring conditions for malfunctions identified in section (f)(7.2.2)(B) (i.e., 0.150 inch leak detection) in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements). Additionally, manufacturers shall track and report the in-use performance of the evaporative system monitors under section (f)(7.2.2)(B) in accordance with section (d)(3.2.1). For purposes of tracking and reporting as required in section (d)(3.2.1), all monitors used to detect malfunctions identified in section (f)(7.2.2)(B) shall be tracked separately but reported as a single set of values as specified in section (d)(5.2.2).

(7.3.3) Manufacturers may disable or abort an evaporative system monitor when the fuel tank level is over 85 percent of nominal tank capacity or during a refueling event.

(7.3.4) Manufacturers may request Executive Officer approval to execute the evaporative system monitor only on driving cycles determined by the manufacturer to be cold starts if the condition is needed to ensure reliable monitoring. The Executive Officer shall approve the request upon determining that data and/or an engineering evaluation submitted by the manufacturer demonstrate that a reliable check can only be made on driving cycles when the cold start criteria are satisfied. However, in making a decision, the Executive Officer will not approve conditions that exclude engine starts from being considered as cold starts solely on the basis that ambient temperature exceeds (i.e., indicates a higher temperature than) engine coolant temperature at engine start.

(7.3.5) Manufacturers may temporarily disable the evaporative purge system to perform an evaporative system leak check.

(7.4) MIL Illumination and Fault Code Storage:

(7.4.1) Except as provided below for fuel cap leaks, general requirements for MIL illumination and fault code storage are set forth in section (d)(2).

(7.4.2) If the OBD system is capable of discerning that a system leak is being caused by a missing or improperly secured fuel cap:

(A) The manufacturer is not required to illuminate the MIL or store a fault code if the vehicle is equipped with an alternative indicator for notifying the vehicle operator of the malfunction. The alternative indicator shall be of sufficient illumination and location to be readily visible under all lighting conditions.

(B) If the vehicle is not equipped with an alternative indicator and the MIL illuminates, the MIL may be extinguished and the corresponding fault codes erased once the OBD system has verified that the fuel cap has been securely fastened and the MIL has not been illuminated for any other type of malfunction.

(C) The Executive Officer may approve other strategies that provide equivalent assurance that a vehicle operator will be promptly notified of a missing or improperly secured fuel cap and that corrective action will be undertaken.

(8) Exhaust Gas Sensor Monitoring

(8.1) Requirement:

(8.1.1) The OBD system shall monitor the output signal, response rate, and any other parameter which can affect emissions of all primary (fuel control) oxygen sensors (conventional switching sensors and wide range or universal sensors) for malfunction.

(8.1.2) The OBD system shall also monitor all secondary oxygen sensors (those used for fuel trim control or as a monitoring device) for proper output signal, activity, and response rate.

(8.1.3) For engines equipped with heated oxygen sensors, the OBD system shall monitor the heater for proper performance.

(8.1.4) For other types of sensors (e.g., hydrocarbon sensors, NOx sensors), the manufacturer shall submit a monitoring plan to the Executive Officer for approval. The Executive Officer shall approve the request upon determining that the manufacturer has submitted data and an engineering evaluation that demonstrate that the monitoring plan is as reliable and effective as the monitoring plan required for conventional sensors under section (f)(8).

(8.2) Malfunction Criteria:

(8.2.1) Primary Sensors:

(A) The OBD system shall detect a malfunction prior to any failure or deterioration of the oxygen 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 1.5 times any of the applicable standards. For response rate (see section (c)), the OBD system shall detect asymmetric malfunctions (i.e., malfunctions that primarily affect only the lean-to-rich response rate or only the rich-to-lean response rate) and symmetric malfunctions (i.e., malfunctions that affect both the lean-to-rich and rich-to-lean response rates). As defined in section (c), response rate includes delays in the sensor to initially react to a change in exhaust gas composition <u>(i.e., delayed response)</u> as well as ~~delays during the~~<u>slower</u> transition<u>s</u> from a rich-to-lean (or lean-to-rich) sensor output <u>(i.e., slow response)</u>. For 2013 and subsequent model year engines, the manufacturer shall submit data and/or engineering analysis to demonstrate that the calibration method used ensures proper detection of all symmetric and asymmetric response rate malfunctions as part of the certification application.

(B) The OBD system shall detect malfunctions of the oxygen sensor caused by ~~either~~ a lack of circuit continuity or out-of-range values.

(C) The OBD system shall detect a malfunction of the oxygen sensor when 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) or causes the fuel system to fail to enter closed-loop operation within a manufacturer-specified time interval.

(D) The OBD system shall detect a malfunction of the oxygen sensor when 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).

(8.2.2) Secondary Sensors:

(A) The OBD system shall detect a malfunction prior to any failure or deterioration of the oxygen sensor voltage, resistance, impedance, current, response rate, amplitude, offset, or other characteristic(s) that would cause an engine's emissions to exceed 1.5 times any of the applicable standards.

(B) The OBD system shall detect malfunctions of the oxygen sensor caused by a lack of circuit continuity.

(C) Sufficient sensor performance for other monitors.

(i) The OBD system shall detect a malfunction of the oxygen 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 monitoring). For this requirement, “sufficient” is defined as the capability of the worst performing acceptable sensor to detect the best performing unacceptable other monitored system or component (e.g., catalyst).

(ii) For systems where it is not technically feasible to satisfy the criteria of section (f)(8.2.2)(C)(i) completely, the OBD system shall, at a minimum, detect a slow rich-to-lean response malfunction during a fuel shut-off event (e.g., deceleration fuel cut event) on all 2013 and subsequent model year engines. The rich-to-lean response check shall monitor both the sensor response time from a rich condition (e.g., 0.7 Volts) prior to the start of fuel shut-off to a lean condition (e.g., 0.1 Volts) expected during fuel shut-off conditions and the sensor transition time in the intermediate sensor range (e.g., from 0.55 Volts to 0.3 Volts).

(iii) Additionally, for systems where it is not technically feasible to satisfy the criteria in section (f)(8.2.2)(C)(i), prior to certification of 2013 model year engines, the manufacturer must submit a comprehensive plan to the Executive Officer demonstrating the manufacturer’s efforts to minimize any gap remaining between the worst performing acceptable sensor and a sufficient sensor. The plan should include quantification of the gap and supporting documentation for efforts to close the gap including sensor monitoring improvements, other system component monitor improvements (e.g., changes to make the catalyst monitor less sensitive to oxygen sensor response), and sensor specification changes, if any. The Executive Officer shall approve the plan upon determining the submitted information supports the necessity of the gap and the plan demonstrates that the manufacturer is taking reasonable efforts to minimize or eliminate the gap in a timely manner.

(D) The OBD system shall detect malfunctions of the oxygen sensor caused by out-of-range values.

(E) The OBD system shall detect a malfunction of the oxygen sensor when a sensor failure or deterioration causes the fuel system (e.g., fuel control) to stop using that sensor as a feedback input (e.g., causes default or open-loop operation).

(8.2.3) Sensor Heaters:

(A) The OBD system shall 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). Subject to Executive Officer approval, other malfunction criteria for heater performance malfunctions may be used upon the Executive Officer determining that the manufacturer has submitted data and/or an engineering evaluation that demonstrate the monitoring reliability and timeliness to be equivalent to the stated criteria in section (f)(8.2.3)(A).

(B) The OBD system shall 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)).

(8.3) Monitoring Conditions:

(8.3.1) Primary Sensors

(A) Manufacturers shall define the monitoring conditions for malfunctions identified in sections (f)(8.2.1)(A) and (D) (e.g., proper response rate) in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements). Additionally, manufacturers shall track and report the in-use performance of the primary sensor monitors under sections (f)(8.2.1)(A) and (D) in accordance with section (d)(3.2.1). For purposes of tracking and reporting as required in section (d)(3.2.1), all monitors used to detect malfunctions identified in sections (f)(8.2.1)(A) and (D) shall be tracked separately but reported as a single set of values as specified in section (d)(5.2.2).

(B) Except as provided in section (f)(8.3.1)(C), monitoring for malfunctions identified in sections (f)(8.2.1)(B) and (C) (i.e., circuit continuity, out-of-range, and open-loop malfunctions) shall be conducted continuously.

(C) A manufacturer may request Executive Officer approval to 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). The Executive Officer shall approve the disablement upon determining that the manufacturer has submitted test data and/or documentation that demonstrate 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.

(8.3.2) Secondary Sensors

(A) Manufacturers shall define monitoring conditions for malfunctions identified in sections (f)(8.2.2)(A) and (C) (e.g., proper sensor activity) in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements). Additionally, ~~F~~for all 2013 and subsequent model year engines meeting the monitoring requirements of section (f)(8.2.2)(C)(i) or (ii), manufacturers shall track and report the in-use performance of the secondary sensor monitors under sections (f)(8.2.2)(A) and (C) in accordance with section (d)(3.2.1). ~~f~~For purposes of tracking and reporting as required in section (d)(3.2.1), all monitors used to detect malfunctions identified in sections (f)(8.2.2)(A) and (C) shall be tracked separately but reported as a single set of values as specified in section (d)(5.2.2).

(B) Except as provided in section (f)(8.3.2)(C), monitoring for malfunctions identified in sections (f)(8.2.2)(B), (D), and (E) (i.e., open circuit, out-of-range malfunctions, open-loop malfunctions) shall be conducted continuously.

(C) A manufacturer may request Executive Officer approval to disable continuous exhaust gas sensor monitoring when an oxygen sensor malfunction cannot be distinguished from other effects (e.g., disable out-of-range low monitoring during fuel cut conditions). The Executive Officer shall approve the disablement upon determining that the manufacturer has submitted test data and/or documentation that demonstrate 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.

(8.3.3) Sensor Heaters

(A) Manufacturers shall define monitoring conditions for malfunctions identified in section (f)(8.2.3)(A) (i.e., sensor heater performance) in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements).

(B) Monitoring for malfunctions identified in section (f)(8.2.3)(B) (i.e., circuit malfunctions) shall be conducted continuously.

(8.4) MIL Illumination and Fault Code Storage: General requirements for MIL illumination and fault code storage are set forth in section (d)(2). To the extent feasible, the OBD system shall separately detect lack of circuit continuity and out-of-range faults as required under sections (f)(8.2.1)(B), (f)(8.2.2)(B), and (f)(8.2.2)(D) and store different fault codes for each distinct malfunction (e.g., out-of-range low, out-of-range high, open circuit). For sensors with sensing elements externally connected to a sensor control module, manufacturers are not required to store different fault codes for lack of circuit continuity and out-of-range faults if: (1) the sensing element (i.e., probe or sensor externally connected to the sensor control module) is a subcomponent integral to the function of the complete sensor unit; (2) the sensing element is permanently attached to the sensor control module with wires or one-time connectors; (3) the complete sensor unit is designed, manufactured, installed, and serviced per manufacturer published procedures as a single component; and (4) the sensor control module and sensing element are calibrated together during the manufacturing process such that neither can be individually replaced in a repair scenario. Additionally, ~~M~~manufacturers are not required to store separate fault codes for lack of circuit continuity faults that cannot be distinguished from other out-of-range circuit faults.

(9) Variable Valve Timing, Lift, and/or Control (VVT) System Monitoring

(9.1) Requirement: The OBD system shall monitor the VVT system on engines so-equipped for target error and slow response malfunctions. Manufacturers must submit data and/or an analysis identifying all possible failure modes of the VVT system (e.g., partial or complete blockage of hydraulic passages, broken return springs, a failure of a single cylinder-specific pin to move into the desired position on a lift mechanism) and the effect each has (e.g., failure modes and effects analysis) across the entire range of operating conditions. The individual electronic components (e.g., actuators, valves, sensors) that are used in the VVT system shall be monitored in accordance with the comprehensive components requirements in section (g)(3).

(9.2) Malfunction Criteria:

(9.2.1) Target Error: The OBD system shall 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 1.5 times any of the applicable standards. Systems with discrete operating states (e.g., two step valve train systems) are not required to detect a malfunction prior to exceeding the threshold but are required to detect all failures that exceed the threshold.

(9.2.2) Slow Response: The OBD system shall 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 1.5 times any of the applicable standards for gasoline engines. Systems with discrete operating states are not required to detect a malfunction prior to exceeding the threshold but are required to detect all failures that exceed the threshold.

(9.2.3) For engines in which no failure or deterioration of the VVT system could result in an engine's emissions exceeding 1.5 times any of the applicable standards, the OBD system shall detect a malfunction of the VVT system when proper functional response of the ~~system~~ electronic components to computer commands does not occur.

(9.3) Monitoring Conditions: Manufacturers shall define the monitoring conditions for VVT system malfunctions identified in section (f)(9.2) in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements), with the exception that monitoring shall occur every time the monitoring conditions are met during the driving cycle in lieu of once per driving cycle as required in section (d)(3.1.2). Additionally, manufacturers shall track and report the in-use performance of the VVT system monitors under section (f)(9.2) in accordance with section (d)(3.2.1). For purposes of tracking and reporting as required in section (d)(3.2.1), all monitors used to detect malfunctions identified in section (f)(9.2) shall be tracked separately but reported as a single set of values as specified in section (d)(5.2.2).

(9.4) MIL Illumination and Fault Code Storage: General requirements for MIL illumination and fault code storage are set forth in section (d)(2).

(g) *Monitoring Requirements For All Engines.*

(1) Engine Cooling System Monitoring

(1.1) Requirement:

(1.1.1) The OBD system shall monitor the thermostat on engines so-equipped for proper operation.

(1.1.2) The OBD system shall monitor the engine coolant temperature (ECT) sensor for circuit continuity, out-of-range values, and rationality faults.

(1.1.3) For engines that use an engine and/or engine component temperature sensor or system (e.g., oil temperature, cylinder head temperature) ~~other than~~ in lieu of or in addition to 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 following requirements shall apply:

(A) For engines that use an engine and/or engine component temperature sensor or system in lieu of the cooling system and ECT sensor, the manufacturer shall submit a monitoring plan to the Executive Officer for approval. The Executive Officer shall approve the request upon determining that the manufacturer has submitted data and an engineering evaluation that demonstrate that the monitoring plan is as reliable and effective as the monitoring required for the engine cooling system under section (g)(1).

(B) For 2024 and subsequent model year engines that use an engine and/or engine component temperature sensor or system in addition to the cooling system and ECT sensor (including systems that use more than one thermostat or flow control device to regulate different temperatures in different cooling circuits and use input from at least two temperature sensors in separate cooling circuits for an indication of engine operating temperatures for emission control purposes), the manufacturer shall submit a monitoring plan to the Executive Officer for approval. The Executive Officer shall approve the request upon determining that the manufacturer has submitted data and an engineering evaluation that demonstrate that the monitoring plan is as reliable and effective as the monitoring required for the engine cooling system under section (g)(1).

(1.1.4) For vehicles with engine cooling systems that include components modulated by a control unit (e.g., electrical water pump, electrically heated thermostat) to regulate the ECT, the manufacturer shall submit a monitoring plan to the Executive Officer for approval. The Executive Officer shall approve the plan 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 requirements specified for the thermostat under section (g)(1).

(1.2) Malfunction Criteria:

(1.2.1) Thermostat

(A) The OBD system shall detect a thermostat malfunction if, within an Executive Officer-approved time interval or time-equivalent calculated value after engine start, any of the following conditions occur:

(i) The coolant temperature does not reach the highest temperature required by the OBD system to enable other diagnostics;

(ii) The coolant temperature does not reach a warmed-up temperature within 20 degrees Fahrenheit (or 11.1 degrees Celsius) of the manufacturer’s nominal thermostat regulating temperature. Subject to Executive Officer approval, a manufacturer may utilize lower temperatures for this criterion upon the Executive Officer determining that the manufacturer has demonstrated that the fuel, spark timing, and/or other coolant temperature-based modifications to the engine control strategies would not cause an emission increase of 50 or more percent of any of the applicable standards (e.g., 50 degree Fahrenheit emission test).

(B) For 2016 and subsequent model year engines, the OBD system shall detect a thermostat fault if, after the coolant temperature has reached the temperatures indicated in sections (g)(1.2.1)(A)(i) and (ii), the coolant temperature drops below the temperature indicated in section (g)(1.2.1)(A)(i).

(C) Executive Officer approval of the time interval or time-equivalent calculated value after engine start under section (g)(1.2.1)(A) above shall be granted upon determining that the data and/or engineering evaluation submitted by the manufacturer supports the specified times.

(D) For monitoring of malfunctions under section (g)(1.2.1)(A) and (B), with Executive Officer approval, a manufacturer may use alternate malfunction criteria and/or monitoring conditions (see section (g)(1.3)) 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. Executive Officer approval shall be granted upon determining that the manufacturer has submitted data that demonstrate that a properly operating system does not reach the specified temperatures, that the monitor is capable of meeting the specified malfunction criteria at engine start temperatures greater than 50 degrees Fahrenheit, and that the possibility for cooling system malfunctions to go undetected and disable other OBD monitors is minimized to the extent technically feasible.

(E) A manufacturer may request Executive Officer approval to be exempted from the requirements of thermostat monitoring under sections (g)(1.2.1)(A) and (B). Executive Officer approval shall be granted upon determining that the manufacturer has demonstrated that a malfunctioning thermostat cannot cause a measurable increase in emissions during any reasonable driving condition nor cause any disablement of other monitors.

(1.2.2) ECT Sensor

(A) Circuit Continuity. The OBD system shall detect a malfunction when a lack of circuit continuity or out-of-range values occur.

(B) Time to Reach Closed-Loop/Feedback/Feed-Forward Enable Temperature.

(i) The OBD system shall detect a malfunction if the ECT sensor does not achieve the highest stabilized minimum temperature which is needed for closed-loop,~~/~~ feedback ~~control~~or feed-forward operation of all emission control systems/strategies (e.g., fuel system, EGR system) within an Executive Officer-approved time interval after engine start. For engines that can have either stoichiometric or non-stoichiometric closed-loop operation of the fuel system, “closed-loop” operation shall be defined as follows:

a. For 2010 through 2023 model year engines, “closed-loop” operation shall mean either stoichiometric or non-stoichiometric closed-loop operation, whichever one the manufacturer chooses.

b. For 2024 and subsequent model year engines, “closed-loop” operation shall mean stoichiometric closed-loop operation across the engine loads observed on the FTP cycle.

(ii) The time interval shall be a function of starting ECT and/or a function of intake air temperature. Executive Officer approval of the time interval shall be granted upon determining that the data and/or engineering evaluation submitted by the manufacturer supports the specified times.

(iii) Manufacturers are exempted from the requirements of section (g)(1.2.2)(B) if the manufacturer does not utilize ECT to enable closed-loop/feedback/feed-forward ~~control~~ operation of any emission control system/strategy.

(C) Stuck in Range Below the Highest Minimum Enable Temperature. To the extent feasible when using all available information, the OBD system shall 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 diagnostics (e.g., an OBD system that requires ECT to be greater than 140 degrees Fahrenheit to enable a diagnostic must detect malfunctions that cause the ECT sensor to inappropriately indicate a temperature below 140 degrees Fahrenheit). Manufacturers are exempted from this requirement for temperature regions in which the monitors required under sections (g)(1.2.1) or (g)(1.2.2)(B) will detect ECT sensor malfunctions as defined in section (g)(1.2.2)(C).

(D) Stuck in Range Above the Lowest Maximum Enable Temperature.

(i) To the extent feasible when using all available information, the OBD system shall 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 diagnostics (e.g., an OBD system that requires ECT to be less than 90 degrees Fahrenheit at engine start to enable a diagnostic must detect malfunctions that cause the ECT sensor to inappropriately indicate a temperature above 90 degrees Fahrenheit).

(ii) Manufacturers are exempted from this requirement for temperature regions in which the monitors required under sections (g)(1.2.1), (g)(1.2.2)(B), or (g)(1.2.2)(C) (i.e., ECT sensor or thermostat malfunctions) will detect ECT sensor malfunctions as defined in section (g)(1.2.2)(D) or in which the MIL will be illuminated under the requirements of sections (d)(2.2.1)(E) or (d)(2.2.2)(E) for default mode operation (e.g., overtemperature protection strategies).

(iii) Manufacturers are exempted from the requirements of section (g)(1.2.2)(D) for temperature regions where the temperature gauge indicates a temperature in the red zone (engine overheating zone) for vehicles that have a temperature gauge (not a warning light) on the instrument panel and utilize the same ECT sensor for input to the OBD system and the temperature gauge.

(1.3) Monitoring Conditions:

(1.3.1) Thermostat

(A) Manufacturers shall define the monitoring conditions for malfunctions identified in section (g)(1.2.1)(A) in accordance with section (d)(3.1) except as provided for in section (g)(1.3.1)(E). Additionally, except as provided for in sections (g)(1.3.1)(~~B~~C) through (E), monitoring for malfunctions identified in section (g)(1.2.1)(A) shall be conducted once per driving cycle on every driving cycle in which the ECT sensor indicates, at engine start, a temperature lower than the temperature established as the malfunction criteria in section (g)(1.2.1)(A).

(B) Manufacturers shall define the monitoring conditions for malfunctions identified in section (g)(1.2.1)(B) in accordance with section (d)(3.1) with the exception that monitoring shall occur every time the monitoring conditions are met during the driving cycle in lieu of once per driving cycle.

(C) Manufacturers may disable thermostat monitoring at ambient engine temperatures below 20 degrees Fahrenheit (or -6.7 degrees Celsius).

(D) Manufacturers may request Executive Officer approval to suspend or disable thermostat monitoring required under sections (g)(1.2.1)(A) and (B) if the vehicle is subjected to conditions which could lead to false diagnosis (e.g., vehicle operation at idle for more than 50 percent of the warm-up time, engine block heater operation). With respect to disablement on driving cycles solely due to warm ECT at engine start conditions for thermostat monitoring under section (g)(1.2.1)(A), the manufacturer shall disable the monitor during driving cycles where the ECT at engine start is within 35 degrees Fahrenheit (or 19.4 degrees Celsius) of the thermostat malfunction threshold temperature determined under section (g)(1.2.1)(A) (e.g., if the malfunction threshold temperature is 160 degrees Fahrenheit, the monitor shall be disabled if the ECT at engine start is above 125 degrees Fahrenheit).

(E) Notwithstanding section (g)(1.3.1)(D), manufacturers may request Executive Officer approval to enable thermostat monitoring required under section (g)(1.2.1)(A) during a portion of the driving cycles where the ECT at engine start is warmer than 35 degrees Fahrenheit below the thermostat malfunction threshold temperature determined under section (g)(1.2.1)(A) (e.g., if the malfunction threshold temperature is 160 degrees Fahrenheit, the manufacturer may request approval to have the monitor enabled for a portion of the ECT at engine start region between 125 and 160 degrees Fahrenheit). The Executive Officer shall approve the request upon determining that the manufacturer has submitted test data and/or engineering evaluation that demonstrate that the monitor is able to robustly detect thermostat malfunctions (e.g., cannot result in false passes or false indications of malfunctions) on driving cycles where it is enabled.

(F) With respect to defining enable conditions that are encountered during the FTP cycle as required in (d)(3.1.1) for malfunctions identified in section (g)(1.2.1)(A), the FTP cycle shall refer to on-road driving following the FTP cycle in lieu of testing on an engine dynamometer.

(1.3.2) ECT Sensor

(A) Except as provided below in section (g)(1.3.2)(E), monitoring for malfunctions identified in section (g)(1.2.2)(A) (i.e., circuit continuity and out-of-range) shall be conducted continuously.

(B) Manufacturers shall define the monitoring conditions for malfunctions identified in section (g)(1.2.2)(B) in accordance with section (d)(3.1). Additionally, except as provided for in section (g)(1.3.2)(D), monitoring for malfunctions identified in section (g)(1.2.2)(B) shall be conducted once per driving cycle on every driving cycle in which the ECT sensor indicates a temperature lower than the closed-loop enable temperature at engine start (i.e., all engine start temperatures greater than the ECT sensor out-of-range low temperature and less than the closed-loop enable temperature).

(C) Manufacturers shall define the monitoring conditions for malfunctions identified in sections (g)(1.2.2)(C) and (D) in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements).

(D) Manufacturers may suspend or delay the ~~time to reach closed-loop enable temperature~~ diagnostic(s) required to detect malfunctions specified under section (g)(1.2.2)(B) if the vehicle is subjected to conditions which could lead to false diagnosis (e.g., vehicle operation at idle for more than 50 to 75 percent of the warm-up time).

(E) A manufacturer may request Executive Officer approval to disable continuous ECT sensor monitoring when an ECT sensor malfunction cannot be distinguished from other effects. The Executive Officer shall approve the disablement upon determining that the manufacturer has submitted test data and/or engineering evaluation that demonstrate 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.

(1.4) MIL Illumination and Fault Code Storage: General requirements for MIL illumination and fault code storage are set forth in section (d)(2).

(2) Crankcase Ventilation (CV) System Monitoring

(2.1) Requirement: The OBD system shall monitor the CV system on engines so-equipped for system integrity. Engines not subject to crankcase emission control requirements shall be exempt from monitoring of the CV system.

(2.2) Malfunction Criteria:

(2.2.1) For the purposes of section (g)(2), "CV system" is defined as any form of crankcase ventilation system, regardless of whether it utilizes positive pressure or whether it vents to the atmosphere, the intake, or the exhaust. "CV valve" is defined as any form of valve orifice, and/or filter/separator used to restrict, control, or alter the composition (e.g., remove oil vapor or particulate matter) of the crankcase vapor flow. Further, any additional external CV system tubing or hoses used to equalize crankcase pressure or to provide a ventilation path between various areas of the engine (e.g., crankcase and valve cover) are considered part of the CV system "between the crankcase and the CV valve" and subject to the malfunction criteria in section (g)(2.2.2) or (g)(2.2.3) below.

(2.2.2) For engines not included in the phase-in specified in section (g)(2.2.3), the following criteria apply for CV system monitoring:

(A) Except as provided in sections (g)(2.2.2)(B) through (F) below, the OBD system shall detect a malfunction of the CV system when a disconnection of the system occurs between ~~either~~ the crankcase and the CV valve~~,~~ or between the CV valve and the intake ducting.

~~(2.2.3)~~ (B) If disconnection in the system results in a rapid loss of oil or other overt indication of a CV system malfunction such that the vehicle operator is certain to respond and have the vehicle repaired, the Executive Officer shall exempt the manufacturer from detection of that disconnection.

~~(2.2.4)~~ (C) The Executive Officer shall exempt a manufacturer from detecting a disconnection between the crankcase and the CV valve upon determining that the disconnection cannot be made without first disconnecting a monitored portion of the system (e.g., the CV system is designed such that the CV valve is fastened directly to the crankcase in a manner which makes it significantly more difficult to remove the valve from the crankcase rather than disconnect the line between the valve and the intake manifold/ducting (taking aging effects into consideration)) and the line between the valve and the intake ducting is monitored for disconnection. The manufacturer shall file a request and submit data and/or engineering evaluation in support of the exemption.

~~(2.2.5)~~ (D) Subject to Executive Officer approval, system designs that utilize tubing between the valve and the crankcase shall be exempted from the monitoring requirement for detection of disconnection between the CV valve and the crankcase. The manufacturer shall file a request and submit data and/or engineering evaluation in support of the request. The Executive Officer shall approve the request upon determining 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/ducting, and (3) not subject to disconnection per manufacturer's maintenance, service, and/or repair procedures for non-CV system repair work.

~~(2.2.6)~~ (E) The Executive Officer shall exempt a manufacturer from detecting a disconnection between the CV 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 CV system design that is integral to the induction system or to the engine (e.g., machined passages rather than tubing or hoses). The manufacturer shall file a request and submit data and/or engineering evaluation in support of the exemption.

~~(2.2.7)~~ (F) For engines certified on an engine dynamometer having an open CV system (i.e., a system that releases crankcase emissions to the atmosphere without routing them to the intake ducting or to the exhaust upstream of the aftertreatment), the manufacturer shall submit a plan for Executive Officer approval of the monitoring strategy, malfunction criteria, and monitoring conditions prior to OBD certification. Executive Officer approval shall be based on the effectiveness of the monitoring strategy to

(i) monitor the performance of the CV system to the extent feasible with respect to the malfunction criteria in section (g)(2.2.~~1~~2~~) through (g)(2.2.4)~~ and the monitoring conditions required by the diagnostic, and (ii) monitor the ability of the CV system to control crankcase vapor emitted to the atmosphere relative to the manufacturer's design and performance specifications for a properly functioning system (e.g., if the system is equipped with a filter and/or separator to reduce crankcase emissions to the atmosphere, the OBD system shall monitor the integrity of the filter and/or function of the separator).

(2.2.3) For 30 percent of 2025 model year, 60 percent of 2026 model year, and 100 percent of 2027 and subsequent model year engines, the following criteria apply for CV system monitoring:

(A) Except as provided in sections (g)(2.2.3)(B) and (C) below, the OBD system shall detect a malfunction of the CV system when a disconnection of the system occurs between the crankcase and the CV valve, or between the CV valve and intake ducting. For any hose, tube, or line that transports crankcase vapors, the OBD system shall detect a CV system malfunction when the system contains a disconnection or break equal to or greater than the smallest internal cross-sectional area of that hose, tube, or line. For the purposes of section (g)(2.2.3), "hose, tube, or line" includes any fittings that are used for connection such as nipples or barbs that the hoses must be placed over for proper attachment.

(B) Manufacturers are not required to detect disconnections or breaks of any CV system hose, tube, or line if the disconnection or break (1) causes the vehicle to stall immediately during idle operation; (2) is unlikely to occur due to a CV system design that is integral to the induction system (e.g., machined passages rather than tubing or hoses); (3) results in a rapid loss of oil or other overt indication of a CV system malfunction such that the vehicle operator is certain to respond and have the vehicle repaired; or (4) occurs downstream of where the crankcase vapors are delivered to the air intake system.

(C) For engines certified on an engine dynamometer having an open CV system (i.e., a system that releases crankcase emissions to the atmosphere without routing them to the intake ducting or to the exhaust upstream of the aftertreatment), the manufacturer shall submit a plan for Executive Officer approval of the monitoring strategy, malfunction criteria, and monitoring conditions prior to OBD certification. Executive Officer approval shall be based on the effectiveness of the monitoring strategy to (i) monitor the performance of the CV system to the extent feasible with respect to the malfunction criteria in sections (g)(2.2.3)(A) and (B) and the monitoring conditions required by the diagnostic, and (ii) monitor the ability of the CV system to control crankcase vapor emitted to the atmosphere relative to the manufacturer's design and performance specifications for a properly functioning system (e.g., if the system is equipped with a filter and/or separator to reduce crankcase emissions to the atmosphere, the OBD system shall monitor the integrity of the filter and/or function of the separator).

(2.3) Monitoring Conditions: Manufacturers shall define the monitoring conditions for malfunctions identified in section (g)(2.2) in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements).

(2.4) MIL Illumination and Fault Code Storage: General requirements for MIL illumination and fault code storage are set forth in section (d)(2). The stored fault code need not specifically identify the CV system (e.g., a fault code for idle speed control or fuel system monitoring can be stored) if the manufacturer demonstrates 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 CV system.

(3) Comprehensive Component Monitoring

(3.1) Requirement:

(3.1.1) Except as provided in sections (g)(3.1.3), (g)(3.1.4), (g)(3.1.5), (g)(3.1.6), and (g)(4), the OBD system shall monitor for malfunction any electronic powertrain component/system not otherwise described in sections (e)(1) through (g)(2) that either provides input to (directly or indirectly) or receives commands from ~~the~~ an on-board computer~~(s)~~ or smart device, and any of the following: (1) can affect NMHC, NOx, CO, or PM 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, (3) is used as an input to (directly or indirectly) an inducement strategy on 2024 and subsequent model year engines, or (4) is used as an input to (directly or indirectly) or output from an AECD strategy. Each input to or output from a smart device that meets criterion (1) or (2) above shall be monitored pursuant to section (g)(3). Further detection or pinpointing of faults internal to the smart device is not required. If the control system detects deterioration or malfunction of the component/system and takes direct action to compensate or adjust for it, manufacturers may not use the criteria under section (g)(3) and are instead subject to the default action requirements of section (d)(2.2.1)(E) or (d)(2.2.2)(E), as applicable.

(A) Input Components: 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, fuel composition sensor (e.g. flexible fuel vehicles), and electronic components used to comply with any applicable engine idling requirements of title 13, CCR section 1956.8.

(B) Output Components/Systems: Output components/systems required to be monitored may include the idle speed control system, fuel injectors, glow plug system, variable length intake manifold runner systems, supercharger or turbocharger electronic components, heated fuel preparation systems, and the wait-to-start lamp on diesel applications.

(3.1.2) For purposes of criteria (1) in section (g)(3.1.1) above, the manufacturer shall determine whether an engine input or output component/system can affect emissions when operating without any control system compensation or adjustment for deterioration or malfunction (as described in section (g)(3.1.1)). If the Executive Officer reasonably believes that a manufacturer has incorrectly determined that a component/system cannot affect emissions, the Executive Officer shall require the manufacturer to provide emission data showing that the component/system, when malfunctioning and installed in a suitable test vehicle, does not have an emission effect. The Executive Officer may request emission data for any reasonable driving condition.

(3.1.3) Manufacturers shall monitor for malfunction electronic powertrain input or output components/systems associated with an electronic transfer case, electronic power steering system, transmission (except as provided below in section (g)(3.1.6)), or other components that are driven by the engine and not related to the control of fueling, air handling, or emissions only if the component or system is used as part of the diagnostic strategy for any other monitored system or component.

(3.1.4) Except as specified for hybrid vehicles in section (g)(3.1.5), manufacturers shall monitor for malfunction electronic powertrain input or output components/systems associated with components that only affect emissions by causing additional electrical load to the engine and are not related to the control of fueling, air handling, or emissions only if the component or system is used as part of the diagnostic strategy for any other monitored system or component.

(3.1.5) For hybrid vehicles:

(A) Except as provided in section (d)(7.6) and section (g)(3.1.5)(B), ~~for hybrid vehicles,~~ manufacturers shall submit a plan to the Executive Officer for approval of the hybrid components determined by the manufacturer to be subject to monitoring in section (g)(3.1.1). In general, the Executive Officer shall approve the plan if it includes monitoring of all components/systems used as part of the diagnostic strategy for any other monitored system or component, monitoring of all energy input devices to the electrical propulsion system, monitoring of battery and charging system performance, monitoring of electric motor performance, and monitoring of regenerative braking performance.

(B) For 2024 and subsequent model year engines, manufacturers are subject to the applicable requirements specified in section (g)(3.2.3).

(3.1.6) For OBD systems that receive vehicle speed information from a transmission control unit and use vehicle speed as part of the diagnostic strategy for any other OBD monitored system or component:

(A) The OBD system shall monitor the vehicle speed information to the extent feasible in accordance with the requirements of section (g)(3);

(B) The OBD system shall detect a fault and illuminate the MIL when the OBD system is unable to properly receive the vehicle speed information; and

(C) If the transmission control unit monitors the vehicle speed information and indicates an error of the information to the OBD system (e.g., valid vehicle speed data is no longer available), the OBD system shall handle the error indication as a default mode of operation subject to the MIL illumination requirements under section (d)(2.2).

(3.2) Malfunction Criteria:

(3.2.1) Input Components:

(A) The OBD system shall detect malfunctions of input components caused by ~~a lack of~~ circuit ~~continuity~~ faults (or for digital inputs, lack of communication to the on-board computer), out-of-range values, and, where feasible, rationality faults. To the extent feasible, the rationality fault diagnostics shall verify that a sensor output is neither inappropriately high nor inappropriately low (i.e., shall be "two-sided" diagnostics).

(B) To the extent feasible, the OBD system shall separately detect and store different fault codes that distinguish rationality faults from ~~lack of~~ circuit ~~continuity~~ faults and out-of-range faults. Two-sided rationality fault diagnostics are not required to set separate fault codes for each side. Additionally:

(i) For computer encoded digital inputs: lack of communication from the input to the on-board computer shall be separately detected and store a separate fault code. Separate fault codes are not required for each distinct out-of-range fault.

(ii) For all other inputs: For ~~input~~ component ~~lack of~~ circuit ~~continuity~~ and out-of-range faults, the OBD system shall~~, to the extent feasible,~~ separately detect and store different fault codes for each distinct malfunction (e.g., out-of-range low, out-of-range high, open circuit). Notwithstanding, ~~T~~the OBD system is not required to store separate fault codes for lack of circuit continuity faults that cannot be distinguished from other out-of-range ~~circuit~~ faults. For sensors that are fixed to a circuit board within a diagnostic or emission critical control unit, as defined in section (c), manufacturers may combine circuit and out-of-range value faults into a single fault code that identifies the malfunctioning sensor.

(C) For input components that are used to activate alternate strategies that can affect emissions (e.g., AECDs, engine shutdown systems or strategies to meet NOx idling standards required by title 13, CCR section 1956.8), the OBD system shall detect rationality malfunctions that cause the system to erroneously activate or deactivate the alternate strategy. To the extent feasible when using all available information, the rationality fault diagnostics shall detect a malfunction if the input component inappropriately indicates a value that activates or deactivates the alternate strategy. For example, if an alternate strategy requires the intake air temperature to be greater than 120 degrees Fahrenheit to activate, the OBD system shall detect malfunctions that cause the intake air temperature sensor to inappropriately indicate a temperature above 120 degrees Fahrenheit.

(D) For input components that are directly or indirectly used for any emission control strategies that are not covered under sections (e), (f), and (g)(1) (e.g., exhaust temperature sensors used for a control strategy that regulates SCR catalyst inlet temperature within a target window), the OBD system shall detect rationality malfunctions that prevent the component from correctly sensing any condition necessary for the strategy to operate in its intended manner. These malfunctions include faults that inappropriately prevent or delay the activation of the emission control strategy, cause the system to erroneously exit the emission control strategy, or where the control strategy has used up all of the adjustments or authority allowed by the manufacturer and is still unable to achieve the desired condition. The Executive Officer may waive detection of specific malfunctions upon determining that the manufacturer has submitted data and/or an engineering evaluation that demonstrate that reliable detection of the malfunction is technically infeasible or would require additional hardware.

(E) For engines that require precise alignment between the camshaft and the crankshaft, the OBD system shall monitor the crankshaft position sensor(s) and camshaft position sensor(s) to verify proper alignment between the camshaft and crankshaft in addition to monitoring the sensors for circuit continuity and rationality malfunctions. Proper alignment monitoring between a camshaft and a crankshaft shall 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 shall detect a malfunction of the misalignment between the camshaft and crankshaft at one of the following two levels:

(i) The smallest number of teeth/cogs misalignment that can be detected using the existing hardware; or~~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)~~.

(ii) ~~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 shall detect a malfunction when t~~The minimum number of teeth/cogs misalignment needed to cause a measurable emission increase~~ has occurred~~.

(3.2.2) Output Components/Systems:

(A) The OBD system shall detect a malfunction of an output component/system when proper functional response of the component and system to computer commands does not occur. If a functional check is not feasible, the OBD system shall detect malfunctions of output components/systems caused by a lack of circuit continuity or circuit fault (e.g., short to ground or high voltage), or communication errors or the lack of communication if the signal to the output component is digital. For output component lack of circuit continuity faults and circuit faults, the OBD system is not required to store different fault codes for each distinct malfunction (e.g., open circuit, shorted low). Manufacturers are not required to activate an output component/system when it would not normally be active for the purposes of performing a functional ~~monitoring~~ check of the output component~~s~~/system~~s~~ as required in section (g)(3).

(B) The idle control system shall be monitored for proper functional response to computer commands.

(i) For gasoline engines using monitoring strategies based on deviation from target idle speed, a malfunction shall 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 Executive Officer shall allow larger engine speed tolerances upon determining that a manufacturer has submitted data and/or an engineering evaluation which demonstrate that the tolerances can be exceeded without a malfunction being present.

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 monitors.

(ii) For diesel engines, a malfunction shall be detected when any of the following conditions occur:

a. The idle control system cannot achieve or maintain the idle speed within +/-50 percent of the manufacturer-specified target or desired engine speed.

b. The idle control system cannot achieve the target or desired idle speed within the smallest engine speed tolerance range required by the OBD system to enable any other monitors.

c. For 2013 and subsequent model year engines, the idle control system cannot achieve the fueling quantity within the smallest fueling quantity tolerance range required by the OBD system to enable any other monitors.

d. For 2013 and subsequent model year engines, the idle control system cannot achieve the target idle speed with a fuel injection quantity within +/-50 percent of the fuel quantity necessary to achieve the target idle speed for a properly functioning engine and the known operating conditions.

(C) Glow plugs/intake air heater systems shall be monitored for proper functional response to computer commands and for circuit continuity faults. The glow plug/intake air heater circuit(s) shall be monitored for proper current and voltage drop. The Executive Officer shall approve other monitoring strategies based on manufacturer's data and/or engineering analysis demonstrating equally reliable and timely detection of malfunctions. Except as provided below, the OBD system shall detect a malfunction when a single glow plug/intake air heater no longer operates within the manufacturer's specified limits for normal operation. If a manufacturer demonstrates that a single glow plug failure cannot cause a measurable increase in emissions during any reasonable driving condition, the OBD system shall detect a malfunction for the minimum number of glow plugs needed to cause an emission increase. Further, to the extent feasible on existing engine designs (without adding additional hardware for this purpose) and on all 2013 and subsequent model year engines, the stored fault code shall identify the specific malfunctioning glow plug(s).

(D) Except as provided for below, ~~T~~the wait-to-start lamp circuit shall be monitored for malfunctions that cause the lamp to fail to illuminate when commanded on (e.g., burned out bulb). The manufacturer is exempt from monitoring the wait-to-start lamp if any of the following criteria are met:

(i) For wait-to-start lamps located on the instrument cluster on an LCD screen, a malfunction that causes the wait-to-start lamp to black out also causes the vehicle speed, engine speed, and fuel level displays to black out; or

(ii) The engine is prohibited from cranking until the glow plugs have been activated for a manufacturer-determined amount of time necessary for optimum cold start performance and emission control.

(E) For output components/systems that are directly or indirectly used for any emission control strategies that are not covered under sections (e), (f), and (g)(1) (e.g., an intake throttle used for a control strategy that adjusts intake throttle position to regulate SCR catalyst inlet temperature within a target window), the OBD system shall detect functional malfunctions that prevent the component/system from achieving the desired functional response necessary for the strategy to operate in its intended manner. These malfunctions include faults that inappropriately prevent or delay the activation of the emission control strategy, cause the system to erroneously exit the emission control strategy, or where the control strategy has used up all of the adjustments or authority allowed by the manufacturer and is still unable to achieve the desired condition. The Executive Officer may waive detection of specific malfunctions upon determining that the manufacturer has submitted data and/or an engineering evaluation that demonstrate that reliable detection of the malfunction is technically infeasible or would require additional hardware.

(F) For 2015 and subsequent model year engines that utilize fuel control system components (e.g., injectors, fuel pump) that have tolerance compensation features implemented in hardware or software during production or repair procedures (e.g., individually coded injectors for flow characteristics that are programmed into an electronic control unit to compensate for injector to injector tolerances, fuel pumps that use in-line resistors to correct for differences in fuel pump volume output), the components shall be monitored to ensure the proper compensation is being used.

(i) Except as provided in section (g)(3.2.2)(F)(ii) below, the system shall detect a fault if the compensation being used by the control system does not match the compensation designated for the installed component (e.g., the flow characteristic coding designated on a specific injector does not match the compensation being used by the fuel control system for that injector). If a manufacturer demonstrates that a single component (e.g., injector) using the wrong compensation cannot cause a measurable increase in emissions during any reasonable driving condition, the manufacturer shall detect a malfunction for the minimum number of components using the wrong compensation needed to cause an emission increase. ~~Further~~To the extent feasible, the stored fault code shall identify the specific component(s) for which the control system is using the wrong ~~that does not match the~~ compensation.

(ii) Monitoring of the fuel control system components under section (g)(3.2.2)(F)(i) is not required if the manufacturer demonstrates that both of the following criteria are satisfied: (1) no fault of the components' tolerance compensation features (e.g., wrong compensation being used) could cause emissions to increase by 15 percent or more of the applicable NMHC, NOx, CO, or PM standard as measured from an applicable emission test cycle; and (2) no fault of the components' tolerance compensation features can cause emissions to exceed the applicable NMHC, NOx, CO, or PM standard as measured from an applicable emission test cycle. For purposes of determining if the emission criteria above are met, the manufacturers shall request Executive Officer approval of the test plan for which the emission impact will be determined. The test plan shall include the worst case component or combination of failed components and the degree of mismatch (e.g., wrong compensation) used as well as the test procedure and emission test cycles used to demonstrate the emission impact, including the necessary preconditioning cycles used by the system to correct or adapt for any mismatch and mitigate the emission impact. Executive Officer approval shall be granted upon determining that the manufacturer has submitted data and/or engineering analysis that demonstrate that the conditions necessary for the system to correct or adapt will readily occur in a timely manner during in-use operation, ~~and~~ that the test conditions represent worst case emissions from typical in-use service actions when considering the distribution and variance of the compensation values and parts (e.g., replacement of one or more plus-one-sigma injectors with minus-one-sigma injectors without updating of the compensation value), and that the data and/or engineering analysis support the selection of the worst case failure mode (e.g., demonstration of the single-cylinder minus-one-sigma and single-cylinder plus-one-sigma failure modes versus the all-cylinder demonstration of minus-one-sigma and plus-one sigma).

(3.2.3) Hybrid Components

(A) Energy Storage System (ESS)

(i) Manufacturers shall submit a plan for Executive Officer approval of the monitoring strategy, malfunction criteria, and monitoring conditions for monitoring of the hybrid ESS state of health. The Executive Officer shall approve the plan upon determining that the manufacturer has demonstrated the monitor properly detects malfunctions and that the monitor is able to detect any hybrid ESS state of health fault that prevents any of the following: (1) activating and maintaining emission control strategies (e.g., if the ESS cannot support motoring of the engine to maintain emissions control), (2) operation of the vehicle to meet or exceed the minimum acceptable in-use monitor performance ratio requirements specified in section (d)(3.2.2), or (3) utilization of the ESS in movement of the vehicle (e.g. the engine cannot be started, the motor is unable to move the vehicle or provide motor assist due to ESS deterioration).

(ii) The OBD system shall monitor the ESS state of charge for malfunctions that result in any of the following:

a. The state of charge cannot be controlled within the normal manufacturer-defined useable range intended for hybrid vehicle operation.

b. The hybrid system is not able to maintain the state of charge required by the OBD system to enable other diagnostics.

(iii) The OBD system shall monitor the ESS cell balancing system for proper functional response to computer commands. The OBD system shall detect a malfunction when the ESS cell balancing system can no longer maintain the individual cell voltages desired. In lieu of monitoring individual cell voltages, manufacturers may monitor the individual switches used to command cell balancing for proper functional response. If the OBD system does not determine cell balance using individual cell voltages, manufacturers shall submit a plan for Executive Officer approval of the monitoring strategy, malfunction criteria, and monitoring conditions for monitoring the ESS cell balancing system. In general, the Executive Officer will approve the plan if it includes functional monitoring of components used for cell balancing.

(iv) The individual electronic components that are used as inputs or outputs for the ESS (e.g., battery temperature sensors, battery voltage sensors, battery cells) shall be monitored in accordance with the requirements of sections (g)(3.2.1) and (3.2.2).

(v) For monitors of malfunctions specified under sections (g)(3.2.3)(A)(iii) and (iv), manufacturers at a minimum shall store separate fault codes relating to hybrid ESS malfunctions pinpointing the smallest replaceable unit for in-use repair as defined by the manufacturer. Manufacturers may further pinpoint components and/or failure modes.

(B) Hybrid Thermal Management Systems

(i) ESS Thermal Management Systems

a. The individual electronic input and output components that are used for ESS thermal management (i.e., heating or cooling) shall be monitored in accordance with the requirements of sections (g)(3.2.1) and (3.2.2). Electronic components used for hybrid battery thermal management and commanded solely by driver demand are exempt from this monitoring requirement.

b. To the extent feasible, the OBD system shall perform a functional check of the cooling performance and, if applicable, heating performance.

(ii) Motor/Generator Inverter Thermal Management Systems

a. The individual electronic input and output components that are used for motor/generator inverter thermal management (i.e., heating or cooling) shall be monitored in accordance with the requirements of sections (g)(3.2.1) and (3.2.2). Electronic components used for motor/generator inverter thermal management and commanded solely by driver demand are exempt from this monitoring requirement.

b. To the extent feasible, the OBD system shall perform a functional check of the cooling performance and, if applicable, heating performance.

(C) Regenerative Braking: The OBD system shall detect a malfunction of a component when a failure disables the regenerative braking function or affects regenerative braking performance.

(D) Drive Motor: Manufacturers shall submit a plan for Executive Officer approval of the monitoring strategy, malfunction criteria, and monitoring conditions for the drive motor system. The Executive Officer shall approve the plan upon determining that the manufacturer has demonstrated that the monitor properly detects malfunctions, and that the monitor is able to detect any drive motor fault that prevents any of the following: (1) activating and maintaining emission control strategies, (2) operation of the vehicle to meet or exceed the minimum acceptable in-use monitor performance ratio requirements specified in section (d)(3.2.2), or (3) utilization of the motor in movement of the vehicle (e.g. the motor can no longer be used to move the vehicle or provide assist, the engine cannot be started).

(E) Generator: Manufacturers shall submit a plan for Executive Officer approval of the monitoring strategy, malfunction criteria, and monitoring conditions for the generator system. The Executive Officer shall approve the plan upon determining that the manufacturer has demonstrated that the monitor properly detects malfunctions, and that the monitor is able to detect any generator fault that prevents any of the following: (1) activating and maintaining emission control strategies, (2) operation of the vehicle to meet or exceed the minimum acceptable in-use monitor performance ratio requirements specified in section (d)(3.2.2), or (3) proper functional response in accordance with the malfunction criteria in section (g)(3.2).

(F) Plug-in Hybrid Electric Vehicle ESS Charger: For plug-in hybrid electric vehicles, the OBD system shall detect malfunctions of the on-board ESS charger when a failure disables ESS charging or affects charging performance (e.g., preventing the ESS from fully charging or limits charging rate). Detection of indeterminate ESS charging failures that cannot be distinguished from failures originating outside the vehicle (e.g., same symptom could be caused by a malfunction of a vehicle component or the off-board power supply) or charging failures originating outside the vehicle (e.g., malfunction of the electric vehicle supply equipment, poor electrical service) is not required.

(G) For hybrid components that are not addressed in sections (g)(3.2.3)(A) through (F) above, manufacturers shall monitor those hybrid components determined by the manufacturer to be subject to monitoring in section (g)(3.1.1) in accordance with the input component and output component requirements in sections (g)(3.2.1) and (g)(3.2.2).

(H) Monitoring of hybrid components as specified in sections (g)(3.2.3)(A) through (G) above is not required if manufacturers can demonstrate:

(i) The component is not used as part of the diagnostic strategy for any other monitored system or component, and

(ii) No malfunction of the component or system can affect emissions as determined by the criteria in section (g)(3.1.2).

(3.3) Monitoring Conditions:

(3.3.1) Input Components:

(A) Except as provided in section (g)(3.3.1)(C), input components shall be monitored continuously for proper range of values and circuit continuity.

(B) For rationality ~~monitoring~~ fault diagnostics (where applicable) manufacturers shall define the monitoring conditions for detecting malfunctions in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements), with the exception that rationality ~~monitoring~~ fault diagnostics shall occur every time the monitoring conditions are met during the driving cycle in lieu of once per driving cycle as required in section (d)(3.1.2).

(C) A manufacturer may request Executive Officer approval to disable continuous input component proper range of values or circuit continuity monitoring when a malfunction cannot be distinguished from other effects. The Executive Officer shall approve the disablement upon determining that the manufacturer has submitted test data and/or documentation that demonstrate 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.

(3.3.2) Output Components/Systems:

(A) Except as provided in section (g)(3.3.2)(D), monitoring for circuit continuity and circuit faults shall be conducted continuously.

(B) Except as provided in section (g)(3.3.2)(C), for functional ~~monitoring~~checks, manufacturers shall define the monitoring conditions for detecting malfunctions in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements).

(C) For the idle control system, manufacturers shall define the monitoring conditions for functional ~~monitoring~~ checks in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements), with the exception that functional ~~monitoring~~ checks shall occur every time the monitoring conditions are met during the driving cycle in lieu of once per driving cycle as required in section (d)(3.1.2).

(D) A manufacturer may request Executive Officer approval to disable continuous output component circuit continuity or circuit fault monitoring when a malfunction cannot be distinguished from other effects. The Executive Officer shall approve the disablement upon determining that the manufacturer has submitted test data and/or documentation that demonstrate 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.

(3.3.3) Hybrid Components

(A) Manufacturers shall define the monitoring conditions for malfunctions identified in sections (g)(3.2.3)(A)(i) through (iii), (g)(3.2.3)(B)(i)b., (g)(3.2.3)(B)(ii)b., and (g)(3.2.3)(C) through (F) in accordance with sections (d)(3.1) and (d)(3.2) (i.e., minimum ratio requirements), with the exception that monitoring shall occur every time the monitoring conditions are met during the driving cycle in lieu of once per driving cycle as required in section (d)(3.1.2).

(3.4) MIL Illumination and Fault Code Storage:

(3.4.1) Except as provided in sections (g)(3.4.2) and (3.4.4) below, general requirements for MIL illumination and fault code storage are set forth in section (d)(2). Additional fault code storage requirements are provided in section (g)(3.2.1)(B) for input components, section (g)(3.2.2)(A) for output components/systems, and section (g)(3.2.3)(A)(v) for hybrid components.

(3.4.2) Exceptions to general requirements for MIL illumination. For 2010 through 2023 model year engines, MIL illumination is not required in conjunction with storing a confirmed or MIL-on fault code for any comprehensive component if both conditions (A) and (B) below are met:

(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.

(3.4.3) For purposes of determining the emission increase in section (g)(3.4.2)(A), the manufacturer shall request Executive Officer approval of the test cycle/vehicle operating conditions for which the emission increase will be determined. Executive Officer approval shall be granted upon determining that the manufacturer has submitted data and/or engineering evaluation that demonstrate that the testing conditions represent in-use driving conditions where emissions are likely to be most affected by the malfunctioning component. For purposes of determining whether the specified percentages in section (g)(3.4.2)(A) are exceeded, if the approved testing conditions are comprised of an emission test cycle with an exhaust emission standard, the measured increase shall be compared to a percentage of the exhaust emission standard (e.g., if the increase is equal to or more than 15 percent of the exhaust emission standard for that test cycle). If the approved testing conditions are comprised of a test cycle or vehicle operating condition that does not have an exhaust emission standard, the measured increase shall be calculated as a percentage of the baseline test (e.g., if the increase from a back-to-back test sequence between normal and malfunctioning condition is equal to or more than 15 percent of the baseline test results from the normal condition).

(3.4.4) For malfunctions required to be detected by section (g)(3.2.2)(B)(ii)d. (idle control fuel injection quantity faults), the stored fault code is not required to specifically identify the idle control system (e.g., a fault code for cylinder fuel injection quantity imbalance or combustion quality monitoring can be stored).

(4) Other Emission Control System Monitoring

(4.1) Requirement: For other emission control systems that are: (1) not identified or addressed in sections (e)(1) through (g)(3) (e.g., hydrocarbon traps, homogeneous charge compression ignition (HCCI) control systems), or (2) identified or addressed in section (g)(3) but not corrected or compensated for by an adaptive control system (e.g., swirl control valves), manufacturers shall submit a plan for Executive Officer approval of the monitoring strategy, malfunction criteria, and monitoring conditions prior to introduction on a production engine. Executive Officer approval shall be based on the effectiveness of the monitoring strategy, the malfunction criteria utilized, the monitoring conditions required by the diagnostic, and, if applicable, the determination that the requirements of section (g)(4.2) and (g)(4.3) below are satisfied.

(4.2) For engines that utilize emission 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 of section (g)(4.1) above, may elect to have the OBD system monitor the shaft to which all valves in one intake bank are physically attached in lieu of 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 shall verify all shaft segments for proper functional response (e.g., by verifying the segment or portion of the shaft furthest from the actuator properly functions). 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.

(4.3) For emission control strategies that are not covered under sections (e), (f), and (g)(1) (e.g., a control strategy that regulates SCR catalyst inlet temperatures within a target window), Executive Officer approval shall be based on the effectiveness of the plan in detecting malfunctions that prevent the strategy from operating in its intended manner. These malfunctions include faults that inappropriately prevent or delay the activation of the emission control strategy, faults that cause the system to erroneously exit the emission control strategy, and faults where the control strategy has used up all of the adjustments or authority allowed by the manufacturer and is still unable to achieve the desired condition. The Executive Officer may waive detection of specific malfunctions upon determining that the manufacturer has submitted data and/or an engineering evaluation that demonstrate that reliable detection of the malfunction is technically infeasible or would require additional hardware.

(5) Exceptions to Monitoring Requirements

(5.1) Upon request of a manufacturer or upon the best engineering judgment of ARB, the Executive Officer may revise the emission threshold for any monitor in sections (e) through (g) if the most reliable monitoring method developed requires a higher threshold to prevent false indications of a malfunction. Additionally, except as specified in section (e)(8.2.1)(C), for 2010 through 2015 model year engines, the Executive Officer may revise the PM filter malfunction criteria of section (e)(8.2.1) to exclude detection of specific failure modes (e.g., partially melted substrates) if the most reliable monitoring method developed requires the exclusion of specific failure modes to prevent false indications of a malfunction.

(5.2) For 2010 through 2012 model year diesel engines, in determining the malfunction criteria for diesel engine monitors in sections (e)(1), (3), (4), (5), (8.2.2), (9.2.1)(A), and (e)(10), the manufacturer shall use a threshold of 2.5 times any of the applicable NMHC, CO, or NOx standards in lieu of 2.0 times any of the applicable standards.

(5.3) Manufacturers may request Executive Officer approval to disable an OBD system monitor at ambient temperatures below 20 degrees Fahrenheit (or -6.7 degrees Celsius) (low ambient temperature conditions may be determined based on intake air or engine coolant temperature at engine start) or at elevations above 8000 feet above sea level. The Executive Officer shall approve the request upon determining that the manufacturer has provided data and/or an engineering evaluation that demonstrate that monitoring during the conditions would be unreliable. A manufacturer may further request, and the Executive Officer shall approve, that an OBD system monitor be disabled at other ambient temperatures upon determining that the manufacturer has demonstrated with data and/or an engineering evaluation that misdiagnosis would occur at the ambient temperatures because of its effect on the component itself (e.g., component freezing).

(5.4) Manufacturers may request Executive Officer approval to disable monitoring systems that can be affected by low fuel level or running out of fuel (e.g., misfire detection) when the fuel level is 15 percent or less of the nominal capacity of the fuel tank. The Executive Officer shall approve the request upon determining that the manufacturer has submitted data and/or an engineering evaluation that demonstrate that monitoring at the fuel levels would be unreliable and the OBD system is able to detect a malfunction if the component(s) used to determine fuel level erroneously indicates a fuel level that causes the disablement.

(5.5) Manufacturers may disable monitoring systems that can be affected by vehicle battery or system voltage levels.

(5.5.1) For monitoring systems affected by low vehicle battery or system voltages, manufacturers may disable monitoring systems when the battery or system voltage is below 11.0 Volts. Manufacturers may request Executive Officer approval to utilize a voltage threshold higher than 11.0 Volts to disable system monitoring. The Executive Officer shall approve the request upon determining that the manufacturer has submitted data and/or an engineering evaluation that demonstrate that monitoring at the 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 will detect a malfunction at the voltage used to disable other monitors.

(5.5.2) For monitoring systems affected by high vehicle battery or system voltages, manufacturers may request Executive Officer approval to disable monitoring systems when the battery or system voltage exceeds a manufacturer-defined voltage. The Executive Officer shall approve the request upon determining that the manufacturer has submitted data and/or an engineering evaluation that demonstrate that monitoring above the manufacturer-defined voltage would be unreliable and that either the electrical charging system/alternator warning light is illuminated (or voltage gauge is in the "red zone") or the OBD system monitors the battery or system voltage and will detect a malfunction at the voltage used to disable other monitors.

(5.6) A manufacturer may request Executive Officer approval to disable monitors that can be affected by PTO activation on engines or vehicles designed to accommodate the installation of PTO units (as defined in section (c)).

(5.6.1) Except as allowed in section (g)(5.6.2) below, a manufacturer may request Executive Officer approval to disable an affected monitor provided disablement occurs only while the PTO unit is active and the OBD readiness status (specified under section (h)(4.1)) and PTO activation time are appropriately tracked and erased as described in this section. The Executive Officer shall approve the request for disablement based on the manufacturer's demonstration that the affected monitor cannot robustly detect malfunctions (e.g., cannot avoid false passes or false indications of malfunctions) while the PTO unit is active. The OBD system shall track the cumulative engine runtime with PTO active and clear OBD readiness status (i.e., set all monitors to indicate "not complete") no later than the start of the next ignition cycle if 750 minutes of cumulative engine runtime with PTO active has occurred since the last time the affected monitor has determined the component or system monitored by the affected monitor is or is not malfunctioning (i.e., has completed). The PTO timer shall pause whenever PTO changes from active to not active and resume counting when PTO is re-activated. The timer shall be reset to zero after the affected monitor has completed and no later than the start of the next ignition cycle. Once the PTO timer has reached 750 minutes and the OBD readiness status has been cleared, the PTO timer may not cause the OBD system to clear the readiness status again until after the PTO timer has reset to zero (after the monitor has completed) and again reached 750 minutes. This PTO timer is a different timer than the one specified under section (h)(5.2.1)(C).

(5.6.2) For 2010 through 2012 model year engines, in lieu of requesting Executive Officer approval for disabling an affected monitor according to section (g)(5.6.1) above, a manufacturer may disable affected monitors, provided disablement occurs only while the PTO unit is active, and the OBD readiness status is cleared by the on-board computer (i.e., all monitors set to indicate "not complete") while the PTO unit is activated. If the disablement occurs, the readiness status may be restored to its state prior to PTO activation when the disablement ends.

(5.7) The manufacturer may request to exempt a specific component from all monitoring requirements in the following cases:

(5.7.1) The manufacturer may request to exempt a specific component from all monitoring requirements if all malfunctions of the component affect emissions or the diagnostic strategy for any other monitored component or system only when the ambient temperature is below 20 degrees Fahrenheit (or -6.7 degrees Celsius). The Executive Officer shall approve the request upon the manufacturer submittal of data or engineering evaluation supporting that ~~The OBD system is not required to monitor an electronic powertrain component/system if~~ the following criteria are met when the ambient temperature is above 20 degrees Fahrenheit (or -6.7 degrees Celsius): (1) a malfunction of the component does not affect emissions during any reasonable driving condition, (2) a malfunction of the component does not affect the diagnostic strategy for any other monitored component or system, and (3) the ambient temperature is determined based on a temperature sensor monitored by the OBD system (e.g., IAT sensor). ~~The manufacturer shall determine whether a component/system meets these criteria.~~ If the Executive Officer reasonably believes that a manufacturer has incorrectly determined that a component/system meets these criteria, the Executive Officer shall require the manufacturer to provide emission and/or other diagnostic data showing that the component/system, when malfunctioning and installed in a suitable test vehicle, does not have an effect on emissions or other diagnostic strategies. The Executive Officer may request emission data for any reasonable driving condition at ambient temperatures above 20 degrees Fahrenheit (or -6.7 degrees Celsius).

(5.7.2) The manufacturer may request to exempt a specific component from all monitoring requirements if all malfunctions of the component affect emissions or the diagnostic strategy for any other monitored component or system only when the vehicle speed is above 82 miles-per-hour. The Executive Officer shall approve the request upon the manufacturer submittal of data or engineering evaluation supporting that the following criteria are met when the vehicle speed is below 82 miles-per-hour: (1) a malfunction of the component does not affect emissions during any reasonable driving condition, (2) a malfunction of the component does not affect the diagnostic strategy for any other monitored component or system, and (3) the vehicle speed is determined based on a sensor monitored by the OBD system (e.g., vehicle speed sensor). If the Executive Officer reasonably believes that a manufacturer has incorrectly determined that a component/system meets these criteria, the Executive Officer shall require the manufacturer to provide emission and/or other diagnostic data showing that the component/system, when malfunctioning and installed in a suitable test vehicle, does not have an effect on emissions or other diagnostic strategies.

(5.8) Whenever the requirements in section (e), (f), or (g) of this regulation require a manufacturer to meet a specific phase-in schedule:

(5.8.1) Except as provided for in section (g)(5.8.3) below for the diesel NOx converting catalyst and NOx and PM sensor phase-ins and in section (e)(8.2.1) for the PM filter monitor phase-in, manufacturers may use an alternate phase-in schedule in lieu of the phase-in schedule set forth in sections (e), (f), or (g) if the alternate phase-in schedule provides for equivalent compliance volume as defined in section (c).

(5.8.2) Small volume manufacturers may use an alternate phase-in schedule in accordance with section (g)(5.8.1) in lieu of the required phase-in schedule or may use a different schedule as follows:

(A) For the diesel misfire monitor phase-in schedule in section (e)(2.2.2), the manufacturer may meet the requirement on all engines by the 2018 model year in lieu of meeting the specific phase-in requirements for the 2016 and 2017 model years.

(B) For the diesel misfire monitor phase-in schedule in section (e)(2.3.3), the manufacturer may meet the monitoring conditions requirements of section (e)(2.3.3)(A)(i) on all engines subject to (e)(2.2.2) through the 2020 model year and the monitoring conditions requirements of section (e)(2.3.3)(A)(ii) on all 2021 and subsequent model year engines in lieu of the specific phase-in requirements in section (e)(2.3.3)(A) for the 2019 and 2020 model years.

(C) For the diesel NOx converting catalyst monitor phase-in schedules in section (e)(6), the manufacturer may use the malfunction criteria in sections (e)(6.2.1)(B) and (e)(6.2.2)(A)(ii) for all 2014 and 2015 model year engines in lieu of the malfunction criteria and required phase-in schedule in sections (e)(6.2.1)(C) and (e)(6.2.2)(A)(iii).

(D) For the diesel PM filter monitor phase-in schedule in section (e)(8), the manufacturer may use the malfunction criteria in section (e)(8.2.1)(B) for all 2014 and 2015 model year engines in lieu of the malfunction criteria and required phase-in schedule in section (e)(8.2.1)(C).

(E) For the diesel NOx sensor phase-in schedules in section (e)(9), the manufacturer may use the malfunction criteria in section (e)(9.2.2)(A)(ii) for all 2014 and 2015 model year engines in lieu of the malfunction criteria and required phase-in schedule in section (e)(9.2.2)(A)(iii).

(5.8.3) In lieu of meeting the diesel NOx converting catalyst and NOx and PM sensor phase-ins set forth in sections (e)(6.2.1), (e)(6.2.2), and (e)(9.2.2), a manufacturer may request Executive Officer approval to use a manufacturer-defined phase-in for each requirement. The Executive Officer shall approve the manufacturer-defined phase-in if it meets the following criteria:

(A) For the requirements in sections (e)(6.2.1)(C), (e)(6.2.2)(A)(iii), and (e)(9.2.2)(A)(iii) (i.e., requiring a NOx threshold of +0.3 g/bhp-hr):

(i) The phase-in shall provide for a compliance volume of engines certified to the +0.3 g/bhp-hr NOx threshold that is equivalent to the volume of the required phase-in set forth in each of the above-referenced sections (i.e., the phase-in of 20 percent of 2014 model year diesel engines and 50 percent of 2015 model year diesel engines). The compliance volume shall be calculated in accordance with the calculation methodology in the definition of “alternate phase-in” in section (c) (i.e., (20*2 years) + (50*1 year) = 90 for the required phase-in). The compliance volume shall be considered equivalent if the calculated total is equal to or greater than 90.

(ii) The calculated compliance volume for the manufacturer-defined phase-in may not include engines meeting the +0.3 g/bhp-hr NOx threshold requirement earlier than the 2013 model year.

(iii) For the 2013 through 2017 model years, engines meeting the requirements in sections (e)(6.2.1)(D), (e)(6.2.2)(A)(iv), and (e)(9.2.2)(A)(iv) (i.e., requiring a NOx threshold of +0.2 g/bhp-hr) shall also be considered as meeting the +0.3 g/bhp-hr NOx threshold requirement and included in the calculated compliance volume and shall not be subtracted from the calculated compliance volume.

(iv) For the 2016 model year, if the proposed phase-in results in a combined percentage of engines meeting the +0.3 g/bhp-hr and the +0.2 g/bhp-hr thresholds being less than 50 percent of all diesel engines, the manufacturer shall subtract those engines that do not meet the above thresholds in both the 2015 and 2016 model years from the required percentage of 50 percent when calculating the compliance volume according to the calculation methodology in the definition of “alternate phase-in” section (c).

(v) All engines shall meet either the +0.3 g/bhp-hr NOx threshold or the +0.2 g/bhp-hr NOx threshold no later than the 2017 model year.

(B) For the requirements in sections (e)(6.2.1)(D), (e)(6.2.2)(A)(iv), and (e)(9.2.2)(A)(iv) (i.e., requiring a NOx threshold of +0.2 g/bhp-hr):

(i) The phase-in shall provide for a compliance volume of engines certified to the +0.2 g/bhp-hr NOx threshold that is equivalent to the volume of the required phase-in set forth in each of the above-referenced sections (i.e., 100 percent of 2016 model year diesel engines). The compliance volume shall be calculated in accordance with the calculation methodology in the definition of “alternate phase-in” in section (c) (i.e., (100*1 year) = 100 for the required phase-in). The compliance volume shall be considered equivalent if the calculated total is equal to or greater than 100.

(ii) The calculated compliance volume for the manufacturer-defined phase-in shall not include engines meeting the +0.2 g/bhp-hr NOx threshold requirement earlier than the 2015 model year.

(iii) For the 2016 model year only, engines meeting the NOx threshold of +0.3 g/bhp-hr and carried over from the 2014 or 2015 model year per sections (e)(6.2.1)(E), (e)(6.2.2)(A)(v), and (e)(9.2.2)(A)(v) shall also be considered as meeting the +0.2 g/bhp-hr NOx threshold requirement and included in the calculated compliance volume and shall not be subtracted from the calculated compliance volume.

(iv) If the phase-in includes engines that do not meet the +0.2 g/bhp-hr NOx threshold in the 2017 model year, the manufacturer shall subtract those engines that do not meet the threshold in the 2016 and 2017 model years (except as allowed for the 2016 model year in section (g)(5.8.3)(B)(iii) above) from the required percentage of 100 percent when calculating the compliance volume according to the calculation methodology in the definition of “alternate phase-in” section (c).

(v) All engines shall meet the +0.2 g/bhp-hr NOx threshold no later than the 2018 model year.

(5.9) Whenever the requirements in sections (e) through (g) of this regulation require monitoring “to the extent feasible”, the manufacturer shall submit its proposed monitor(s) for Executive Officer approval. The Executive Officer shall approve the proposal upon determining that the proposed monitor(s) meets the criteria of “to the extent feasible” by considering the best available monitoring technology to the extent that it is known or should have been known to the manufacturer and given the limitations of the manufacturer’s existing hardware, the extent and degree to which the monitoring requirements are met in full, the limitations of monitoring necessary to prevent significant errors of commission and omission, and the extent to which the manufacturer has considered and pursued alternative monitoring concepts to meet the requirements in full. The manufacturer's consideration and pursuit of alternative monitoring concepts shall include evaluation of other modifications to the proposed monitor(s), the monitored components themselves, and other monitors that use the monitored components (e.g., altering other monitors to lessen the sensitivity and reliance on the component or characteristic of the component subject to the proposed monitor(s)).

(h) *Standardization Requirements.*

(1) Reference Documents:
The following ~~Society of Automotive Engineers (~~SAE~~)~~ and International Organization of Standards (ISO) documents are incorporated by reference into this regulation:

(1.1) SAE J1930 "Electrical/Electronic Systems Diagnostic Terms, Definitions, Abbreviations, and Acronyms – Equivalent to ISO/TR 15031-2", ~~October 2008~~March 2017 (SAE J1930).

(1.1.1) SAE J1930-DA "Electrical/Electronic Systems Diagnostic Terms, Definitions, Abbreviations, and Acronyms Web Tool Spreadsheet", March ~~2012~~2017.

(1.2) SAE J1962 "Diagnostic Connector ~~– Equivalent to ISO/DIS 15031-3: December 14, 2001~~", ~~April 2002~~July 2016 (SAE J1962).

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

(1.4) SAE J1979 "E/E Diagnostic Test Modes", February ~~2012~~ 2017 (SAE J1979).

(1.4.1) SAE J1979-DA "Digital Annex of E/E Diagnostic Test Modes", ~~October 2011~~May 2019.

(1.5) SAE J2012 "Diagnostic Trouble Code Definitions", December ~~2007~~ 2016 (SAE J2012).

(1.5.1) SAE J2012-DA "Digital Annex of Diagnostic Trouble Code Definitions and Failure Type Byte Definitions", ~~July 2010~~December 2016.

(1.6) ISO 15765-4 "Road Vehicles-Diagnostic~~s~~ ~~C~~communication over Controller Area Network (DoCAN) - Part 4: Requirements for emission-related systems", ~~February 2011~~ April 2016 (ISO 15765-4).

(1.7) SAE J1939 consisting of:

(1.7.1) J1939 ~~Recommended Practice for a~~ Serial Control and Communications Heavy Duty Vehicle Network – Top Level Document, ~~April 2011~~August 2013;

(A) J1939-DA "Digital Annex of Serial Control and Communication Heavy Duty Vehicle Network Data," April 2019;

(1.7.2) J1939/1 On-Highway Equipment Control and Communication Network ~~May 2011~~November 2012;

(1.7.3) J1939/11 Physical Layer, 250~~K~~ Kbps~~bits/s~~, Twisted Shielded Pair, ~~September 2006~~December 2016;

(1.7.4) J1939/13 Off-Board Diagnostic Connector, October ~~2011~~2016;

(1.7.5) J1939/15 ~~Reduced~~ Physical Layer, 250~~K~~ Kbps ~~bits/sec~~, UnN-Shielded Twisted Pair (UTP), August ~~2008~~2015;
(1.7.6) J1939/21 Data Link Layer, ~~December 2010~~March 2016;
(1.7.7) J1939/31 Network Layer, ~~May 2010~~April 2014;
(1.7.8) J1939/71 Vehicle Application Layer ~~(Through May 2010)~~, ~~March 2011~~October 2016;
(1.7.9) J1939/73 Application Layer—Diagnostics, ~~February 2010~~May 2017;
(1.7.10) J1939/81 Network Management, ~~June 2011~~March 2017; and
(1.7.11) J1939/84 OBD Communications Compliance Test Cases for Heavy Duty Components and Vehicles, ~~December 2010~~October 2017.

(1.8) SAE J2403 "Medium/Heavy-Duty E/E Systems Diagnosis Nomenclature," February ~~2011~~ 2014 (SAE J2403).

(1.9) SAE J1699-3 "Vehicle OBD II Compliance Test Cases", ~~December 2009~~July 2017 (SAE J1699-3).

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

(1.11) SAE J3162 "Heavy Duty OBD IUMPR Data Collection Tool Process," September 2018 (SAE J3162)

(1.12) ISO 2575 "Road Vehicles – Symbols for Controls, Indicators and Tell-Tales," July 2010 (ISO 2575).

(2) Diagnostic Connector:
A standard data link connector conforming to SAE J1962 or SAE J1939-13 specifications (except as specified in section (h)(2.3)) shall be incorporated in each vehicle.

(2.1) For the 2010 through 2012 model year engines:

(2.1.1) The connector shall 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 connector may not 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).

(2.1.2) If the connector is covered, 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 may not require opening or the removal of any storage accessory (e.g., ashtray, coinbox). The label shall be submitted to the Executive Officer for review and approval, at or before the time the manufacturer submits its certification application. The Executive Officer shall approve the label upon determining that it clearly identifies that the connector is located behind the cover and is consistent with language and/or symbols commonly used in the automotive industry.

(2.2) For 2013 and subsequent model year engines:

(2.2.1) Except as provided in sections (h)(2.2.1)(A) and (B), ~~T~~the connector shall 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 foot pedal closest to the driver's side of the vehicle (left most pedal in a left hand drive vehicle) excluding a foot-activated emergency brake if equipped (e.g., typically the brake pedal for an automatic transmission equipped vehicle or the clutch pedal for a manual transmission equipped vehicle) and at a location no higher than the bottom of the steering wheel when in the lowest adjustable position.

(A) For vehicles with a steering wheel and not equipped with a driver's side door, the connector shall 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.

(B) For vehicles that do not have a steering wheel or foot pedal (e.g., autonomous vehicles), the manufacturer shall submit a plan to the Executive Officer for approval of the proposed location for the connector. The Executive Officer shall approve the connector location upon determining that the location is easy to identify and access by a technician or inspector.

(2.2.2) The connector shall be mounted in an uncovered location and may not be covered with or located behind any form of panel, access door, or storage device (e.g., fuse panel cover, hinged door, ashtray, coinbox) that requires opening or removal to access the connector. The connector may be equipped with a dust cap in the shape and size of the diagnostic connector for environmental protection purposes but the dust cap must be removable by hand without the use of any tools and be labeled "OBD" to aid technicians in identifying the connector.

(2.2.3) The connector shall be mounted in a manner that allows vehicle operation and driving (e.g., does not interfere with use of driver controls such as the clutch, brake, and accelerator pedal) while a scan tool is connected to the vehicle.

(2.3) The location of the connector shall be capable of being easily identified and accessed (e.g., to connect an off-board tool). Except for as allowed in section (h)(2.2.1)(A) and (B), ~~F~~for vehicles equipped with a driver's side door, the connector shall be capable of being easily identified and accessed by a technician standing (or "crouched") on the ground outside the driver's side of the vehicle with the driver's side door open. For vehicles not equipped with a driver's side door, the connector shall be capable of being easily identified and accessed by a technician inside the vehicle and observing the foot-well region from an eyesight level located at the bottom of the steering wheel.

(2.4) If the ISO 15765-4 protocol (see section (h)(3)) is used for the required OBD standardized functions, the connector shall meet the "Type A" specifications of SAE J1962. Any pins in the connector that provide electrical power shall 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).

(2.5) If the SAE J1939 protocol (see section (h)(3)) is used for the required OBD standardized functions, the connector shall meet the “Type 1” or “Type 2” specifications of SAE J1939-13 if the 250 kbps baud rate of J1939 is used and the “Type 2” specifications of J1939-13 if the 500 kbps baud rate of J1939 is used. Any pins in the connector that provide electrical power shall be properly fused to protect the integrity and usefulness of the connector for diagnostic purposes.

(2.6) Manufacturers may equip 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~~ can be mated with SAE J1962 “Type A” or ~~the specifications of~~ SAE J1939-13 external test equipment:

(2.6.1) For 2010 through 2015 model year engines, if the additional connector is located in the vehicle interior near the required connector of section (h)(2), the connector(s) must be clearly labeled to identify which connector is used to access the standardized OBD information required in section (h).

(2.6.2) For 2016 and subsequent model year engines, the additional connector may not be in the location specified in section (h)(2.2.1).

(3) Communications to a Scan Tool:
All OBD control modules (e.g., engine, auxiliary emission control module) on a single vehicle shall use the same protocol for communication of required emission-related messages from on-board to off-board network communications to a scan tool meeting SAE J1978 specifications or designed to communicate with an SAE J1939 network. Engine manufacturers shall not alter normal operation of the engine emission control system due to the presence of off-board test equipment accessing information required by section (h). The OBD system shall use one of the following standardized protocols:

(3.1) ISO 15765-4. All required emission-related messages using this protocol shall use a 500 kbps baud rate.

(3.2) SAE J1939. ~~This protocol may only be used on vehicles with diesel engines (including diesel engines converted to alternate-fueled engines).~~ For 2010 through 2015 model year engines, all required emission-related messages using this protocol on an individual vehicle shall use either the 250 kbps or the 500 kbps baud rate. The 250 kbps baud rate may not be used on 2016 or subsequent model year engines.

(4) Required Emission Related Functions:
The following standardized functions shall be implemented in accordance with the specifications in SAE J1979 or SAE J1939 to allow for access to the required information by a scan tool meeting SAE J1978 specifications or designed to communicate with an SAE J1939 network:

(4.1) Readiness Status: In accordance with SAE J1979/J1939-73 specifications, the OBD system shall indicate “complete” or “not complete” since the fault memory was last cleared for each of the installed monitored components and systems identified in sections (e)(1) through (f)(9), and (g)(3) except (e)(11) and (f)(4).

(4.1.1) The readiness status for the following component/system readiness bits shall always indicate "complete":

(A) Diesel misfire (section (e)(2)) for engines ~~without a separate~~with a single monitor designed to detect both misfires identified in section (e)(2.2.1) and subject to the monitoring conditions of sections (e)(2.3.1) and (e)(2.3.2) and misfires identified in section (e)(2.2.2) and subject to the monitoring conditions of (e)(2.3.3);

(B) Gasoline misfire (section (f)(2)); and

(C) Diesel and gasoline comprehensive component (section (g)(3)).

(4.1.2) For 2010 through 2015 model year engines, for components and systems not listed in section (h)(4.1.1) above, the readiness status shall immediately indicate "complete" upon the respective monitor(s) (except those monitors specified under section (h)(4.1.7) below) determining that the component or system is not malfunctioning. The readiness status for a component or system shall also indicate "complete" if after the requisite number of decisions necessary for determining MIL status has been fully executed, the monitor indicates a malfunction for the component or system.

(4.1.3) For 2016 and subsequent model year engines, for components and systems not listed in section (h)(4.1.1) above, the readiness status for each component/system readiness bit listed below shall immediately indicate "complete" if any of the following conditions occur: (1) all the respective supported monitors listed below for each component/system have fully executed and determined that the component or system is not malfunctioning, or (2) at least one of the monitors listed below for each component/system has determined that the component or system is malfunctioning after the requisite number of decisions necessary for determining the MIL status have been fully executed, regardless of whether or not the other monitors listed have been fully executed:

(A) Diesel Fuel System: sections (e)(1.2.1), (e)(1.2.2), and (e)(1.2.3)

(B) Diesel Misfire: section (e)(2.2.1) for engines with a separate monitor designed to detect misfires identified in section (e)(2.2.1) and subject to the monitoring conditions of sections (e)(2.3.1) and (e)(2.3.2)

(C) Diesel EGR/VVT: sections (e)(3.2.1), (e)(3.2.2), (e)(3.2.3), (e)(3.2.5), (e)(3.2.6), and (e)(10.2)

(D) Diesel Boost Pressure Control System: sections (e)(4.2.1), (e)(4.2.2), (e)(4.2.3), and (e)(4.2.4)

(E) Diesel NMHC Converting Catalyst: sections (e)(5.2.2) and (e)(5.2.3)(A)

(F) Diesel NOx Converting Catalyst: section (e)(6.2.1)

(G) Diesel NOx Aftertreatment: sections (e)(7.2.1) and (e)(7.2.2)

(H) Diesel PM Filter:

(i) For 2016 through 2023 model year engines, sections (e)(8.2.1), (e)(8.2.2), (e)(8.2.5), and (e)(8.2.6)

(ii) For 2024 and subsequent model year engines, sections (e)(8.2.1) and (e)(8.2.5)

(I) Diesel Exhaust Gas Sensor:

(i) For 2016 and subsequent model year engines on vehicles using the SAE J1939 protocol for the standardized functions required in section (h), and for 2016 through 2023 model year engines on vehicles using the ISO 15765-4 protocol for the standardized functions required in section (h), sections (e)(9.2.1)(A)(i), (e)(9.2.1)(A)(iv), (e)(9.2.1)(B)(i), (e)(9.2.1)(B)(iv), (e)(9.2.2)(A), (e)(9.2.2)(D), and (e)(9.2.3)(A)

(ii) For 2024 and subsequent model year engines on vehicles using the ISO 15765-4 protocol for the standardized functions required in section (h), sections (e)(9.2.1)(A)(i), (e)(9.2.1)(A)(iv), (e)(9.2.1)(B)(i), (e)(9.2.1)(B)(iv), (e)(9.2.2)(A), (e)(9.2.2)(D), (e)(9.2.3)(A), and (e)(9.2.4)(A)

(J) Diesel Exhaust Gas Sensor Heater: section (e)(9.2.4)(A) for vehicles using the SAE J1939 protocol for the standardized functions required in section (h)

(~~J~~K) Gasoline Fuel System: section (f)(1.2.1)(C)

(~~K~~L) Gasoline EGR/VVT: sections (f)(3.2.1), (f)(3.2.2), (f)(9.2.1), (f)(9.2.2), and (f)(9.2.3)

(~~L~~M) Gasoline Secondary Air System: sections (f)(5.2.1), (f)(5.2.2), (f)(5.2.3), and (f)(5.2.4)

(~~M~~N) Gasoline Catalyst: section (f)(6.2.1)

(~~N~~O) Gasoline Evaporative System: sections (f)(7.2.2)(A) and (f)(7.2.2)(B)

(~~O~~P) Gasoline Oxygen Sensor: sections (f)(8.2.1)(A), (f)(8.2.1)(D), (f)(8.2.2)(A), and (f)(8.2.2)(C)

(Q) Gasoline Oxygen/Exhaust Gas Sensor Heater: section (f)(8.2.3)(A)

(4.1.4) For 2016 and subsequent model year engines, for monitors that detect faults of more than one major emission-related component (e.g., a single monitor that is used to detect both oxygen sensor faults that are tied to the oxygen sensor readiness bit and air-fuel ratio cylinder imbalance faults that are tied to the fuel system readiness bit), the manufacturer shall include the monitor only in the readiness status for the component/system that the monitor is primarily calibrated, intended, or expected in-use to detect faults of.

(4.1.5) Except for the readiness bits listed under section (h)(4.1.1) above, the readiness status for each of the monitored components or systems shall indicate “not complete” whenever fault memory has been cleared or erased by a means other than that allowed in section (d)(2). Normal vehicle shut down (i.e., key off, engine off) may not cause the readiness status to indicate “not complete”.

(4.1.6) If the manufacturer elects to additionally indicate readiness status through the MIL in the key on, engine off position as provided for in section (d)(2.1.3), the readiness status shall be indicated in the following manner: If the readiness status for all monitored components or systems is “complete”, the MIL shall continuously illuminate in the key on, engine off position for at least 15 seconds as required by section (d)(2.1.2). If the readiness status for one or more of the monitored components or systems is “not complete”, after 15-20 seconds of operation in the key on, engine off position with the MIL illuminated continuously as required by section (d)(2.1.2), the MIL shall blink once per second for 5-10 seconds. The data stream value for MIL status (section (h)(4.2)) shall indicate “commanded off” during this sequence unless the MIL has also been “commanded on” for a detected fault.

(4.1.7) Manufacturers are not required to use the following monitors in determining the readiness status for the specific component or system:

(A) Circuit and out-of-range monitors that are required to be continuous;

(B) Gasoline and diesel exhaust gas sensor feedback monitors specified in sections (e)(9.2.1)(A)(iii), (e)(9.2.1)(B)(iii), (e)(9.2.2)(C), (f)(8.2.1)(C), and (f)(8.2.2)(E);

(C) Diesel feedback control monitors specified in sections (e)(1.2.4), (e)(3.2.4), (e)(4.2.5), (e)(6.2.2)(D), (e)(7.2.3), and (e)(8.2.7);

(D) Gasoline fuel system monitors specified in sections (f)(1.2.1)(A), (f)(1.2.1)(B), (f)(1.2.2), and (f)(1.2.4)~~, and (f)(1.2.5)~~.

(4.2) Data Stream: The following signals shall be made available on demand through the standardized data link connector in accordance with SAE J1979/J1939 specifications. The actual signal value shall always be used instead of a default or limp home value.

(4.2.1) For all gasoline engines:

(A) Calculated load value, engine coolant temperature, engine speed, vehicle speed, time elapsed since engine start; and

(B) Absolute load, fuel level (if used to enable or disable any other diagnostics), barometric pressure (directly measured or estimated), engine control module system voltage, commanded equivalence ratio; and

(C) Number of stored confirmed fault codes, 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 driving cycle, complete this driving cycle, or not complete this driving cycle) since last engine shut-off for each monitor used for readiness status, distance traveled (or engine run time for engines not utilizing vehicle speed information) while MIL activated, distance traveled (or engine run time for engines not utilizing vehicle speed information) since fault memory last cleared, and number of warm-up cycles since fault memory last cleared, OBD requirements to which the engine is certified (e.g., California OBD, EPA OBD, European OBD, non-OBD) and MIL status (i.e., commanded-on or commanded-off).

(D) For 2024 and subsequent model year engines, modeled exhaust flow (mass/time), engine reference torque, actual indicated engine - percent torque, nominal engine friction - percent torque, and engine family.

(4.2.2) For all diesel engines:

(A) Calculated load (engine torque as a percentage of maximum torque available at the current engine speed), driver’s demand engine torque (as a percentage of maximum engine torque), actual indicated engine torque (as a percentage of maximum engine torque), nominal engine friction – percent 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 by 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 diagnostics), engine speed, time elapsed since engine start;

(B) Fuel level (if used to enable or disable any other diagnostics), vehicle speed (if used for emission control or any OBD diagnostics), barometric pressure (directly measured or estimated), engine control module system voltage;

(C) Number of stored confirmed/MIL-on fault codes, monitor status (i.e., disabled for the rest of this driving cycle, complete this driving cycle, or not complete this driving cycle) since last engine shut-off for each monitor used for readiness status, distance traveled (or engine run time for engines not utilizing vehicle speed information) while MIL activated, distance traveled (or engine run time for engines not utilizing vehicle speed information) 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, California OBD-child rating (i.e., for engines subject to (d)(7.1.2) or (d)(7.2.3)) EPA OBD, European OBD, non-OBD), MIL status (i.e., commanded-on or commanded-off);

(D) NOx NTE control area status (i.e., inside control area, outside control area, inside manufacturer-specific NOx NTE carve-out area, or deficiency active area), PM NTE control area status (i.e., inside control area, outside control area, inside manufacturer-specific PM NTE carve-out area, or deficiency active area);

(E) For 2013 and subsequent model year engines, normalized trigger for PM filter regeneration (SPN 5466 defined by SAE J1939 for 2016 and subsequent model year engines), PM filter regeneration status (SPN 3700 defined by SAE J1939 for 2016 and subsequent model year engines); and

(F) For 2013 and subsequent model year engines, average distance (or engine run time for engines not utilizing vehicle speed information) between PM filter regenerations.

(G)For 2016 and subsequent model year engines, cylinder fuel rate (mg/stroke), engine torque (including fan or accessory torque), and modeled exhaust flow (mass/time).

(H) For 2022 and subsequent model year engines, engine rated power and vehicle speed.

(I) For 2024 and subsequent model year engines, engine rated speed and engine family.

(~~H~~J) For purposes of the calculated load and torque parameters in section (h)(4.2.2)(A) and the torque, fuel rate, and modeled exhaust flow parameters in section (h)(4.2.2)(G), manufacturers shall report the most accurate values that are calculated within the applicable electronic control unit (e.g., the engine control module). “Most accurate values”, in this context, shall be of sufficient accuracy, resolution, and filtering to be used for the purposes of in-use emission testing with the engine still in a vehicle (e.g., using portable emission measurement equipment).

(4.2.3) For all engines so equipped:

(A) Absolute throttle position, relative throttle position, fuel control system status (e.g., open loop, closed loop), fuel trim (short term, long term, secondary), fuel pressure, ignition timing advance, fuel injection timing, intake air/manifold temperature, engine intercooler 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, PM filter inlet pressure, PM filter inlet temperature, PM filter outlet pressure, PM filter outlet temperature, PM filter delta pressure, exhaust pressure sensor output, exhaust gas temperature sensor output, injection control pressure, commanded injection control pressure, turbocharger/turbine speed, variable geometry turbo position, commanded variable geometry turbo position, turbocharger compressor inlet temperature, turbocharger compressor inlet pressure, turbocharger turbine inlet temperature, turbocharger turbine outlet temperature, wastegate valve position, glow plug lamp status;

(B) For 2013 and subsequent model year engines, EGR temperature, variable geometry turbo control status (e.g., open loop, closed loop), reductant level (e.g., urea tank fill level), alcohol fuel percentage, type of fuel currently being used, NOx adsorber regeneration status, NOx adsorber deSOx status, hybrid battery pack remaining charge;

(C) Oxygen sensor output, air/fuel ratio sensor output, NOx sensor output, evaporative system vapor pressure;

(D) For 2013 and subsequent model year engines, PM sensor output and distance traveled while low/empty SCR reductant driver warning/inducement active.

(E) For 2016 and subsequent model year engines, reductant quality sensor output and corrected NOx sensor output (e.g., raw sensor signal corrected for estimated ammonia concentrations or auto-zero calculations and used by the applicable electronic control unit).

<u>(F) For 2022 and subsequent model year engines, NOx mass emission rate - engine out and NOx mass emission rate – tailpipe.</u>

<u>(G) For 2024 and subsequent model year engines, commanded DEF dosing, DEF dosing mode (A, B, C, etc.), DEF dosing rate, DEF usage for current driving cycle, target ammonia storage level on SCR, modeled actual ammonia storage level on SCR, SCR intake temperature, SCR outlet temperature, stability of NOx sensor reading, EGR mass flow rate, engine fuel rate, vehicle fuel rate, hydrocarbon doser flow rate, hydrocarbon doser injector duty cycle, aftertreatment fuel pressure, charge air cooler outlet temperature, propulsion system active, chassis odometer reading, engine odometer reading (if available), hybrid/EV charging state, hybrid/EV battery system voltage, hybrid/EV battery system current, commanded/target fresh air flow, crankcase pressure sensor output,</u>

crankcase oil separator rotational speed, evaporative system purge pressure sensor output, and vehicle speed limiter speed limit.

(4.3) Freeze Frame:

(4.3.1) "Freeze frame" information required to be stored pursuant to sections (d)(2.2.1)(D), (d)(2.2.2)(D), (e)(1.4.2)(D), (e)(2.4.2)(B), (f)(1.4.4), and (f)(2.4.3) shall be made available on demand through the standardized data link connector in accordance with SAE J1979/J1939-73 specifications.

(4.3.2) "Freeze frame" conditions must include the fault code which caused the data to be stored and all of the signals required in sections (h)(4.2.1)(A) and (4.2.2)(A). Freeze frame conditions shall also include all of the signals required on the engine in sections (h)(4.2.1)(B), (4.2.2)(B), (4.2.2)(E), (4.2.3)(A), and (4.2.3)(B) that are used for diagnostic or control purposes in the specific diagnostic or emission-critical powertrain control unit that stored the fault code.

(4.3.3) Only one frame of data is required to be recorded. Manufacturers may choose to store additional frames provided that at least the required frame can be read by a scan tool meeting SAE J1978 specifications or designed to communicate with an SAE J1939 network.

(4.4) Fault Codes:

(4.4.1) For vehicles using the ISO 15765-4 protocol for the standardized functions required in section (h):

(A) For all monitored components and systems, stored pending, confirmed, and permanent fault codes shall be made available through the diagnostic connector in a standardized format in accordance with SAE J1979 specifications. Standardized fault codes conforming to SAE J2012 shall be employed.

(B) Except as otherwise specified in sections (e) through (g), ~~T~~the stored fault code shall, to the fullest extent possible, pinpoint the likely cause of the malfunction. To the extent feasible, manufacturers shall use separate fault codes for every diagnostic where the diagnostic and repair procedure or likely cause of the failure is different. ~~In general, rationality and functional diagnostics shall use different fault codes than the respective circuit continuity diagnostics. Additionally, input component circuit continuity diagnostics shall use different fault codes for distinct malfunctions (e.g., out-of-range low, out-of-range high, open circuit).~~

(C) Manufacturers shall use appropriate SAE-defined fault codes of SAE J2012 (e.g., P0xxx, P2xxx) whenever possible. With Executive Officer approval, manufacturers may use manufacturer-defined fault codes in accordance with SAE J2012 specifications (e.g., P1xxx). Factors to be considered by the Executive Officer for approval shall include the lack of available SAE-defined fault codes, uniqueness of the diagnostic or monitored component, expected future usage of the diagnostic or component, and estimated usefulness in providing additional diagnostic and repair information to service technicians. Manufacturer-defined fault codes shall be used consistently (i.e., the same fault code may not be used to represent two different failure modes) across a manufacturer's entire product line.

(D) A pending or confirmed fault code (as required in sections (d) and (e) through (g)) shall be stored and available to an SAE J1978 scan tool within 10 seconds after a diagnostic has determined that a malfunction has occurred. A permanent fault code shall be stored and available to an SAE J1978 scan tool no later than the end of an ignition cycle (including electronic control unit shutdown) in which the corresponding confirmed fault code causing the MIL to be illuminated has been stored.

(E) Pending fault codes:

(i) Pending fault codes for all components and systems (including continuously and non-continuously monitored components) shall be made available through the diagnostic connector in accordance with SAE J1979 specifications (e.g., Mode/Service $07).

(ii) A pending fault code(s) shall be stored and available through the diagnostic connector for all currently malfunctioning monitored component(s) or system(s), regardless of the MIL illumination status or confirmed fault code status (e.g., even after a pending fault has matured to a confirmed fault code and the MIL is illuminated, a pending fault code shall be stored and available if the most recent monitoring event indicates the component is malfunctioning).

(iii) Manufacturers using alternate statistical protocols for MIL illumination as allowed in section (d)(2.2.1)(C) shall submit to the Executive Officer a protocol for setting pending fault codes. The Executive Officer shall approve the proposed protocol upon determining that, overall, it is equivalent to the requirements in sections (h)(4.4.1)(E)(i) and (ii) and that it effectively provides service technicians with a quick and accurate indication of a pending failure.

(F) Permanent fault codes:

(i) Permanent fault codes for all components and systems shall be made available through the diagnostic connector in a standardized format that distinguishes permanent fault codes from both pending fault codes and confirmed fault codes.

(ii) A confirmed fault code shall be stored as a permanent fault code no later than the end of the ignition cycle and subsequently at all times that the confirmed fault code is commanding the MIL on (e.g., for currently failing systems but not during the 40 warm-up cycle self-healing process described in section (d)(2.3.1)(B)).

(iii) Permanent fault codes shall be stored in NVRAM and may not be erasable by any scan tool command (generic or enhanced) or by disconnecting power to the on-board computer.

(iv) Permanent fault codes may not be erased when the control module containing the permanent fault code is reprogrammed unless the readiness bits (refer to section (h)(4.1)) for all monitored components and systems in all modules that reported supported readiness for a readiness bit other than the comprehensive components readiness bit are set to “not complete” in conjunction with the reprogramming event.

(v) The OBD system shall have the ability to store a minimum of four current confirmed fault codes as permanent fault codes in NVRAM. If the number of confirmed fault codes currently commanding the MIL on exceeds the maximum number of permanent fault codes that can be stored, the OBD system shall store the earliest detected confirmed fault codes as permanent fault codes. If additional confirmed fault codes are stored when the maximum number of permanent fault codes is already stored in NVRAM, the OBD system may not replace any existing permanent fault code with the additional confirmed fault codes.

(4.4.2) For vehicles using the SAE J1939 protocol for the standardized functions required in section (h):

(A) For all monitored components and systems, stored pending, MIL-on, and previously MIL-on fault codes shall be made available through the diagnostic connector in a standardized format in accordance with SAE J1939 specifications (i.e., Diagnostic Message (DM) 6, DM12, and DM23). Standardized fault codes conforming to SAE J1939 shall be employed.

(B) Except as otherwise specified in sections (e) through (g), ~~T~~the stored fault code shall, to the fullest extent possible, pinpoint the likely cause of the malfunction. To the extent feasible, manufacturers shall use separate fault codes for every diagnostic where the diagnostic and repair procedure or likely cause of the failure is different. ~~In general, rationality and functional diagnostics shall use different fault codes than the respective circuit continuity diagnostics. Additionally, input component circuit continuity diagnostics shall use different fault codes for distinct malfunctions (e.g., out-of-range low, out-of-range high, open circuit).~~

(C) Manufacturers shall use appropriate SAE-defined fault codes of SAE J1939 whenever possible. With Executive Officer approval, manufacturers may use manufacturer-defined fault codes in accordance with SAE J1939 specifications. Factors to be considered by the Executive Officer for approval shall include the lack of available SAE-defined fault codes, uniqueness of the diagnostic or monitored component, expected future usage of the diagnostic or component, and estimated usefulness in providing additional diagnostic and repair information to service technicians. Manufacturer-defined fault codes shall be used consistently (i.e., the same fault code may not be used to represent two different failure modes) across a manufacturer's entire product line.

(D) A pending or MIL-on fault code (as required in sections (d), (e), and (g)) shall be stored and available to an SAE J1939 scan tool within 10 seconds after a diagnostic has determined that a malfunction has occurred. A permanent fault code shall be stored and available to an SAE J1939 scan tool no later than the end of an ignition cycle (including electronic control unit shutdown) in which the corresponding MIL-on fault code causing the MIL to be illuminated has been stored.

(E) Pending fault codes:

(i) Pending fault codes for all components and systems (including continuously and non-continuously monitored components) shall be made available through the diagnostic connector in accordance with SAE J1939 specifications (i.e., DM6).

(ii) Manufacturers using alternate statistical protocols for MIL illumination as allowed in section (d)(2.2.2)(C) shall submit to the Executive Officer a protocol for setting pending fault codes. The Executive Officer shall approve the proposed protocol upon determining that, overall, it is equivalent to the requirements in sections (h)(4.4.2)(E)(i) and that it effectively provides service technicians with a quick and accurate indication of a pending failure.

(F) Permanent fault codes:

(i) Permanent fault codes for all components and systems shall be made available through the diagnostic connector in a standardized format that distinguishes permanent fault codes from pending fault codes, MIL-on fault codes, and previously MIL-on fault codes.

(ii) A MIL-on fault code shall be stored as a permanent fault code no later than the end of the ignition cycle and subsequently at all times that the MIL-on fault code is commanding the MIL on (e.g., for currently failing systems).

(iii) Permanent fault codes shall be stored in NVRAM and may not be erasable by any scan tool command (generic or enhanced) or by disconnecting power to the on-board computer.

(iv) Permanent fault codes may not be erased when the control module containing the permanent fault codes is reprogrammed unless the readiness bits (refer to section (h)(4.1)) for all monitored components and systems in all modules that reported supported readiness for a readiness bit other than the comprehensive components readiness bit are set to “not complete” in conjunction with the reprogramming event.

(v) The OBD system shall have the ability to store a minimum of four current MIL-on fault codes as permanent fault codes in NVRAM. If the number of MIL-on fault codes currently commanding the MIL on exceeds the maximum number of permanent fault codes that can be stored, the OBD system shall store the earliest detected MIL-on fault codes as permanent fault codes. If additional MIL-on fault codes are stored when the maximum number of permanent fault codes is already stored in NVRAM, the OBD system may not replace any existing permanent fault code with the additional MIL-on fault codes.

(4.5) Test Results:

(4.5.1) Except as provided in section (h)(4.5.7), for all monitored components and systems identified in sections (e)(1) through (f)(9) and (g)(2), results of the most recent monitoring of the components and systems and the test limits established for monitoring the respective components and systems shall be stored and available through the data link in accordance with the standardized format specified in SAE J1979 for the ISO 15765-4 protocol or in SAE J1939-73 for the SAE J1939 protocol.

(4.5.2) The test results shall be reported such that properly functioning components and systems (e.g., “passing” systems) do not store test values outside of the established test limits. Test limits shall include both minimum and maximum acceptable values and shall be defined so that a test result equal to either test limit is a “passing” value, not a “failing” value.

(4.5.3) The test results shall be standardized such that the name of the monitored component (e.g., catalyst bank 1) can be identified by a generic scan tool and the test results and limits can be scaled and reported with the appropriate engineering units by a generic scan tool.

(4.5.4) The test results shall be stored until updated by a more recent valid test result or the fault memory of the OBD system computer is cleared.

(4.5.5) If the OBD system fault memory is cleared:

(A) For vehicles using the ISO 15765-4 protocol for the standardized functions required in section (h), all test results shall report values of zero for the test result and test limits. The test results shall be updated once the applicable monitor has run and has valid test results and limits to report.

(B) For vehicles using the SAE J1939 protocol for the standardized functions required in section (h):

(i) For 2010 through 2015 model year engines, all test results shall either (a) report values of zero for the test results and test limits, or (b) report values corresponding to 'test not complete' in accordance with SAE J1939-73 specifications. The test results shall be updated once the applicable monitor has run and has valid test results and limits to report.

(ii) For 2016 and subsequent model year engines, all test results shall report values corresponding to 'test not complete' in accordance with SAE J1939-73 specifications. The test results shall be updated once the applicable monitor has run and has valid test results and limits to report.

(4.5.6) All test results and test limits shall always be reported. The OBD system shall store and report unique test results for each separate diagnostic.

(4.5.7) The requirements of section (h)(4.5) do not apply to gasoline fuel system monitors specified under sections (f)(1.2.1)(A), (f)(1.2.1)(B), (f)(1.2.2), and (f)(1.2.4)~~, and (f)(1.2.5)~~, exhaust gas sensor monitors specified under sections (e)(9.2.1)(A)(iii), (e)(9.2.1)(B)(iii), (e)(9.2.2)(C), (f)(8.2.1)(C), and (f)(8.2.2)(E), cold start emission reduction strategy monitors, circuit and out-of-range monitors that are required to be continuous, ~~and~~ diesel feedback control monitors specified under sections (e)(1.2.4), (e)(3.2.4), (e)(4.2.5), (e)(6.2.2)(D), (e)(7.2.3), and (e)(8.2.7), and CV system monitors that meet the requirements specified under section (g)(2.2.2).

(4.6) Software Calibration Identification:

(4.6.1) Except as provided for in section (h)(4.6.3), on all vehicles, a single software calibration identification number (CAL ID) for each diagnostic or emission critical control unit(s) shall be made available through the standardized data link connector in accordance with the SAE J1979/J1939 specifications.

(4.6.2) A unique CAL ID shall be used for every emission-related calibration and/or software set having at least one bit of different data from any other emission-related calibration and/or software set. Control units coded with multiple emission or diagnostic calibrations and/or software sets shall indicate a unique CAL ID for each variant in a manner that enables an off-board device to determine which variant is being used by the vehicle. Control units that utilize a strategy that will result in MIL illumination if the incorrect variant is used (e.g., control units that contain variants for manual and automatic transmissions but will illuminate the MIL if the variant selected does not match the type of transmission on the vehicle) are not required to use unique CAL IDs.

(4.6.3) Manufacturers may request Executive Officer approval to respond with more than one CAL ID per diagnostic or emission critical powertrain control unit. Executive Officer approval of the request shall be based on the method used by the manufacturer to ensure each control unit will respond to a generic scan tool with the CAL IDs in order of highest to lowest priority with regards to areas of the software most critical to emission and OBD system performance.

(4.7) Software Calibration Verification Number:

(4.7.1) All vehicles shall use an algorithm to calculate a single calibration verification number (CVN) that verifies the on-board computer software integrity for each diagnostic or emission critical electronic control unit. The CVN shall be made available through the standardized data link connector in accordance with the SAE J1979/J1939 specifications. The CVN shall be capable of being used to determine if the emission-related software and/or calibration data are valid and applicable for that vehicle and CAL ID.

(4.7.2) One CVN shall be made available for each CAL ID made available. For diagnostic or emission critical powertrain control units with more than one CAL ID, each CVN shall be output to a generic scan tool in the same order as the CAL IDs are output to the generic scan tool to allow the scan tool to match each CVN to the corresponding CAL ID.

(4.7.3) Manufacturers shall submit information for Executive Officer approval of the algorithm used to calculate the CVN. Executive Officer approval of the algorithm shall be based on the complexity of the algorithm and the determination that the same CVN is difficult to achieve with modified calibration values.

(4.7.4) The CVN shall be calculated at least once per ignition cycle and stored until the CVN is subsequently updated. The stored CVN value may not be erased when fault memory is erased by a generic scan tool in accordance with SAE J1979/J1939 specifications or during normal vehicle shut down (i.e., key off, engine off).

(4.7.5) When a CVN request message is received by the on-board computer, the stored CVN value shall be made available through the data link connector to a generic scan tool.

(A) Except as provided for below in section (h)(4.7.5)(B) and (C), when a CVN request is received, the on-board computer may not use delayed timing in sending the CVN and may not respond with a message indicating that the CVN value is not currently available (e.g.., may not respond with a negative response code, acknowledgement ($00E800_{16}$) parameter group number: Control Byte = 3, or a negative acknowledgement), and may not respond with a default value. Default value is defined as any value or space holder that is not a valid CVN value.

(B) If the CVN request message is received ~~immediately following erasure of the stored CVN value (i.e.,~~ within the first 120 seconds of engine operation after a reprogramming event or a non-volatile memory clear or within the first 120 seconds of engine operation after a volatile memory clear or battery disconnect~~)~~, the on-board computer may respond with one or more messages directing the scan tool to wait or resend the request message after the delay (e.g., a negative response code, acknowledgement ($00E800_{16}$) parameter group number: Control Byte = 3, or a negative acknowledgement). Vehicles complying with SAE J1939 may also send such a response when the on-board computer is already sending a different multi-packet message using TP.BAM. Such messages and delays shall conform to the specifications for transmitting CVN data contained in SAE J1979 or J1939, whichever applies.

(C) If a communication malfunction is preventing access to a CVN value for reporting in response to a scan tool request, a default CVN value may be reported in lieu of a valid CVN value provided that:

(i) a pending fault code or a confirmed/MIL-on fault code is stored with the MIL commanded on pinpointing a communication fault for the module that is unable to report a valid CVN, and

(ii) the default CVN value used cannot be mistaken for a valid CVN (e.g., all zeros or all question marks for the default value cannot be mistaken for a valid CVN).

(4.7.6) For purposes of Inspection and Maintenance (I/M) testing, manufacturers shall make the CVN and CAL ID combination information available for all vehicles in a standardized electronic format that allows for off-board verification that the CVN is valid and appropriate for a specific vehicle and CAL ID. The manufacturer shall use the most recent standardized electronic format ~~is~~ detailed in Attachment F of ARB Mail-Out #MSC 09-22, July 7, 2009, incorporated by reference. Manufacturers shall submit the CVN and CAL ID information to the Executive Officer not more than ~~25~~ 30 calendar days after the close of a calendar quarter. Manufacturers are required to submit information about all CVN and CAL ID combinations applicable for every vehicle, including CVN and CAL ID combinations from field fixes after the production period has ended.

(4.8) Vehicle and Engine Identification Numbers:

(4.8.1) All vehicles shall have the vehicle identification number (VIN) available in a standardized format through the standardized data link connector in accordance with SAE J1979/J1939 specifications. Only one electronic control unit per vehicle shall report the VIN to an SAE J1978/J1939 scan tool.

(4.8.2) All 2013 and subsequent model year engines (except for heavy-duty engines certified to the Low Emission Vehicle III exhaust emission standards defined in title 13, CCR section 1961.2) shall have the engine serial number (ESN) available in a standardized format through the standardized data link connector. Only one electronic control unit per vehicle shall report the ESN to an SAE J1978/J1939 scan tool.

(4.8.3) If the VIN or ESN is reprogrammable, in conjunction with reprogramming of the VIN or the ESN, the OBD system shall erase all emission-related diagnostic information identified in section (h)(4.10.1) in all control modules that reported supported readiness for a readiness bit other than the comprehensive components readiness bit.

(4.9) ECU Name: For 2013 and subsequent model year engines, the name of each electronic control unit that responds to an SAE J1978/J1939 scan tool with a unique address or identifier shall be communicated in a standardized format in accordance with SAE J1979/J1939 (e.g., ECUNAME in Service/Mode $09, InfoType $0A in SAE J1979).

(4.10) Erasure of Emission-Related Diagnostic Information:

(4.10.1) For purposes of section (h)(4.10), “emission-related diagnostic information” includes all the following:

(A) Readiness status (section (h)(4.1))

(B) Data stream information (section (h)(4.2)) including number of stored confirmed/MIL-on fault codes, distance traveled (or engine run time for engines not utilizing vehicle speed information) while MIL activated, number of warm-up cycles since fault memory last cleared, ~~and~~ distance traveled (or engine run time for engines not utilizing vehicle speed information) since fault memory last cleared, MIL status, and monitor status.

(C) Freeze frame information (section (h)(4.3))

(D) Pending, confirmed, MIL-on, and previously MIL-on fault codes (section (h)(4.4~~.~~))

(E) Test results (section (h)(4.5))

(4.10.2) For all vehicles, the emission-related diagnostic information shall be erased ~~if~~ as a result of a command~~ed~~ by a scan tool (generic or enhanced) and may be erased if the power to the on-board computer is disconnected. At a minimum, the emission-related diagnostic information shall be erased as a result of a command by a scan tool while in the key on, engine off position. Further, ~~E~~except as provided for in sections (h)(4.4.1)(F)(iv), (h)(4.4.2)(F)(iv), ~~and~~ (h)(4.8.3), and (h)(4.10.4), if any of the emission-related diagnostic information is erased as a result of a command~~ed to be erased~~ by a scan tool ~~(generic or enhanced)~~ or during an on-board computer reprogramming event, all emission-related diagnostic information shall be erased from all diagnostic or emission critical control units ~~shall be erased~~. For these control units, ~~T~~the OBD system may not ~~allow a scan tool to~~ erase a subset of the emission-related diagnostic information in response to a scan tool command (e.g., in such cases, the OBD system may not ~~allow a scan tool to~~ erase only one of three stored fault codes or only information from one control unit without erasing information from the other control unit(s)).

(4.10.3) A manufacturer may request Executive Officer approval to be exempt from erasing all emission-related diagnostic information from all control units while in the key on, engine off position for the purposes of safety or component protection. The manufacturer shall propose alternate conditions (i.e., conditions other than or in addition to the key on, engine off position) to erase the emission-related diagnostic information. The Executive Officer shall approve the alternate conditions upon determining that the manufacturer has demonstrated all of the following:

(A) The alternate erasure conditions are required for safety or component protection,

(B) The manufacturer defines conditions that can be reasonably satisfied in the vehicle service environment in which all emission-related diagnostic information from control units shall be erased. The OBD system may not allow a scan tool to erase a subset of the emission-related diagnostic information, and

(C) All details of the erasure protocol during these alternate conditions are reported pursuant to title 13, CCR, section 1969.

(4.10.4) A manufacturer may request Executive Officer approval for an alternate erasure protocol in cases where a malfunction activates a component-protection or safety-related default mode. The Executive Officer shall approve the request for an alternate erasure protocol upon determining that the manufacturer has demonstrated all of the following:

(A) The default mode is activated for component protection or safety purposes,

(B) The alternate erasure protocol applies solely to control units that report supported readiness for only the comprehensive component readiness bit. All emission-related diagnostic information from all control units that report supported readiness for readiness bits other than comprehensive components shall be erased pursuant to (h)(4.10.2) or (h)(4.10.3) above,

(C) There exists key on, engine off position conditions that can be reasonably satisfied in the vehicle/engine service environment in which all emission-related diagnostic information in these control module(s) can be erased, and

(D) All details of the alternate erasure protocol are reported pursuant to title 13, CCR, section 1969.

(5) Tracking Requirements:

(5.1) In-use Performance Ratio Tracking Requirements:

(5.1.1) For each monitor required in sections (e) through (g) to separately report an in-use performance ratio, manufacturers shall implement software algorithms to report a numerator and denominator in the standardized format specified below and in accordance with the SAE J1979/J1939 specifications.

(5.1.2) Numerical Value Specifications:

(A) For the numerator, denominator, general denominator, and ignition cycle counter:

(i) Each number shall have a minimum value of zero and a maximum value of 65,535 with a resolution of one.

(ii) Each number shall be reset to zero only when a non-volatile random access memory (NVRAM) reset occurs (e.g., reprogramming event) or, if the numbers are stored in keep-alive memory (KAM), when KAM is lost due to an interruption in electrical power to the control module (e.g., battery disconnect). Numbers may not be reset to zero under any other circumstances including when a scan tool command to clear fault codes or reset KAM is received.

(iii) If either the numerator or denominator for a specific component reaches the maximum value of 65,535 ±2, both numbers shall be divided by two before either is incremented again to avoid overflow problems.

(iv) If the ignition cycle counter reaches the maximum value of 65,535 ±2, the ignition cycle counter shall rollover and increment to zero on the next ignition cycle to avoid overflow problems.

(v) If the general denominator reaches the maximum value of 65,535 ±2, the general denominator shall rollover and increment to zero on the next driving cycle that meets the general denominator definition to avoid overflow problems.

(vi) If a vehicle is not equipped with a component (e.g., oxygen sensor bank 2, secondary air system), the corresponding numerator and denominator for that specific component shall always be reported as follows~~zero~~:

a. For vehicles using the ISO 15765-4 protocol for the standardized functions required in section (h), the values shall be reported as zero.

b. For vehicles using the SAE J1939 protocol for the standardized functions required in section (h), the values shall be reported as FFFF.

(B) For the ratio:

(i) The ratio shall have a minimum value of zero and a maximum value of 7.99527 with a resolution of 0.000122.

(ii) A ratio for a specific component shall be considered to be zero whenever the corresponding numerator is equal to zero and the corresponding denominator is not zero.

(iii) A ratio for a specific component shall be considered to be the maximum value of 7.99527 if the corresponding denominator is zero or if the actual value of the numerator divided by the denominator exceeds the maximum value of 7.99527.

(5.2) Engine Run Time Tracking Requirements:

(5.2.1) For all ~~gasoline and diesel~~ engines, manufacturers shall implement software algorithms to individually track and report in a standardized format the engine run time while being operated in the following conditions:

(A) Total engine run time;

(B) Total idle run time (with “idle” defined as accelerator pedal released by driver, engine speed greater than or equal to 50 to 150 rpm below the normal warmed-up idle speed (as determined in the drive position for vehicles equipped with an automatic transmission), PTO not active, and either vehicle speed less than or equal to one mile per hour or engine speed less than or equal to 200 rpm above normal warmed-up idle), and;

(C) Total run time with PTO active;

(D) For 2013 and subsequent model year diesel engines ~~only~~and 2024 and subsequent model year gasoline and alternate-fueled engines:

(i) total run time with EI-AECD #1 active;

(ii) total run time with EI-AECD #2 active; and so on up to

(iii) total run time with EI-AECD #n active.

(E) For 2024 and subsequent model year diesel engines:
(i) total run time with no delivery of reductant used to control NOx emissions (e.g., diesel exhaust fluid) due to insufficient exhaust temperature, and
(ii) total run time with exhaust temperature below 200 degrees Celsius as measured just upstream of the NOx converting catalyst. If an engine has more than one NOx converting catalyst, tracking shall be based on the temperature upstream of the catalyst that is closest to the engine.

(5.2.2) Numerical Value Specifications: For each counter specified in section (h)(5.2.1):
(A) Each number shall conform to the standardized format specified in SAE J1979/J1939.
(B) Each number shall be reset to zero only when a non-volatile memory reset occurs (e.g., reprogramming event). Numbers may not be reset to zero under any other circumstances including when a scan tool (generic or enhanced) command to clear fault codes or reset KAM is received.
(C) If any of the individual counters reach the maximum value, all counters shall be divided by two before any are incremented again to avoid overflow problems.

(5.2.3) Specifications of EI-AECDs
(A) For purposes of section (h)(5.2.3), the following terms shall be defined as follows:
(i) "Purpose" is defined as the objective of the EI-AECD when it is activated (e.g., EGR valve protection);
(ii) "Action" is defined as a specific component/element act that is commanded when the EI-AECD is activated (e.g., EGR system is derated);
(iii) "Parameter" is defined as a component/element (e.g., ECT, oil temperature) used to determine when to activate the EI-AECD; and
(iv) "Condition" is defined as the specific characteristic/state exhibited by the parameter (e.g., ECT above 100 degrees Celsius) that triggers activation of the EI-AECD.
(B) Each unique combination of action, parameter, and condition within a purpose shall be tracked as a separate EI-AECD and increment the timer(s) at all times the condition necessary to activate the EI-AECD is present.
(i) For EI-AECDs that implement an action of variable degree based on the varying characteristics of a parameter (e.g., derate EGR more aggressively as engine oil temperature continues to increase), the EI-AECD shall be tracked by incrementing two separate timers within a single EI-AECD (e.g., EI-AECD #1 timer 1 and EI-AECD #1 timer 2) as follows:
a. The first of the two timers shall be incremented whenever the EI-AECD is commanding some amount of reduced emission control effectiveness up to but not including 75 percent of the maximum reduced emission control effectiveness that the EI-AECD is capable of commanding during in-use vehicle or engine operation. For example, an overheat protection strategy that progressively

derates EGR and eventually shuts off EGR as oil temperature increases would accumulate time for the first timer from the time derating of EGR begins up to the time that EGR is derated 75 percent. As a second example, an overheat protection strategy that advances fuel injection timing progressively up to a maximum advance of 15 degrees crank angle as the engine coolant temperature increases would accumulate time for the first timer from the time advance is applied up to the time that advance reaches 11.25 degrees (75 percent of the maximum 15 degrees).

b. The second of the two timers shall be incremented whenever the EI-AECD is commanding 75 percent or more of the maximum reduced emission control effectiveness that the EI-AECD is capable of commanding during in-use vehicle or engine operation. For example, the second timer for the first example EI-AECD identified in section (h)(5.2.3)(B)(i) would accumulate time from the time that EGR is derated 75 percent up to and including when EGR is completely shut off. For the second example EI-AECD identified in section (h)(5.2.3)(B)(i), the second timer would accumulate time from the time fuel injection timing advance is at 11.25 degrees up to and including the maximum advance of 15 degrees.

(C) A manufacturer may request Executive Officer approval to combine multiple unique actions, parameters, and/or conditions to be tracked within a single EI-AECD. The manufacturer shall submit a plan for combining, tracking, and incrementing the EI-AECD to the Executive Officer for approval. Executive Officer approval of the plan shall be based on the effectiveness and the equivalence of the incrementing plan to determine the amount of EI-AECD activity per condition relative to the measure of EI-AECD activity under section (h)(5.2.3)(B).

(D) For EI-AECDs that are activated solely due to elevation, the timer shall be incremented only for the portion of EI-AECD activation when the elevation is below 8000 feet (e.g., the timer for an EI-AECD that is activated when the elevation is above 5000 feet shall be incremented only when the EI-AECD is active and the elevation is below 8000 feet).

(E) For EI-AECDs that are initially activated due to engine warm-up and are subsequently reactivated after the engine has warmed up, the timer shall be incremented only when the EI-AECD is active after the initial engine warm-up (e.g., an EI-AECD that turns off an emission control at low engine coolant temperature would not increment the timer during initial warm-up but would increment the timer if coolant temperature subsequently dropped below the low temperature and reactivated the EI-AECD later in the drive cycle).

(F) If more than one EI-AECD is currently active, the timers for both EI-AECDs shall accumulate time, regardless if there is overlap or redundancy in the commanded action (e.g., two different EI-AECDs independently but simultaneously commanding EGR off shall both accumulate time in their respective timers).

<u>(5.3) NOx Emission Tracking Requirements:</u>

<u>(5.3.1) For all 2022 and subsequent model year diesel engines, manufacturers</u>

shall implement software algorithms to track and report in a standardized format the following parameters:

(A) NOx mass – engine out (g);

(B) NOx mass – tailpipe (g);

(C) Engine output energy (EOE) (kWh);

(D) Distance traveled (km);

(E) Engine run time (hours);

(F) Vehicle fuel consumption (liters).

(5.3.2) The parameters in section (h)(5.3.1) shall be stored in the four data arrays described below. Data in each array shall be based on signals that are sampled at a frequency of at least 1 Hertz.

(A) Active 100 Hour Array.

(i) When the NOx sensors used to determine the NOx mass parameters listed in section (h)(5.3.1) are all reporting valid NOx concentration data, data for all parameters in section (h)(5.3.1) shall be stored in the Active 100 Hour Array.

(ii) When the total engine run time value (or, for hybrid vehicles, propulsion system active run time) that is stored in Bin 1 (defined in section (h)(5.3.3)(A) below) of the Active 100 Hour Array reaches 100 hours, all stored data shall be transferred to the Stored 100 Hour Array described in section (h)(5.3.2)(B). All data in the Active 100 Hour Array shall be reset to zero and begin incrementing anew.

(B) Stored 100 Hour Array.

(i) The Stored 100 Hour Array is a static repository for data stored by the Active 100 Hour Array. Stored 100 Hour Array data are overwritten with the data stored in the Active 100 Hour Array only when the total engine run time (or, for hybrid vehicles, propulsion system active run time) stored in Bin 1 (defined in section (h)(5.3.3)(A) below) of the Active 100 Hour Array reaches 100 hours.

(C) Lifetime Array.

(i) When the NOx sensors used to determine the NOx mass parameters listed in section (h)(5.3.1) are all reporting valid NOx concentration data, data for all parameters in section (h)(5.3.1) shall be stored in the Lifetime Array.

(ii) The Lifetime Array maintains a running total of parameter data for the actual life of the engine.

(D) Lifetime Engine Activity Array.

(i) The parameters in section (h)(5.3.1)(C) through (F) are stored in the Lifetime Engine Activity Array whenever the engine is running regardless of NOx sensor status.

(ii) The Lifetime Engine Activity Array maintains a running total of parameter data for the actual life of the engine.

(5.3.3) Each parameter in each array in section (h)(5.3.2) shall be stored in a series of bins that are defined as indicated below. References to "rated power" mean the engine's rated net brake power.

(A) "Bin 1" stores the total value of the parameter in a given array. The values in Bins 2 through 14 must sum to equal the value in Bin 1.

(B) "Bin 2" stores data when the vehicle speed is zero kilometers per hour (km/h) for any level of engine power output;

(C) Bins that store data when the engine power output is less than or equal to 25 percent of rated power:

(i) "Bin 3" is for vehicle speeds greater than zero km/h and less than or equal to 16 km/h (10 mph);

(ii) "Bin 4" is for vehicle speeds greater than 16 km/h and less than or equal to 40 km/h (25 mph);

(iii) "Bin 5" is for vehicle speeds greater than 40 km/h and less than or equal to 64 km/h (40 mph);

(iv) "Bin 6" is for vehicle speeds greater than 64 km/h.

(D) Bins that store data when the engine power output is greater than 25 percent of rated power and less than or equal to 50 percent of rated power:

(i) "Bin 7" is for vehicle speeds greater than zero km/h and less than or equal to 16 km/h (10 mph);

(ii) "Bin 8" is for vehicle speeds greater than 16 km/h and less than or equal to 40 km/h (25 mph);

(iii) "Bin 9" is for vehicle speeds greater than 40 km/h and less than or equal to 64 km/h (40 mph);

(iv) "Bin 10" is for vehicle speeds greater than 64 km/h.

(E) Bins that store data when the engine power output is greater than 50 percent of rated power:

(i) "Bin 11" is for vehicle speeds greater than zero km/h and less than or equal to 16 km/h (10 mph);

(ii) "Bin 12" is for vehicle speeds greater than 16 km/h and less than or equal to 40 km/h (25 mph);

(iii) "Bin 13" is for vehicle speeds greater than 40 km/h and less than or equal to 64 km/h (40 mph);

(iv) "Bin 14" is for vehicle speeds greater than 64 km/h.

(F) "Bin 15" stores data only when the engine is operating within the NOx NTE control area and no exclusions apply.

(G) "Bin 16" stores data only when an active PM filter regeneration event is being commanded.

(H) "Bin 17" stores the total value of the parameter in a given array only when the pause conditions of section (h)(5.3.6)(A) are met.

(I) Storage of data in Bins 1 through 14 occurs independently of data storage in Bins 15 and 16, and is not interrupted or otherwise affected by activity related to Bins 15 and 16.

(5.3.4) The engine-out and tailpipe NOx mass parameters that are calculated by the OBD system to fulfill the requirements in section (h)(5.3) and data stream requirements in section (h)(4.2) must not have an error of more than +/- 20 percent, or alternatively at the manufacturer's discretion, 0.10 g/bhp-hr when divided by the net brake work of the engine. This requirement applies only to the NOx mass parameters in sections (h)(5.3) and (h)(4.2). Manufacturers shall report the most accurate values that are calculated within the applicable electronic control unit (e.g., the engine control module). The NOx mass values shall furthermore be calculated using the most accurate NOx concentration and exhaust flow rate values that are calculated within the applicable electronic control unit. Manufacturers shall not include a humidity correction factor when calculating NOx mass. The Executive Officer shall determine compliance with this requirement by comparing data from the OBD system and the test facility that are submitted by the manufacturer as described in section (j)(2.26). Specifically, the Executive Officer shall compare the total tailpipe NOx mass calculated by the OBD system for the test cycle with the total NOx mass measured by the test facility and give consideration to the consistency of the behavior of the two sets of instantaneous NOx mass values over the test cycle. Notwithstanding the compliance determination based on the data submitted as described in section (j)(2.26), manufacturers may not include any calibration/software feature which adversely impacts the accuracy of the calculated NOx mass values relative to the accuracy demonstrated at the time of certification when the engine operates in conditions outside of the certification testing environment.

(5.3.5) Numerical Value Specifications: For each parameter specified in section (h)(5.3.1):

(A) For parameters in arrays described in section (h)(5.3.2)(A), each number shall be reset to zero when any of the following occur:

(i) A scan tool command to clear fault codes is received;

(ii) An NVRAM reset occurs (e.g., reprogramming event); or

(iii) If the numbers are stored in KAM, when KAM is lost due to an interruption in electrical power to the control module (e.g., battery disconnect).

(B) For parameters in arrays described in sections (h)(5.3.2)(B), (C), and (D), each number shall be reset to zero only when a non-volatile memory reset occurs (e.g., reprogramming event). Numbers may not be reset to zero under any other circumstances including when a scan tool (generic or enhanced) command to clear fault codes or reset KAM is received.

(C) The OBD system shall store each number within 600 seconds after the end of a driving cycle.

(5.3.6) Pause conditions for tracking:

(A) Except for malfunctions described in section (h)(5.3.6)(B) below, the OBD system shall continue tracking all parameters listed in section (h)(5.3.1) if a malfunction has been detected and the MIL is commanded on. Within 10 seconds of the MIL being commanded on, tracked data shall only be stored in Bin 17 as described in section (h)(5.3.3)(H) and storage of data in all other bins (Bins 1-16) shall be paused. When the malfunction is no longer detected and the MIL is no longer commanded on, tracking of all parameters in section (h)(5.3.1) shall resume in Bins 1-16 and shall pause in Bin 17 within 10 seconds.

(B) The OBD system shall pause tracking of all parameters listed in section (h)(5.3.1) within 10 seconds if any of the conditions in sections (h)(5.3.6)(B)(i) through (iii) below occur. When the condition no longer occurs (e.g., the engine stop lamp is not commanded on), tracking of all parameters in section (h)(5.3.1) shall resume within 10 seconds:

(i) A malfunction of any component used to determine vehicle speed has been detected and the MIL is commanded on for that malfunction;
(ii) A NOx sensor malfunction has been detected and the MIL is commanded on for that malfunction;
(iii) The engine stop lamp (if equipped) is commanded on.

(C) The manufacturer may request Executive Officer approval to pause tracking of all parameters listed in section (h)(5.3.1) if a malfunction occurs that is not covered under sections (h)(5.3.6)(B)(i) through (iii) above (e.g., a light is commanded on for vehicles with no engine stop lamps such that the driver is likely to stop the vehicle, the odometer is lost, a malfunction of any component used as a primary input to the exhaust gas flow model occurs). The Executive Officer shall approve the request upon determining based on manufacturer submitted data and/or engineering evaluation that the malfunction will significantly affect the accuracy of the parameter values specified under section (h)(5.3.1).

(5.3.7) The data specified in section (h)(5.3) reflect vehicle operation in various real world conditions including different driving, environmental, and engine load conditions that may not correspond to regulated test procedures. Engine NOx emission levels will vary based on such conditions and as a result, these data may not correspond to the test conditions and/or test procedures associated with California's applicable standards for NOx emissions. Compliance with the applicable standards for NOx emissions for heavy-duty diesel engines and vehicles is determined in accordance with the applicable standards and corresponding test procedures.

(5.4) For all 2022 and subsequent model year engines, manufacturers shall implement software algorithms to individually track and report in a standardized format the following:

(5.4.1) Vehicle fuel consumption;
(5.4.2) Engine fuel consumption;
(5.4.3) Engine idle fuel consumption;
(5.4.4) Engine PTO fuel consumption;
(5.4.5) Distance traveled;
(5.4.6) If so equipped, distance traveled while engine WHR technology is active;
(5.4.7) EOE;
(5.4.8) Positive kinetic energy (PKE);
(5.4.9) Engine run time;
(5.4.10) Idle run time (with "idle" defined as accelerator pedal released by driver, engine speed greater than or equal to 50 to 150 rpm below the normal warmed-up idle speed (as determined in the drive position for vehicles equipped with an automatic transmission), PTO not active, and either vehicle speed less than or equal to one mile per hour (1.6 kilometers per hour) or engine speed less than or equal to 200 rpm above normal warmed-up idle);
(5.4.11) Urban speed run time (with "urban speed" defined as vehicle speed greater than one mile per hour (1.6 kilometers per hour) and less than or equal to 37 miles per hour (60 kilometers per hour));
(5.4.12) PTO run time;
(5.4.13) If so equipped, WHR technology run time;

(5.4.14) For non-hybrid vehicles so equipped, start-stop technology run time;
(5.4.15) If so equipped, automatic engine shutdown technology activation count;
(5.4.16) If so equipped, active technology #1 run time;
(5.4.17) If so equipped, active technology #2 run time; and so on up to
(5.4.18) If so equipped, active technology #n run time;
(5.4.19) If so equipped, distance traveled while active technology #1 is active;
(5.4.20) If so equipped, distance traveled while active technology #2 is active; and so on up to
(5.4.21) If so equipped, distance traveled while active technology #n is active.

(5.5) For all 2022 and subsequent model year hybrid systems on hybrid vehicles, manufacturers shall implement software algorithms to individually track and report in a standardized format the following:
(5.5.1) Propulsion system active run time;
(5.5.2) Idle propulsion system active run time;
(5.5.3) Urban propulsion system active run time.

(5.6) For all 2022 and subsequent model year hybrid systems on plug-in hybrid electric vehicles, manufacturers shall implement software algorithms to individually track and report in a standardized format the following:
(5.6.1) Total distance traveled in charge depleting operation with engine off;
(5.6.2) Total distance traveled in charge depleting operation with engine running;
(5.6.3) Total distance traveled in driver-selectable charge increasing operation;
(5.6.4) Total fuel consumed in charge depleting operation;
(5.6.5) Total fuel consumed in driver-selectable charge increasing operation;
(5.6.6) Total grid energy consumed in charge depleting operation with engine off;
(5.6.7) Total grid energy consumed in charge depleting operation with engine running;
(5.6.8) Total grid energy into the battery.

(5.7) For each parameter specified in sections (h)(5.4), (h)(5.5), and (h)(5.6):
(5.7.1) Each value shall conform to the standardized format specified in SAE J1939 or SAE J1979.
(5.7.2) Except as provided below, each parameter shall be stored in three categories:
(A) The active 100 hour category represents the most current up to 100 hours of operation. All values stored in this category shall reset to zero and begin incrementing anew when the engine run time (or, for hybrid vehicles, propulsion system active run time) in this category reaches 100 hours.
(B) The stored 100 hour category represents values transferred from the active 100 hour category when the engine run time (or, for hybrid vehicles, propulsion system active run time) in the active category reaches 100 hours. The parameter specified under section (h)(5.4.9) is not required to meet section (h)(5.7.2)(B) (or, for hybrid vehicles, the parameter specified in section (h)(5.5.1) is not required to meet section (h)(5.7.2)(B), but the parameter specified in section (h)(5.4.9) is required to meet section (h)(5.7.2)(B)).
(C) The lifetime category represents aggregate values accumulated since the first initial engine operation after production. Parameters specified under

sections (h)(5.4.1), (5.4.5), and (5.4.7) are not required to meet section (h)(5.7.2)(C) if the OBD system meets the requirements of section (h)(5.3). Parameters specified under sections (h)(5.4.9), (5.4.10), and (5.4.12) are not required to meet section (h)(5.7.2)(C).

(5.7.3) For parameters in categories described in section (h)(5.7.2)(A):

(A) Each number shall be reset to zero when any of the following occur:

(i) A scan tool command to clear fault codes is received;

(ii) An NVRAM reset occurs (e.g., reprogramming event) ;or

(iii) If the numbers are stored in KAM, when KAM is lost due to an interruption in electrical power to the control module (e.g., battery disconnect).

(B) The OBD system shall store each number within 600 seconds after the end of a driving cycle.

(5.7.4) For parameters in categories described section (h)(5.7.2)(B) and (C):

(A) Each number shall be reset to zero only when a non-volatile memory reset occurs (e.g., reprogramming event). Numbers may not be reset to zero under any other circumstances including when a scan tool (generic or enhanced) command to clear fault codes or reset KAM is received.

(B) The OBD system shall store each number within 600 seconds after the end of a driving cycle.

(5.7.5) The OBD system shall pause tracking of all parameters listed in sections (h)(5.4), (5.5), and (5.6) within 10 seconds if any of the conditions in sections (h)(5.7.5)(A) through (C) below occur. When the condition no longer occurs (e.g., the engine stop lamp is not commanded on), tracking of all parameters in sections (h)(5.4), (5.5), and (5.6) shall resume within 10 seconds:

(A) A malfunction of any component used to determine vehicle speed has been detected and the MIL is commanded on for that malfunction;

(B) A NOx sensor malfunction has been detected and the MIL is commanded on for that malfunction; or

(C) The engine stop lamp (if equipped) is commanded on.

(5.7.6) The manufacturer may request Executive Officer approval to pause tracking of all parameters listed in sections (h)(5.4), (5.5), and (5.6) if a malfunction occurs that is not covered under sections (h)(5.7.5)(A) through (C) above (e.g., a light is commanded on for vehicles with no engine stop lamps such that the driver is likely to stop the vehicle, the odometer is lost, a malfunction of any component used as a primary input to the exhaust gas flow model occurs). The Executive Officer shall approve the request upon determining based on manufacturer submitted data and/or engineering evaluation that the malfunction will significantly affect the accuracy of the parameter values specified under section (h)(5.3.1).

(5.8) For all 2024 and subsequent model year diesel engines, manufacturers shall implement software algorithms to track and report in a standardized format the following parameters:

(5.8.1) Engine odometer reading (or chassis odometer reading if engine odometer is not available) at the beginning and end of the last 3 PM filter regeneration events; and

(5.8.2) Lifetime counter of PM filter regeneration events.

(5.8.3) Each number in section (h)(5.8) shall be reset to zero only when a non-volatile memory reset occurs (e.g., reprogramming event). Numbers may not be reset to zero under any other circumstances including when a scan tool (generic or enhanced) command to clear fault codes or reset KAM is received.

(6) Data Reporting Requirements for Over-the-Air Reprogramming:

(6.1) For all 2024 and subsequent model year engines, if any of the data required to be stored and made available pursuant to section (h)(5) would be erased by an over-the-air reprogramming of any control module, the manufacturer shall collect all lifetime data stored in the engine pursuant to this section using the over-air-network prior to their erasure.

(6.2) The manufacturer shall submit a report to the Executive Officer containing the average value and standard deviation of each collected parameter for each affected certified engine family as specified in, "Data Record Reporting Procedures for Over-the-Air Reprogrammed Vehicles and Engines", dated August 16, 2018, and hereby incorporated by reference. The manufacturer shall submit the report within 75 calendar days of the availability of the calibration/software update to affected engines. The manufacturer shall submit a separate report for each unique calibration/software update.

(7) Exceptions to Standardization Requirements

(7.1) For an engine that is certified for use in both medium-duty and heavy-duty vehicles, a manufacturer may request Executive Officer approval to implement the tracking requirements in title 13, CCR sections 1968.2 (g)(6.3), (6.4), (6.5), (6.6.2), and (6.8) in lieu of the tracking requirements in sections (h)(5.4) through (5.7). The Executive Officer shall approve the request upon determining based on manufacturer-submitted information that the engine will be used in both medium-duty and heavy-duty vehicles and will meet the tracking requirements in title 13, CCR sections 1968.2(g)(6.5) and (6.8) for technologies installed on the heavy-duty vehicle that are also installed (and meeting the same tracking requirements) on the medium-duty vehicle.

(i) Monitoring System Demonstration Requirements for Certification.

(1) General.

(1.1) Certification requires that manufacturers submit emission test data from one or more durability demonstration test engines (test engines).

(1.2) The Executive Officer may approve other demonstration protocols if the manufacturer can provide comparable assurance that the malfunction criteria are chosen based on meeting the malfunction criteria requirements and that the timeliness of malfunction detection is within the constraints of the applicable monitoring requirements.

(1.3) For flexible fuel engines capable of operating on more than one fuel or fuel combinations, the manufacturer shall submit a plan for providing emission test data to the Executive Officer for approval. The Executive Officer shall approve the plan if it is determined to be representative of expected in-use fuel or fuel combinations and provides accurate and timely evaluation of the monitored systems.

(1.4) For alternate-fueled engines, the manufacturer shall submit a plan for providing emission test data to the Executive Officer for approval. The Executive Officer shall approve the plan if it is determined that the appropriate monitors are tested with respect to the components and systems on the engine and that the monitors are tested on the appropriate fuel or fuel combinations.

(1.5) For engines that are equipped with components/systems defined by any of the monitoring requirements in section (e) and components/systems defined by any of the monitoring requirements in section (f) (e.g., engines with gasoline lean-burn systems that utilize both gasoline and diesel emission control technologies), the manufacturer shall submit a plan for providing emission test data to the Executive Officer for approval. The Executive Officer shall approve the plan if it is determined that the appropriate monitors are tested with respect to the components and systems on the vehicle and to the monitoring plan approved by the Executive Officer in accordance with section (d)(8.2).

(2) Selection of Test Engines:

(2.1) Prior to submitting any applications for certification for a model year, a manufacturer shall notify the Executive Officer of the engine families and engine ratings within each family planned for that model year. The Executive Officer will then select the engine family(ies) and the specific engine rating within the engine family(ies) that the manufacturer shall use as demonstration test engines to provide emission test data. The selection of test vehicles for production vehicle evaluation, as specified in section (l)(2), may take place during this selection process.

(2.2) Number of test engines:

(2.2.1) For the 2010 model year, a manufacturer shall provide emission test data of a test engine from the OBD parent rating.

(2.2.2) For the 2011 and 2012 model years, a manufacturer certifying one to seven engine families in a model year shall provide emission test data of a test engine from one OBD child rating. A manufacturer certifying eight or more engine families in a model year shall provide emission test data of test engines from two OBD child ratings. The Executive Officer may waive the requirement for submittal of data of one or more of the test engines if data have been previously submitted for all of the OBD parent and OBD child ratings.

(2.2.3) For the 2013 and subsequent model years, a manufacturer certifying one to five engine families in a model year shall provide emission test data of a test engine from one engine rating. A manufacturer certifying six to ten engine families in a model year shall provide emission test data from test engines from two engine ratings. A manufacturer certifying eleven or more engine families in a model year shall provide emission test data of test engines from three engine ratings. The Executive Officer may waive the requirement for submittal of data of one or more of the test engines if data have been previously submitted for all of the engine ratings.

(2.2.4) For a given model year, a manufacturer may elect to provide emission data of test engines from more engine ratings than required by section (i)(2.2.1) through (2.2.3). For each additional engine rating tested in that given model year, the Executive Officer shall reduce the number of engine ratings required for testing in one future model year under sections (i)(2.2.2) through (2.2.3) by one.

(2.3) Aging and data collection of diesel test engines:

(2.3.1) For 2010 through 2012 model year test engines, a manufacturer shall use an engine aged for a minimum of 125 hours plus exhaust aftertreatment emission controls aged by an accelerated aging process to be representative of full useful life. Manufacturers are required to submit for Executive Officer approval a description of the accelerated aging process and/or supporting data. The Executive Officer shall approve the process upon determining that the submitted description and/or data demonstrate that the process ensures that deterioration of the exhaust aftertreatment emission controls is stabilized sufficiently such that it is representative of the manufacturer's best estimates for the performance of the emission control at the end of the useful life. The Executive Officer may not require manufacturers to provide actual in-use or high mileage data to verify or validate that the aging is equivalent to full useful life for purposes of section (i)(2.3.1).

(2.3.2) For 2013 through 2015 model year test engines:

(A) A manufacturer shall collect emission and deterioration data from an actual high mileage system(s) (consisting of the engine, engine emission controls, and aftertreatment) to validate its accelerated aging process. The manufacturer shall collect the data from a 2010 or newer model year system that is the most representative of system designs planned for the 2013 model year and has a minimum actual mileage of full useful life or 185,000 miles, whichever is lower. The manufacturer shall collect and report the data to ARB prior to the end of 2011. The manufacturer shall submit a plan for system selection, procurement, and data collection to the Executive Officer for approval prior to proceeding with the data collection. The Executive Officer shall approve the plan upon determining that the submitted description will result in the manufacturer gathering data necessary to quantify emission performance and deterioration of the system elements in a manner that will allow comparison to deterioration and performance levels achieved with the manufacturer's accelerated aging process.

(B) For testing of 2013 through 2015 model year engines, a manufacturer shall use a system (engine, engine emission controls, and aftertreatment) aged by an accelerated aging process to be representative of full useful life. Manufacturers are required to submit for Executive Officer approval a description of the accelerated aging process and supporting data. The Executive Officer shall approve the process upon determining that the submitted description and data demonstrate that the aging process will result in a system representative of the manufacturer's best estimates of the system performance at full useful life and that the manufacturer has utilized the data collected under section (i)(2.3.2)(A) to validate the correlation of the aging process to actual high mileage systems up to a minimum of full useful life or 185,000 miles.

(2.3.3) For 2016 ~~and subsequent~~ through 2023 model year test engines:

(A) A manufacturer shall collect emission and deterioration data from an actual high mileage system(s) (consisting of the engine, engine emission controls, and aftertreatment) to validate its accelerated aging process. The manufacturer shall collect the data from a 2010 or newer model year system that is the most representative of system designs planned for the 2016 model year and has a minimum actual mileage of full useful life. The manufacturer shall collect and report the data to ARB prior to the end of 2014. The manufacturer shall submit a plan for system selection, procurement, and data collection to the Executive Officer for approval prior to proceeding with the data collection. The Executive Officer shall approve the plan upon determining that the submitted description will result in the manufacturer gathering data necessary to quantify emission performance and deterioration of the system elements in a manner that will allow comparison to deterioration and performance levels achieved with the manufacturer's accelerated aging process.

(B) For testing of 2016 ~~and subsequent~~through 2023 model year engines, a manufacturer shall use a system (engine, engine emission controls, and aftertreatment) aged by an accelerated aging process to be representative of full useful life. Manufacturers are required to submit for Executive Officer approval a description of the accelerated aging process and supporting data. The Executive Officer shall approve the process upon determining that the submitted description and data demonstrate that the aging process will result in a system representative of the manufacturer's best estimates of the system performance at full useful life and that the manufacturer has utilized the data collected under section (i)(2.3.3)(A) to validate the correlation of the aging process to actual high mileage systems up to a minimum of full useful life.

(2.3.4) For 2024 and subsequent model year engines test engines:

(A) A manufacturer shall collect emission, deterioration and performance data from an actual high mileage system(s) (consisting of the engine, engine emission controls, and aftertreatment) to validate its accelerated aging process. The manufacturer shall collect the data from a system(s) that is the most representative of the system design to be certified and has a minimum actual mileage of full useful life. The manufacturer shall submit a plan for system selection, procurement, and data collection to the Executive Officer for approval prior to proceeding with the data collection. The Executive Officer shall approve the plan upon determining that the submitted description will result in the manufacturer gathering data necessary to quantify emission performance, system performance, and deterioration of the system elements in a manner that will allow comparison to deterioration and performance levels achieved with the manufacturer's accelerated aging process. The material and information used to validate a manufacturer's accelerated aging process shall include, but is not limited to, the following:

(i) Fuel burn rate, calculated total fuel consumed over full useful life, and calculated amount of reductant used by the system over full useful life to be used as metrics to determine sufficient accelerated aging in replicating a full useful life system.

(ii) Correlation between a representative actual full useful life system(s) and the test engine of any and all adaptation/learning parameters implemented by the manufacturer to maintain emission control performance to the applicable emission certification standard over the life of the system.

(B) A manufacturer shall use a system (consisting of the engine, engine emission controls, aftertreatment) aged by an accelerated aging process which results in a representative full useful life system. Manufacturers are required to submit for Executive Officer approval a description of the accelerated aging process and data to support the accelerated aging process. The Executive Officer shall approve the process upon determining that the process includes (but is not limited to) the conditions under section (i)(2.3.4)(B)(i) through (vi) below, that the submitted description and data demonstrate that the aging process will result in a system representative of the manufacturer's best estimates of the system performance at full useful life, and that the manufacturer has utilized the data collected under section (i)(2.3.4)(A) to validate the correlation of the aging process to actual high mileage systems up to a minimum of full useful life.

(i) Minimum system (engine, engine emission controls, aftertreatment) accelerated aging process aging hours as specified below:

a. For heavy heavy-duty engines: 2,500 hours

b. For medium heavy-duty engines: 1,063 hours

c. For light heavy-duty engines: 632 hours

(ii) Operation at rated horsepower.

(iii) Operation at load levels greater than 80% of the rated torque, with sustained intervals at 100% of the rated torque.

(iv) Operation over transient conditions (e.g., Mode 2 of FTP cycle).

(v) The calculated number of regeneration events experienced over full useful life.

(vi) Thermal cycling events (i.e., system shut down with a subsequent cold start). These thermal cycling events (i.e., shut down periods) shall not be included in the minimum aging hours specified in section (i)(2.3.4)(B)(i) above.

(2.4) Aging of gasoline engines: For the test engine(s), a manufacturer shall use a certification emission durability test engine(s) system (i.e., consisting of the engine, engine emission controls, and aftertreatment), a representative high mileage engine(s) system, or an engine(s) system aged to the end of the full useful life using an ARB-approved alternative durability procedure (ADP).

(3) Required Testing:

Except as provided below, the manufacturer shall perform single-fault testing based on the applicable test with the following components/systems set at their malfunction criteria limits as determined by the manufacturer for meeting the requirements of sections (e), (f), and (g) or sections (d)(7.1.2) and (d)(7.2.3) for extrapolated OBD systems. Except as specified below, the component/system being evaluated shall be deteriorated to the applicable malfunction limit (s) established by the manufacturer and calibrated to the emission threshold malfunction criteria using methods established by the manufacturer in accordance with section (d)(6.4).

(3.1) Required testing for Diesel/Compression Ignition Engines:

(3.1.1) Fuel System: The manufacturer shall perform a separate test for each malfunction limit established by the manufacturer for the fuel system parameters (e.g., fuel pressure, injection timing) and calibrated to the emission threshold malfunction criteria (e.g., 2.0 times the standard) in sections (e)(1.2.1) through (e)(1.2.3). When performing a test for a specific parameter, the fuel system shall be operating at the malfunction criteria limit for the applicable parameter only. All other parameters shall be with normal characteristics. For testing of the malfunction limits in section (e)(1.2.1) on engines required to meet section (e)(1.2.7)(B), the manufacturer shall perform a test for each of the following that is applicable: (1) with a high side fault (i.e., fault that causes too much pressure) that affects all injectors equally, (2) with a low side fault (i.e., fault that causes too little pressure) that affects all injectors equally, and (3) for systems that have single component failures which could affect a single injector, with a fault that affects the worst case injector (i.e., a fault on the injector that will result in the worst case emissions). For testing of the malfunction limits in sections (e)(1.2.2) and (e)(1.2.3) on engines required to meet section (e)(1.2.7)(C), the manufacturer shall perform a test for each of the following: (1) with a high side fault (e.g., too much fuel quantity, too advanced timing) that affects all injectors equally, (2) with a low side fault (e.g., too little fuel quantity, too retarded timing) that affects all injectors equally, and (3) with a fault that affects the worst case injector (i.e., a fault on the injector that will result in the worst case emissions). In conducting the fuel system demonstration tests, the manufacturer may use computer modifications to cause the fuel system to operate at the malfunction limit if the manufacturer can demonstrate to the Executive Officer that the computer modifications produce test results equivalent to an induced hardware malfunction.

(3.1.2) Misfire Monitoring: For 2013 model year engines subject to section (e)(2.2.5), the manufacturer shall perform a test at the malfunction limit specified in section (e)(2.2.5). A misfire demonstration test is not required for diesel engines not subject to section (e)(2.2.5).

(3.1.3) EGR System: The manufacturer shall perform a test at each flow, slow response, and cooling limit calibrated to the emission threshold malfunction criteria (e.g., 2.0 times the standard) in sections (e)(3.2.1) through (3.2.3) and (e)(3.2.5). In conducting the EGR cooler performance demonstration test, the EGR cooler(s) being evaluated shall be deteriorated to the applicable malfunction criteria using methods established by the manufacturer in accordance with section (e)(3.2.9). In conducting the EGR system slow response demonstration tests, the manufacturer may use computer modifications to cause the EGR system to operate at the malfunction limit if the manufacturer can demonstrate to the Executive Officer that the computer modifications produce test results equivalent to an induced hardware malfunction or that there is no reasonably feasible method to induce a hardware malfunction.

(3.1.4) Boost Pressure Control System: The manufacturer shall perform a test at each boost, response, and cooling limit calibrated to the emission threshold malfunction criteria (e.g., 2.0 times the standard) in sections (e)(4.2.1) through (4.2.3) and (e)(4.2.4). In conducting the charge air undercooling demonstration test, the charge air cooler(s) being evaluated shall be deteriorated to the applicable malfunction limit established by the manufacturer in section (e)(4.2.4) using methods established by the manufacturer in accordance with section (e)(4.2.8).

(3.1.5) NMHC Catalyst: The manufacturer shall perform a separate test for each monitored NMHC catalyst(s) that is used for a different purpose (e.g., oxidation catalyst upstream of a PM filter, NMHC catalyst used downstream of an SCR catalyst). The catalyst(s) being evaluated shall be deteriorated to the applicable malfunction limit(s) established by the manufacturer and calibrated to the emission threshold malfunction criteria (e.g., 2.0 times the standard) in section (e)(5.2.2)(A) and (e)(5.2.2)(B) using methods established by the manufacturer in accordance with section (e)(5.2.4). For each monitored NMHC catalyst(s), the manufacturer shall also demonstrate that the OBD system will detect a catalyst malfunction with the catalyst at its maximum level of deterioration (i.e., the substrate(s) completely removed from the catalyst container or "empty" can). Emission data are not required for the empty can demonstration.

(3.1.6) NOx Catalyst: The manufacturer shall perform a separate test for each monitored NOx catalyst(s) that is used for a different purpose (e.g., passive lean NOx catalyst, SCR catalyst). The catalyst(s) being evaluated shall be deteriorated to the applicable malfunction limit(s) established by the manufacturer and calibrated to the emission threshold malfunction criteria (e.g., 2.0 times the standard) in sections (e)(6.2.1) and (e)(6.2.2)(A) using methods established by the manufacturer in accordance with section (e)(6.2.3). For each monitored NOx catalyst(s), the manufacturer shall also demonstrate that the OBD system will detect a catalyst malfunction with the catalyst at its maximum level of deterioration (i.e., the substrate(s) completely removed from the catalyst container or "empty" can). Emission data are not required for the empty can demonstration.

(3.1.7) NOx Adsorber: The manufacturer shall perform a test using a NOx adsorber(s) deteriorated to the malfunction limit calibrated to the emission threshold malfunction criteria (e.g., 2.0 times the standard) in section (e)(7.2.1). The manufacturer shall also demonstrate that the OBD system will detect a NOx adsorber malfunction with the NOx adsorber at its maximum level of deterioration (i.e., the substrate(s) completely removed from the container or "empty" can). Emission data are not required for the empty can demonstration.

(3.1.8) PM Filter: The manufacturer shall perform a test using a PM filter(s) deteriorated to each applicable malfunction limit calibrated to the emission threshold malfunction criteria (e.g., 2.0 times the standard) in sections (e)(8.2.1), (e)(8.2.2), and (e)(8.2.4)(A). The manufacturer shall also demonstrate that the OBD system will detect a PM filter malfunction with the filter at its maximum level of deterioration (i.e., the filter(s) completely removed from the filter container or "empty" can). Emission data are not required for the empty can demonstration.

(3.1.9) Exhaust Gas Sensor: The manufacturer shall perform a test for each exhaust gas sensor parameter at each malfunction limit calibrated to the emission threshold malfunction criteria (e.g., 2.0 times the standard) in sections (e)(9.2.1)(A)(i), (e)(9.2.1)(B)(i)a. through b., and (e)(9.2.2)(A)~~(i) through (ii)~~. When performing a test, all exhaust gas sensors used for the same purpose (e.g., for the same feedback control loop, for the same control feature on parallel exhaust banks) shall be operating at the malfunction criteria limit for the applicable parameter only. All other exhaust gas sensor parameters shall be with normal characteristics.

(3.1.10) VVT System: The manufacturer shall perform a test at each target error limit and slow response limit calibrated to the emission threshold malfunction criteria (e.g., 2.0 times the standard) in sections (e)(10.2.1) and (e)(10.2.2). For VVT systems with discrete operating states (e.g., two step valve train systems) that are not required to detect a malfunction prior to exceeding the threshold but are required to detect all failures that exceed the threshold, the manufacturer shall perform a test for the worst case failure mode that results in a target error malfunction and the worst case failure mode that results in a slow response malfunction. For these worst case failure modes, the manufacturer is required to provide data and/or engineering analysis used to determine that the tested failure mode will result in the worst case emissions compared to all the other failure modes. In conducting the VVT system demonstration tests, the manufacturer may use computer modifications to cause the VVT system to operate at the malfunction limit if the manufacturer can demonstrate to the Executive Officer that the computer modifications produce test results equivalent to an induced hardware malfunction.

(3.1.11) Cold Start Emission Reduction Strategy: The manufacturer shall perform a test at the malfunction limit calibrated to the emission threshold malfunction criteria (e.g., 2.0 times the standard) for the system or for each component monitored according to section (e)(11.2.2). In conducting the cold start emission reduction strategy demonstration tests, the manufacturer may use computer modifications to cause the cold start emission reduction strategy to operate at the malfunction limit if the manufacturer can demonstrate that the computer modifications produce test results equivalent to an induced hardware malfunction.

(3.1.12) For each of the testing requirements of section (i)(3.1), if the manufacturer has established that only a functional check is required because no failure or deterioration of the specific tested system could result in an engine's emissions exceeding the emission threshold malfunction criteria (e.g., 2.0 times any of the applicable standards), the manufacturer is not required to perform a demonstration test; however the manufacturer is required to provide the data and/or engineering analysis used to determine that only a functional test of the system(s) is required.

(3.2) Required testing for Gasoline/Spark-Ignited Engines:

(3.2.1) Fuel System:

(A) For engines with adaptive feedback based on the primary fuel control sensor(s), the manufacturer shall perform a test with the adaptive feedback based on the primary fuel control sensor(s) at the rich limit(s) and a test at the lean limit(s) established by the manufacturer and calibrated to the emission threshold malfunction criteria (e.g., 1.5 times the standard) in section (f)(1.2.1)(A). For purposes of fuel system testing, the fault(s) induced may result in a uniform distribution of fuel and air among the cylinders. Non-uniform distribution of fuel and air used to induce a fault may not cause misfire.

(B) For engines with feedback based on a secondary fuel control sensor(s) and subject to the malfunction criteria in section (f)(1.2.1)(B), the manufacturer shall perform a test with the feedback based on the secondary fuel control sensor(s) at the rich limit(s) and a test at the lean limit(s) established by the manufacturer and calibrated to the emission threshold malfunction criteria (e.g., 1.5 times the standard) in section (f)(1.2.1)(B).

(C) For engines subject to the malfunction criteria in section (f)(1.2.1)(C) (monitoring of air-fuel ratio cylinder imbalance faults), the manufacturer shall perform a test at the malfunction limit(s) calibrated to the emission threshold malfunction criteria (e.g., 1.5 times the standard) in section (f)(1.2.1)(C). The manufacturer shall perform the test at the rich limit and another test at the lean limit with a fault induced on the worst case cylinder for each limit. The manufacturer shall submit data and/or analysis demonstrating that a fault of the cylinder(s) will result in the worst case emissions for each malfunction limit.

(D) For other fuel metering or control systems, the manufacturer shall perform a test at the criteria limit(s).

(E) In conducting the fuel system demonstration tests, the manufacturer may use computer modifications to cause the fuel system to operate at the malfunction limit if the manufacturer can demonstrate to the Executive Officer that the computer modifications produce test results equivalent to an induced hardware malfunction.

(3.2.2) Misfire: The manufacturer shall perform a test at the malfunction limit calibrated to the emission threshold malfunction criteria (e.g., 1.5 times the standard) in section (f)(2.2.2).

(3.2.3) EGR System: The manufacturer shall perform a test at each flow limit calibrated to the emission threshold malfunction criteria (e.g., 1.5 times the standard) in sections (f)(3.2.1) and (f)(3.2.2).

(3.2.4) Cold Start Emission Reduction Strategy: The manufacturer shall perform a test at the malfunction limit calibrated to the emission threshold malfunction criteria (e.g., 1.5 times the standard) for each component monitored according to section (f)(4.2.1)(A) or (f)(4.2.2)(B). <u>In conducting the cold start emission reduction strategy demonstration tests, the manufacturer may use computer modifications to cause the cold start emission reduction strategy to operate at the malfunction limit if the</u>

manufacturer can demonstrate that the computer modifications produce test results equivalent to an induced hardware malfunction.

(3.2.5) Secondary Air System: The manufacturer shall perform a test at each flow limit calibrated to the emission threshold malfunction criteria in sections (f)(5.2.1) and (f)(5.2.2).

(3.2.6) Catalyst: The manufacturer shall perform a test using a catalyst system deteriorated to the emission threshold malfunction criteria (e.g., 1.5 times the standard) in section (f)(6.2.1) using methods established by the manufacturer in accordance with section (f)(6.2.2). The manufacturer shall also demonstrate that the OBD system will detect a catalyst system malfunction with the catalyst system at its maximum level of deterioration (i.e., the substrate(s) completely removed from the catalyst container or “empty” can). Emission data are not required for the empty can demonstration.

(3.2.7) Exhaust Gas Sensor:

(A) The manufacturer shall perform a test with all primary oxygen sensors (conventional switching sensors and wide range or universal sensors) used for fuel control simultaneously possessing a response rate deteriorated to the malfunction limit calibrated to the emission threshold malfunction criteria (e.g., 1.5 times the standard) in section (f)(8.2.1)(A). For conventional switching sensors, the manufacturer shall perform a test for each of the following malfunctions (1) the single worst case response rate malfunction among all symmetric and asymmetric patterns required by section (f)(8.2.1)(A), and (2) the worst case asymmetric response rate malfunction that results in ~~delays during~~ slower transitions from rich-to-lean or lean-to-rich sensor output (i.e., asymmetric slow response malfunction). For wide range or universal sensors, the manufacturer shall perform a test for each of the following malfunctions: (1) the single worst case response rate malfunction among all symmetric and asymmetric patterns required by section (f)(8.2.1)(A), and (2) the symmetric response rate malfunction that results in ~~delays during~~slower transitions from rich-to-lean and lean-to-rich sensor output (i.e., symmetric slow response malfunction). For systems where the same response rate pattern meets the criteria of (1) and (2) above, only one demonstration test is required. For the response rate patterns not tested, the manufacturer is required to provide the data and/or engineering analysis used to determine that the tested response pattern for criterion (1) will result in the worst case emissions compared to all the other response rate malfunctions. Manufacturers shall also perform a test for any other oxygen sensor parameter under sections (f)(8.2.1)(A) and (f)(8.2.2)(A) that can cause engine emissions to exceed the emission threshold malfunction criteria (e.g., 1.5 times the applicable standards due to a shift in air/fuel ratio at which oxygen sensor switches, decreased amplitude). When performing additional test(s), all primary and secondary (if applicable) oxygen sensors used for fuel control shall be operating at the malfunction criteria limit for the applicable parameter only. All other primary and secondary oxygen sensor parameters shall be with normal characteristics.

(B) For engines utilizing sensors other than oxygen sensors for primary fuel control (e.g., hydrocarbon sensors), the manufacturer shall submit, for Executive Officer approval, a demonstration test plan for performing testing of all of the sensor parameters that can cause engine emissions to exceed the emission threshold malfunction criteria (e.g., 1.5 times the applicable standards). The Executive Officer shall approve the plan if it is determined that it will provide data that will assure proper performance of the diagnostics of the sensors, consistent with the intent of section (i).

(3.2.8) VVT System: The manufacturer shall perform a test at each target error limit and slow response limit calibrated to the emission threshold malfunction criteria (e.g., 1.5 times the standard) in sections (f)(9.2.1) and (f)(9.2.2). For VVT systems with discrete operating states (e.g., two step valve train systems) that are not required to detect a malfunction prior to exceeding the threshold but are required to detect all failures that exceed the threshold, the manufacturer shall perform a test for the worst case failure mode that results in a target error malfunction and the worst case failure mode that results in a slow response malfunction. For these worst case failure modes, the manufacturer is required to provide data and/or engineering analysis used to determine that the tested failure mode will result in the worst case emissions compared to all the other failure modes. In conducting the VVT system demonstration tests, the manufacturer may use computer modifications to cause the VVT system to operate at the malfunction limit if the manufacturer can demonstrate to the Executive Officer that the computer modifications produce test results equivalent to an induced hardware malfunction.

(3.2.9) For each of the testing requirements of section (i)(3.2), if the manufacturer has established that only a functional check is required because no failure or deterioration of the specific tested system could result in an engine's emissions exceeding the emission threshold malfunction criteria (e.g., 1.5 times any of the applicable standards), the manufacturer is not required to perform a demonstration test; however the manufacturer is required to provide the data and/or engineering analysis used to determine that only a functional test of the system(s) is required.

(3.3) Required Testing for All Engines:

(3.3.1) Other Emission Control Systems: The manufacturer shall conduct demonstration tests for all other emission control components (e.g., hydrocarbon traps, adsorbers) designed and calibrated to an emission threshold malfunction criteria (e.g., 1.5 times the applicable standards) under the provisions of section (g)(4).

(3.3.2) For each of the testing requirements of section (i)(3.3), if the manufacturer has established that only a functional check is required because no failure or deterioration of the specific tested system could result in an engine's emissions exceeding the emission threshold malfunction criteria (e.g., 1.5 times any of the applicable standards), the manufacturer is not required to perform a demonstration test; however the manufacturer is required to provide the data and/or engineering analysis used to determine that only a functional test of the system(s) is required.

(3.3.3) The manufacturer shall perform baseline emission tests with no malfunctions implanted on the system (engine, engine emission controls, aftertreatment) before performing the required testing in section (i)(3.1) for diesel/compression ignition engines, section (i)(3.2) for gasoline/spark-ignited engines, and section (i)(3.3.1) for all engines. On engines equipped with emission controls that experience infrequent regeneration events, the manufacturer shall adjust the emission test results. The manufacturer shall adjust the emission result using the procedure described in CFR title 40, part 86.004-28(i) (current as of August 21, 2018, and incorporated by reference in section (d)(6.2)) on 2020 and earlier model year engines, and 1065.680 (current as of August 21, 2018, and incorporated by reference in section (d)(6.2)) on 2021 and subsequent model year engines. The baseline emission test results shall be used for purposes of determining whether or not any exhaust emission constituent exceed the applicable certification emission standard.

(3.4) The manufacturer may electronically simulate deteriorated components if the manufacturer can demonstrate to the Executive Officer that the computer modifications produce test results equivalent to an induced hardware malfunction but may not make any engine control unit modifications (unless otherwise provided above or exempted pursuant to this section) when performing demonstration tests. All equipment necessary to duplicate the demonstration test must be made available to ARB upon request. A manufacturer may request Executive Officer approval to electronically simulate a deteriorated component with engine control unit modifications. The Executive Officer shall approve the request upon determining the manufacturer has submitted data and/or engineering analysis demonstrating that is technically infeasible, very difficult, and/or resource intensive to implant the fault with modifications external to the engine control unit.

(3.5) For each of the testing requirements of (i)(3), when performing a test, all components or systems used in parallel for the same purpose (e.g., separate VVT actuators on the intake valves for Bank 1 and Bank 2, separate NOx converting catalysts on parallel exhaust banks) shall be simultaneously deteriorated to the malfunction criteria limit. Components or systems in series or used for different purposes (e.g., upstream and downstream exhaust gas sensors in a single exhaust bank, separate high pressure and low pressure EGR systems) may not be simultaneously deteriorated to the malfunction criteria limit.

(3.6) For each of the testing requirements under section (i)(3), if the manufacturer has established that only a functional check is required because no failure or deterioration of the specific tested system could result in an engine's emissions exceeding the emission threshold malfunction criteria (e.g., 1.5 times the standards), the manufacturer is not required to perform a demonstration test; however the manufacturer is required to provide the data and/or engineering analysis used to determine that only a functional test of the system(s) is required.

(4) Testing Protocol:

(4.1) Implanting of Malfunction and Malfunction Preconditioning Cycles:~~.~~

(4.1.1) Implanting of malfunction:

(A) If the Executive Officer approves the use of a malfunction preconditioning cycle under section (i)(4.1.2), the manufacturer shall set the system or component on the test engine for which detection is to be tested at the malfunction criteria limit(s) immediately prior to conducting the first malfunction preconditioning cycle in section (i)(4.1.2) below. If a second malfunction preconditioning cycle is permitted in accordance with section (i)(4.1.3) below, the manufacturer may adjust the system or component to be tested before conducting the second malfunction preconditioning cycle. The manufacturer may not replace, modify, or adjust the system or component after the last malfunction preconditioning cycle has taken place.

(B) If the Executive Officer does not approve the use of any malfunction preconditioning cycle under sections (i)(4.1.2) and (4.1.3), the manufacturer shall set the system or component on the test engine for which detection is to be tested at the malfunction criteria limit(s) immediately prior to conducting the applicable malfunction detection cycle(s) and exhaust emission tests under section (i)(4.2).

(C) The manufacturer may not run a manual PM filter regeneration event immediately before or any time after the malfunction is implanted, except for the following:

(i) When conducting the regeneration emission test under section (i)(4.2.3),

(ii) If allowed under section (i)(4.2.1)(C)) for a monitor that requires a regeneration event to enable monitoring, or

(iii) If a regeneration event is expected to occur during demonstration testing of a specific monitor under section (i)(4.1.2), (4.1.3), (4.2.1), or (4.2.2), the manufacturer may request Executive Officer approval to run a manual PM filter regeneration event before the malfunction is implanted for that specific monitor. Executive Officer approval shall be based on the manufacturer submitting data and/or engineering evaluation demonstrating that a regeneration event will most likely to occur during demonstration testing of the monitor (e.g., based on soot model information). If the Executive Officer approves the manual regeneration event, the manufacturer shall manually trigger a PM filter regeneration event while operating the engine on an FTP cycle and before the implanting the malfunction.

(4.1.2) Optional Malfunction Preconditioning cycle: The manufacturer may request Executive Officer approval to use a malfunction preconditioning cycle prior to conducting ~~each of~~ the ~~above emission~~ tests under section (i)(4.2) below. The Executive Officer shall approve the request upon determining that a manufacturer has provided data and/or engineering evaluation that demonstrate that the malfunction preconditioning cycle is necessary for the emission control system to stabilize ~~the~~ emissions ~~control system~~ (e.g., through control system adaptation or learning) due to the introduction of the malfunction and is not solely intended for the purpose of adding monitoring time to detect a malfunction. The manufacturer may not require the test engine to be cold soaked prior to conducting the malfunction preconditioning cycle in order for the monitoring system testing to be successful.

(4.1.3) Optional second malfunction preconditioning cycle: The manufacturer may

~~also~~ request Executive Officer approval to use an additional identical malfunction preconditioning cycle following a 20 minute hot soak after the ~~initial~~ first malfunction preconditioning cycle under section (i)(4.1.2). The Executive Officer shall approve the request upon determining that a manufacturer has provided data and/or engineering evaluation that demonstrate that the additional malfunction preconditioning cycle is necessary for the emission control system to stabilize ~~the~~ emissions ~~control system~~ (e.g., through control system adaptation or learning) due to the introduction of the malfunction and is not solely intended for the purpose of adding monitoring time to detect a malfunction. ~~The manufacturer may not require the test engine to be cold soaked prior to conducting preconditioning cycles in order for the monitoring system testing to be successful. If a second preconditioning cycle is permitted, the manufacturer may adjust the system or component to be tested before conducting the second preconditioning cycle. The manufacturer may not replace, modify, or adjust the system or component after the last preconditioning cycle has taken place.~~

(4.2) Demonstration Test Sequence:

~~(4.2.1) The manufacturer shall set the system or component on the test engine for which detection is to be tested at the malfunction criteria limit(s) prior to conducting the applicable emission test (or preconditioning, if approved).~~

(4.2.~~2~~1) Malfunction detection cycle: After the manufacturer has met the malfunction preconditioning cycle requirements under section (i)(4.1):

(A) For monitors designed to run on the FTP cycle as described under section (d)(3.1.1):

(i) If the emission threshold malfunction criteria are based on the SET cycle/standard as determined under section (d)(6.1), ~~T~~the test engine shall be operated over the ~~first engine start of the~~ FTP ~~emission test~~ cycle~~(i.e., the cold start) or a SET cycle~~ to allow for the initial detection of the tested system or component malfunction (i.e., storage of a pending fault code). The test engine shall then be operated over a second FTP cycle to allow the OBD system to store a confirmed/MIL-on fault code and illuminate the MIL. If required by the designated monitoring strategy, ~~an additional~~a cold soak ~~and first engine start of the FTP cycle (i.e., the cold start)~~ may be performed prior to conducting ~~this~~ these ~~test~~ cycles (e.g., for two-trip monitors that only run during cold starts on the FTP cycle).

(ii) If the emission threshold malfunction criteria are based on the FTP cycle/standard as determined under section (d)(6.1) or for monitors not required to meet the criteria under section (d)(6.1) (e.g., gasoline engine monitors), the manufacturer shall omit the malfunction detection cycles under section (i)(4.2.1) and shall operate the test engine over the FTP exhaust emissions test under section (i)(4.2.2). However, if a cold soak is required by the designated monitoring strategy, a cold soak followed by one FTP cycle may be performed to allow for the initial detection of the tested system or component malfunction, and then the manufacturer shall operate the test engine over the FTP exhaust emissions test under section (i)(4.2.2).

(B) For monitors designed to run on the SET cycle as described under section (d)(3.1.3):

(i) If the emission threshold malfunction criteria are based on the SET cycle/standard as determined under section (d)(6.1), the test engine shall be operated over one SET cycle to allow for the initial detection of the tested system or component malfunction (i.e., storage of a pending fault code). Then the manufacturer shall operate the test engine over the SET exhaust emission test under section (i)(4.2.2). If required by the designated monitoring strategy, a cold soak may be performed prior to conducting this cycle.

(ii) If the emission threshold malfunction criteria are based on the FTP cycle/standard as determined under section (d)(6.1) or for monitors not required to meet the criteria under section (d)(6.1) (e.g., gasoline engine monitors), the test engine shall be operated over the SET cycle to allow for the initial detection of the tested system or component malfunction (i.e., storage of a pending fault code). The test engine shall then be operated over the SET cycle to allow the OBD system to store a confirmed/MIL-on fault code and illuminate the MIL. If required by the designated monitoring strategy, a cold soak may be performed prior to conducting these cycles (e.g., for two-trip monitors that only run during cold starts on the SET cycle).

(C) For monitors designed to run over alternate monitoring conditions other than the SET cycle and approved under section (d)(3.1.3) (e.g., a monitor that is designed to run on the FTP cycle and requires a regeneration event to enable the monitor), the test engine shall be operated over the alternate conditions to allow for initial detection of the tested system or component malfunction (i.e., storage of a pending fault code). The manufacturer shall then operate the test engine over the alternate conditions to allow for the OBD system to store the confirmed/MIL-on fault code and illuminate the MIL.

(D) The manufacturer shall omit a malfunction detection cycle(s) under sections (i)(4.2.1) above if initial detection of the tested system or component malfunction was achieved during the malfunction preconditioning cycle under section (i)(4.1.2) or (4.1.3) above or the monitor uses a one-trip fault detection strategy (i.e., the monitor stores a confirmed/MIL-on fault code and illuminates the MIL in one driving cycle).

(4.2.~~3~~2) Exhaust emission test:~~The test engine shall then be operated over the second engine start of the FTP emission test (i.e., the hot start) or an SET emission test. The second SET cycle may be omitted from the testing protocol if it is unnecessary (e.g., one-trip fault detection strategies that run on the SET)~~ The manufacturer shall operate the test engine over the applicable exhaust emission test (for diesel engines, the test cycle determined under section (d)(6.1.1)). Except with Executive Officer approval, the “exhaust emission test” may not include any other test cycle (e.g., any test cycle used to precondition the engine specifically for demonstrating compliance with the tailpipe emission standards) prior to running the exhaust emission test cycle. The manufacturer may request

Executive Officer approval to operate the engine on an additional test cycle or other operating conditions prior to running the exhaust emission test. Executive Officer approval shall be granted upon determining that a manufacturer has provided data and/or an engineering evaluation that demonstrate that the additional test cycle/conditions is necessary to stabilize the emission control system.

(4.2.3) Regeneration emission test: On engines equipped with emission controls that experience infrequent regeneration events, immediately following the exhaust emission test under section (i)(4.2.2), the manufacturer shall run an additional test (i.e., the regeneration emission test) after the exhaust emission test described under section (i)(4.2.2). During the regeneration emission test, the manufacturer shall operate the test engine over the applicable exhaust emission test (for diesel engines, the test cycle determined under section (d)(6.1.1)) with a PM filter regeneration event triggered during the test. The manufacturer may alternatively request Executive Officer approval to perform the regeneration emission test for each demonstration required under section (i)(3) after all exhaust emission tests under section (i)(4.2.2) for all monitors have been completed.

(4.3) Test Data Collection:

(4.3.1) During the test sequence of section (i)(4.2), the manufacturer shall collect data described in section (i)(4.3.2)(B) below immediately prior to each engine shut-down (e.g., the end of each malfunction preconditioning cycle ~~in section (i)(4.2.1)~~, the end of the cold start FTP cycle ~~in section (i)(4.2.3)~~, the end of the warm start FTP cycle ~~in section (i)(4.2.3)~~). If the data cannot be collected immediately prior to engine shut-down, the data shall be collected immediately after engine shut-down. The manufacturer shall collect the data described in section (i)(4.3.2)(A) below during the test cycle in which the MIL is illuminated. The manufacturer shall collect the emission data specified in section (i)(4.3.2)(C) during the exhaust emission tests specified under section (i)(4.2.2) and (4.2.3) above.

(4.3.2) The manufacturer shall collect the following data:

(A) Approximate time on the test cycle (in seconds after engine start) when the MIL illuminates (e.g., MIL illuminated at 402 seconds into the cold start FTP cycle);

(B) All data required by sections (h)(4.1) through (h)(4.9) and (h)(5) including readiness status, current data stream values, fault code(s), freeze frame data, test results, CAL ID, CVN, VIN, ESN, ECU Name, in-use performance ratios, and engine run time tracking data;~~.~~ and

(C) Emission test data: For 2010 through 2023 model year engines, the emission test data shall include NMHC, CO, NOx, and PM emission data as applicable (based on the applicable emission threshold malfunction criteria). For all 2024 and subsequent model year engines, the emission test data shall include NMHC, CO, NOx, and PM emission data as applicable (based on the applicable emission threshold malfunction criteria), and CO_2 emission data for all monitors. For the CO_2 emission data, the manufacturer may request Executive Officer approval to submit the raw measured (e.g., not fuel-corrected) CO_2 values. The Executive

Officer shall approve the request upon determining, based on manufacturer-submitted information, that the raw measured CO_2 values are sufficient to assess the CO_2 impacts of each malfunction.

(4.3.3) For 2024 and subsequent model year diesel engines, the manufacturer shall collect the following data stream values at 1 second intervals (i.e., 1 Hertz) and submit the data in a comma separated values file: engine speed, actual engine torque, reference engine maximum torque, engine coolant temperature, engine oil temperature, fuel rate, modeled exhaust flow, intake air/manifold temperature, air flow rate (from mass air flow sensor), fuel injection timing, EGR mass flow rate, commanded EGR valve duty cycle/position, actual EGR valve duty cycle/position, EGR error between actual and commanded, boost pressure, commanded/target boost pressure, PM filter inlet temperature, PM filter outlet temperature, exhaust gas temperature sensor output, variable geometry turbo position, corrected NOx sensor output, DEF dosing mode, stability of NOx sensor reading, engine friction – percent torque, commanded DEF dosing, DEF usage for current driving cycle, DEF dosing rate, charge air cooler outlet temperature, SCR intake temperature, SCR outlet temperature, modeled actual ammonia storage level on SCR, and target ammonia storage level on SCR. These data shall be collected during any baseline testing and during demonstration testing of the NOx converting catalyst during the exhaust emission test cycle under section (i)(4.2.2).

(4.4) A manufacturer required to test more than one test engine (section (i)(2.2)) may utilize internal calibration sign-off test procedures (e.g., forced cool downs, less frequently calibrated emission analyzers) instead of official test procedures to obtain the emission test data required in section (i) for all but one of the required test engines. The manufacturer may elect this option if the data from the alternative test procedure are representative of official emission test results. Manufacturers using this option are still responsible for meeting the malfunction criteria specified in sections (e) through (g) when emission tests are performed in accordance with official test procedures.

(4.5) A manufacturer may request Executive Officer approval to utilize an alternate testing protocol for demonstration of MIL illumination if the engine dynamometer emission test cycle does not allow all of a monitor's enable conditions to be satisfied. A manufacturer may request the use of an alternate engine dynamometer test cycle or the use of chassis testing to demonstrate proper MIL illumination. In evaluating the manufacturer's request, the Executive Officer shall consider the technical necessity for using an alternate test cycle and the degree to which the alternate test cycle demonstrates that in-use operation with the malfunctioning component will properly result in MIL illumination.

(4.6) For heavy-duty engines certified to the Low Emission Vehicle III exhaust emission standards defined in title 13, CCR section 1961.2, a manufacturer may request Executive Officer approval to utilize an alternate testing protocol (e.g., chassis testing) for demonstration of MIL illumination. The Executive Officer shall approve the alternate testing protocol upon determining the protocol meets the requirements of title 13, CCR section 1968.2(h)(5).

(5) Evaluation Protocol:

(5.1) Full OBD engine ratings subject to sections (d)(7.1.1), (d)(7.2.2), or (d)(7.3) shall be evaluated according to the following protocol.

(5.1.1) For all tests conducted under section (i), the MIL shall be illuminated upon detection of the tested system or component malfunction before the end of the emission test specified in (i)(4.2.~~3~~2) in accordance with the requirements of sections (e) through (g).

(5.1.2) Except as provided in section (i)(5.1.2)(A) and (B) below, ~~I~~if the MIL illuminates prior to emissions exceeding the applicable emission threshold malfunction criteria specified in sections (e) through (g), no further demonstration is required. With respect to the misfire monitor demonstration test, if a manufacturer has elected to use the minimum misfire malfunction criteria of five or one percent as allowed in sections (e)(2.2.2)~~(A)~~ and (f)(2.2.2)(A), respectively, no further demonstration is required if the MIL illuminates with misfire implanted at the malfunction criteria limit.

(A) If the MIL illuminates prior to emissions exceeding the applicable emission threshold malfunction criteria specified in section (e) through (g) and a default fuel or emission control strategy is used when a malfunction is detected, the test engine shall be retested with the system or component adjusted to the worst acceptable limit (i.e., the applicable monitor indicates the system or component's performance is passing but at the closest possible value relative to the monitor threshold value at which a fault would be detected that would invoke the default strategy and illuminate the MIL). The manufacturer may request the Executive Officer to accept test data when the system or component's performance is at the worst acceptable limit within a margin of error necessary to accommodate testing variability and/or other practical limitations in setting the performance at the absolute worst acceptable limit. The Executive Officer shall accept the test data upon determining that the test data adequately demonstrate that emissions do not exceed the applicable malfunction criteria at the tested worst acceptable limit and that emissions will not exceed the applicable emission threshold malfunction criteria before performance exceeds the monitor threshold for fault detection. Alternatively, the manufacturer may request Executive Officer approval to use computer modifications to disable the default fuel or emission control strategy when retesting the engine. The Executive Officer shall approve the plan upon determining that the test data and/or engineering evaluation submitted by the manufacturer demonstrate that (1) emissions do not exceed the applicable malfunction criteria with the system or component adjusted to the best performing unacceptable level of performance, and (2) the computer modifications used to disable the default fuel or emission control strategy produce emissions results equivalent to the production-level calibration.

(B) For monitors of VVT systems with discrete operating states (e.g., two step valve train systems) that are not required to detect a malfunction prior to exceeding the threshold but are required to detect all failures that exceed the threshold, if the MIL illuminates, no further testing is required.

(5.1.3) If the MIL does not illuminate when the system or component is set at its limit(s), the criteria limit or the OBD system is not acceptable.

(A) Except as provided for in section (i)(5.1.3)(C), ~~I~~if the MIL first illuminates after emissions exceed the applicable emission threshold malfunction criteria specified in sections (e) through (g), the test engine shall be retested with the tested system or component adjusted so that the MIL will illuminate without emissions exceeding the applicable emission threshold malfunction criteria specified in sections (e) through (g). If the system or component cannot be adjusted to meet this criterion because a default fuel or emission control strategy is used when a malfunction is detected (e.g., open loop fuel control used after an oxygen sensor malfunction is determined), the test engine shall be retested with the system or component adjusted to the worst acceptable limit (i.e., the applicable monitor indicates the system or component's performance is passing but at the closest possible value relative to the monitor threshold value at which a fault would be detected that would invoke the default strategy and illuminate the MIL). The manufacturer may request the Executive Officer to accept test data when the system or component's performance is at the worst acceptable limit within a margin of error necessary to accommodate testing variability and/or other practical limitations in setting the performance at the absolute worst acceptable limit. The Executive Officer shall accept the test data upon determining that the test data adequately demonstrate that emissions do not exceed the applicable malfunction criteria at the tested worst acceptable limit and that emissions will not exceed the applicable emission threshold malfunction criteria before performance exceeds the monitor threshold for fault detection. Alternatively, the manufacturer may request Executive Officer approval to use computer modifications to disable the default fuel or emission control strategy when retesting the engine. The Executive Officer shall approve the plan upon determining that the test data and/or engineering evaluation submitted by the manufacturer demonstrate that (1) emissions do not exceed the applicable malfunction criteria with the system or component adjusted to the best performing unacceptable level of performance, and (2) the computer modifications used to disable the default fuel or emission control strategy produce emissions results equivalent to the production-level calibration. For the catalyst (i.e., components monitored under sections (e)(5.2.2), (e)(6.2.1), (e)(7.2.1), and (f)(6.2.1)) and PM filter system (i.e., sections (e)(8.2.1) and (e)(8.2.4)(A)), ~~T~~these testing provisions under section (i)(5.1.3)(A) shall ~~only~~ apply ~~to testing of the catalyst (i.e., components monitored under sections (e)(5.2.2), (e)(6.2.1), (e)(7.2.1), and (f)(6.2.1)) or PM filter system (i.e., (e)(8.2.1) and (e)(8.2.4))~~ only if the on-board computer invokes a default fuel or emission control strategy upon detection of the relevant catalyst or PM filter malfunction. Otherwise, the provisions of section (i)(5.1.3)(B) shall apply to testing of the catalyst or PM filter system.

(B) Except as provided for in section (i)(5.1.3)(A), in testing the catalyst (i.e., components monitored under sections (e)(5.2.2), (e)(6.2.1), (e)(7.2.1), and (f)(6.2.1)) or PM filter system (i.e., (e)(8.2.1) and (e)(8.2.4)(A)), if the MIL first illuminates after emissions exceed the applicable emission threshold malfunction criteria specified in sections (e) and (f), the tested engine shall be retested with a less deteriorated catalyst/PM filter system (i.e., more of the applicable engine out pollutants are converted or trapped). Adjustment and testing of the catalyst or PM filter system's performance may be repeated until successful results are obtained. For the OBD system to be approved, either of the following conditions must be satisfied by the test results:

(i) The MIL is illuminated and emissions do not exceed the emission threshold malfunction criteria specified in sections (e) or (f); or

(ii) The manufacturer demonstrates that the MIL illuminates within the upper and lower limits of the malfunction criteria identified below. The demonstration shall be deemed appropriate when the test results show:

a. The MIL is illuminated and emissions exceed the emission threshold malfunction criteria specified in sections (e) or (f) by 20 percent or less of the applicable standard (e.g., emissions are less than 2.2 times the applicable standard for an emission threshold malfunction criterion of 2.0 times the standard); and

b. The MIL is not illuminated and emissions are below the emission threshold malfunction criteria specified in sections (e) or (f) by no more than 20 percent of the standard (e.g., emissions are between 1.8 and 2.0 times the applicable standard for an emission threshold malfunction criterion of 2.0 times the standard).

(C) For monitors of VVT systems with discrete operating states (e.g., two step valve train systems) that are not required to detect a malfunction prior to exceeding the threshold but are required to detect all failures that exceed the threshold, if the MIL does not illuminate when the VVT system is tested using the worst case failure mode, the OBD system is not acceptable.

(5.1.4) If an OBD system is determined unacceptable by the above criteria, the manufacturer may recalibrate and retest the system on the same test engine. In such a case, the manufacturer must confirm, by retesting, that all systems and components that were tested prior to recalibration and are affected by the recalibration function properly under the OBD system as recalibrated.

(5.2) OBD child ratings subject to sections (d)(7.1.2) or (d)(7.2.3) (i.e., extrapolated OBD) shall be evaluated according to the following protocol.

(5.2.1) For all tests conducted under section (i), the MIL shall be illuminated upon detection of the tested system or component malfunction before the end of the emission test specified in (i)(4.2.~~3~~2) in accordance with the malfunction criteria established by the manufacturer under sections (d)(7.1.2) and (d)(7.2.3).

(5.2.2) Except for testing of the catalyst or PM filter system, if the MIL first illuminates after the tested component or system significantly exceeds the applicable malfunction criteria established by the manufacturer, the test engine shall be retested with the tested system or component adjusted so that the MIL will illuminate at the applicable malfunction criteria established by the manufacturer.

(5.2.3) In testing the catalyst or PM filter system, if the MIL first illuminates after the tested component or system significantly exceeds the applicable malfunction criteria established by the manufacturer, the tested engine shall be retested with a less deteriorated catalyst/PM filter system (i.e., more of the applicable engine out pollutants are converted or trapped). For the OBD system to be approved, testing shall be continued until either of the following conditions are satisfied:

(A) The MIL is illuminated and the tested component or system is at the applicable malfunction criteria established by the manufacturer; or

(B) The manufacturer demonstrates that the MIL illuminates within the upper and lower limits of the threshold identified below. The manufacturer shall demonstrate acceptable limits by continuing testing until the test results show:

(i) The MIL is illuminated and monitoring results indicate the tested component or system exceeds the malfunction criteria established by the manufacturer by 10 percent or less of the monitored parameter; and

(ii) The MIL is not illuminated and monitoring results indicate the tested component or system is below the malfunction criteria established by the manufacturer by 10 percent or less of the monitored parameter.

(6) Confirmatory Testing:

(6.1) ARB may perform confirmatory testing to verify the emission test data submitted by the manufacturer under the requirements of section (i) comply with the requirements of section (i) and the malfunction criteria identified in sections (e) through (g). This confirmatory testing is limited to the engine rating represented by the demonstration engine(s).

(6.2) ARB or its designee may install appropriately deteriorated or malfunctioning components (or simulate a deteriorated or malfunctioning component) in an otherwise properly functioning test engine of an engine rating represented by the demonstration test engine(s) in order to test any of the components or systems required to be tested in section (i). Upon request by the Executive Officer, the manufacturer shall make available an engine and all test equipment (e.g., malfunction simulators, deteriorated components) necessary to duplicate the manufacturer’s testing. The Executive Officer shall make the request within six months of reviewing and approving the demonstration test engine data submitted by the manufacturer for the specific engine rating.

(j) Certification Documentation.

(1) When submitting an application for certification of an engine, the manufacturer shall submit the following documentation. If any of the items listed below are standardized for all of a manufacturer’s engines, the manufacturer may, for each model year, submit one set of documents covering the standardized items for all of its engines.

(1.1) For the required documentation not standardized across all engines, the manufacturer may propose to the Executive Officer that it be allowed to submit documentation for certification from one engine that is representative of other engines. The Executive Officer shall approve the engine as representative if the engine possesses the most stringent exhaust emission standards and OBD monitoring requirements and covers all of the emission control devices for the engines covered by the submitted documentation. Upon approval, this grouping shall be known as an "OBD certification documentation group".

(1.2) With Executive Officer approval, one or more of the documentation requirements of section (j) may be waived or modified if the information required would be redundant or unnecessarily burdensome to generate.

(1.3) To the extent possible, the certification documentation shall use SAE J1930 or J2403 terms, abbreviations, and acronyms.

(2) The following information shall be submitted as part of the certification application. Except as provided below for demonstration data, the Executive Officer will not issue an Executive Order certifying the covered engines without the information having been provided. The information must include:

(2.1) A description of the functional operation of the OBD system including a complete written description for each monitoring strategy, including those carried out by a smart device, that outlines every step in the decision-making process of the monitor. Algorithms, diagrams, samples of data, and/or other graphical representations of the monitoring strategy shall be included where necessary to adequately describe the information.

(2.2) A table, in the standardized format detailed in Attachment C of ARB Mail-Out #MSC 09-22.

(2.2.1) The table must include the following information for each monitored component or system (either computer-sensed or -controlled) of the emission control system, including those monitored by a smart device:

(A) Corresponding fault code
(B) Monitoring method or procedure for malfunction detection
(C) Primary malfunction detection parameter and its type of output signal
(D) Fault criteria limits used to evaluate output signal of primary parameter
(E) Other monitored secondary parameters and conditions (in engineering units) necessary for malfunction detection
(F) Monitoring time length and frequency of checks
(G) Criteria for storing fault code
(H) Criteria for illuminating malfunction indicator light
(I) Criteria used for determining out-of-range values and input component rationality ~~checks~~fault diagnostics

(2.2.2) Wherever possible, the table shall use the following engineering units:

(A) Degrees Celsius (°C) for all temperature criteria
(B) KiloPascals (KPa) for all pressure criteria related to manifold or atmospheric pressure
(C) Grams (g) for all intake air mass criteria
(D) Pascals (Pa) for all pressure criteria related to evaporative system vapor pressure
(E) Miles per hour (mph) for all vehicle speed criteria
(F) Relative percent (%) for all relative throttle position criteria (as defined in SAE J1979/J1939)
(G) Voltage (V) for all absolute throttle position criteria (as defined in SAE J1979/J1939)

(H) Milligrams per stroke (mg/stroke) for all fuel quantity-based per ignition event criteria~~ for diesel engines,~~ and per ~~crankshaft revolution~~stroke (/~~rev~~stroke) for all other changes per ignition event based criteria (e.g., airflow in g/~~rev~~ stroke instead of g/~~stroke~~ rev or g/firing) ~~for gasoline and diesel engines~~

(I) Per second (/sec) for all changes per time based criteria (e.g., g/sec)

(J) Percent of nominal tank volume (%) for all fuel tank level criteria

(2.3) A logic flowchart describing the step-by-step evaluation of the enable criteria and malfunction criteria for each monitored emission-related component or system.

(2.4) ~~Emission test data, a~~A description of the testing sequence (e.g., the number and types of malfunction preconditioning cycles) for each tested monitor, the data required to be collected in section (i)(4.3), and a description of the modified or deteriorated components used for fault simulation with respect to the demonstration tests specified in section (i). The manufacturer shall also include a summary of any issues that were found during testing under section (i), including issues where the engine does not meet one or more of the requirements in section 1971.1 (e.g., a monitor does not detect a malfunction before emissions exceed the emission threshold malfunction criteria in section (e) through (g)). The Executive Officer may approve conditional certification of an engine prior to the submittal of this data for ARB review and approval. Factors to be considered by the Executive Officer in approving the late submission of information identified in section (j)(2.4) shall include the reason for the delay in the data collection, the length of time until data will be available, and the demonstrated previous success of the manufacturer in submitting the data prior to certification.

(2.5) For gasoline engines, data supporting the misfire monitor, including:

(2.5.1) The established percentage of misfire that can be tolerated without damaging the catalyst over the full range of engine speed and load conditions.

(2.5.2) Data demonstrating the probability of detection of misfire events of the misfire monitoring system over the full engine speed and load operating range as detailed in ARB Mail-Out #MSC 09-22 for the following misfire patterns: random cylinders misfiring at the malfunction criteria established in section (f)(2.2.2), one cylinder continuously misfiring, and paired cylinders continuously misfiring.

(2.5.3) Data identifying all disablement of misfire monitoring that occurs during the FTP. For every disablement that occurs during the cycles, the data shall identify: when the disablement occurred relative to the driver's trace, the number of engine revolutions that each disablement was present for, and which disable condition documented in the certification application caused the disablement. The number of 1000-revolution intervals completed and the number of 1000-revoluation intervals in which the FTP misfire threshold was exceeded shall also be identified. The data shall be submitted in the standardized format detailed in Attachment A: Misfire Disablement and Detection Chart of ARB Mail-Out #MSC 09-22.

(2.5.4) Manufacturers are not required to use the durability demonstration engine to collect the misfire data for sections (j)(2.5.1) through (2.5.3).

(2.6) For diesel engines subject to the monitoring requirements of section (e)(2.2.2), data supporting the misfire monitor, including:

(2.6.1) Data demonstrating the probability of detection of misfire events of the misfire monitoring system as detailed in ARB Mail-Out #MSC 09-22 over the required engine speed and load operating range for the following misfire patterns: random cylinders misfiring at the malfunction criteria specified in section (e)(2.2.2), one cylinder continuously misfiring, and paired cylinders continuously misfiring.

(2.6.2) Data identifying all disablement of misfire monitoring that occurs during the EPA Urban Dynamometer Driving Schedule for Heavy-Duty Vehicles specified in 40 CFR Part 86, Appendix I (d) as it existed on July 1, 2012, and incorporated by reference herein. For every disablement that occurs during the cycle, the data shall identify: when the disablement occurred relative to the driver's trace, the number of engine revolutions that each disablement was present for, and which disable condition documented in the certification application caused the disablement. The number of 1000-revolution intervals completed and the number of 1000-revoluation intervals in which the misfire threshold was exceeded shall also be identified. The data shall be submitted in the standardized format detailed in Attachment A: Misfire Disablement and Detection Chart of ARB Mail-Out #MSC 09-22. For manufacturers certifying an OBD certification documentation group in accordance with section (j)(1.1), the manufacturer shall provide these data in section (j)(2.6.2) for the representative engine(s).

(2.7) Data supporting the criteria used to detect a malfunction of the fuel system, EGR system, boost pressure control system, catalyst, NOx adsorber, PM filter, cold start emission reduction strategy, secondary air, evaporative system, VVT system, exhaust gas sensors, and other emission controls which causes emissions to exceed the applicable malfunction criteria specified in sections (e), (f), and (g). For diesel engine monitors in sections (e) and (g) that are required to indicate a malfunction before emissions exceed an emission threshold based on any applicable standard (e.g., 1.5 times any of the applicable standards), the information shall also include the test cycle and standard determined by the manufacturer to be the most stringent for each applicable monitor in accordance with section (d)(6.1) and the adjustment factors determined by the manufacturer (including all details of how each adjustment factor was calculated) for each applicable monitor in accordance with section (d)(6.2). For gasoline engine monitors in sections (f) and (g) that are required to indicate a malfunction before emissions exceed an emission threshold based on any applicable standard (e.g., 1.5 times any of the applicable standards) on gasoline engines with emission controls that experience infrequent regeneration events, the information shall also include the adjustment factors determined by the manufacturer (including all details of how each adjustment factor was calculated) for each applicable monitor in accordance with section (d)(6.2).

(2.8) A listing of all electronic powertrain input and output signals (including those not monitored by the OBD system) that identifies which signals are monitored by the OBD system. For input and output signals that are monitored as comprehensive components, the listing shall also identify the specific fault code for each malfunction criteria (e.g., out of range low, out of range high, open circuit, rationality low, rationality high).

(2.9) A written description of all parameters and conditions necessary to begin closed-loop/feedback control of emission control systems (e.g., fuel system, boost pressure, EGR flow, SCR reductant delivery, PM filter regeneration, fuel system pressure).

(2.10) A written identification of the communication protocol utilized by each engine for communication with an SAE J1978/J1939 scan tool.

(2.11) A pictorial representation or written description of the diagnostic connector <u>(including any covers or labels)</u> and its location~~ including any covers or labels~~ <u>representative of every engine covered by the application. The manufacturer may submit one set of information for a group of vehicles whose diagnostic connectors have the same design, orientation, and location.</u>

(2.12) A written description of the method used by the manufacturer to meet the requirements of section (g)(2) for CV system monitoring including diagrams or pictures of valve and/or hose connections.

(2.13) A written description of each AECD utilized by the manufacturer including the sensor signals and/or calculated values used to invoke each AECD, the engineering data and/or analysis demonstrating the need for such an AECD, the actions taken when each AECD is activated, the expected in-use frequency of operation of each AECD, the expected emission impact from each AECD activation, and~~, for diesel engines,~~ the identification of each AECD that has been determined by the manufacturer to be an EI-AECD and the assignment by the manufacturer to the data required to be tracked and reported in the standardized format specified in section (h)(6) (e.g., the AECD of “engine overheat protection as determined by coolant temperature greater than…” is an EI-AECD and is reported as EI-AECD #1 to a generic scan tool).

(2.14) A written description of each NOx and PM NTE deficiency and emission carve-out utilized by the manufacturer including the sensor signals and/or calculated values used to invoke each NTE deficiency or carve-out, the engineering data and/or analysis demonstrating the need for such an NTE deficiency or carve-out, the actions taken when each NTE deficiency or carve-out is activated, the expected in-use frequency of operation of each NTE deficiency or carve-out, and the expected emission impact from each NTE deficiency or carve-out activation.

(2.15) Build specifications provided to engine purchasers or chassis manufacturers detailing all specifications or limitations imposed on the engine purchaser relevant to OBD requirements or emission compliance (e.g., allowable MIL locations, connector location specifications, cooling system heat rejection rates). A description of the method or copies of agreements used to ensure engine purchasers or chassis manufacturers will comply with the OBD and emission relevant build specifications (e.g., signed agreements, required audit/evaluation procedures).

(2.16) A cover letter identifying all concerns and deficiencies applicable to the equivalent previous model year engine, the changes and/or resolution of each concern or deficiency for the current model year engine, <u>a list of modifications to the OBD system that were made as part of a running change</u>

or field fix applied to the previous model year (for this engine or another engine), and all other known issues that apply to the current model year engine (e.g., concerns or deficiencies of another engine that also apply to this engine).

(2.17) A checklist of all the malfunction criteria in sections (e), (f), and (g) and the corresponding diagnostic noted by fault code for each malfunction criterion. The manufacturer shall use ~~T~~the formats of the checklists ~~are~~ detailed in Attachments G and H of ARB Mail-Out #MSC 09-22, July 7, 2009, incorporated by reference.

(2.18) A list of all components/systems required to track and report in-use performance under section (d)(3.2.1), the corresponding diagnostic(s) noted by fault code used to increment the numerator for each component/system, and a description of the incrementing specifications for the in-use monitor performance numerator and denominator for each diagnostic.

(2.19) A list of the test results required to be made available under section (h)(4.5) and the corresponding diagnostic(s) noted by fault code for each test result.

(2.20) A timeline showing the start of engine production and the start of vehicle production for the engine family, and the required deadlines for production engine/vehicle evaluation testing of the standardized requirements (according to section (l)(1.2)), ~~and~~ the monitoring requirements (according to section (l)(2.1)), and in-use monitoring performance requirements (according to section (l)(3)).

(2.21) A statement of compliance indicating that the engine(s) in the application comply with the requirements of section 1971.1, with the exception of issues indicated under section (j)(2.16) if applicable, and indicating that the manufacturer will comply with the required deadlines for submission of results/data for production engine/vehicle evaluation testing under section (l)(1) through (l)(3).

(2.22) A written description of the cold start emission reduction strategy, including a description of all the actions taken while the cold start emission reduction strategy is active and a description of all parameters and conditions necessary to enable and disable the cold strategy emission reduction strategy.

(2.23) For 2024 and subsequent model year diesel engines, data demonstrating the net brake torque reported by the engine dynamometer and the “calculated net brake torque” during the FTP and SET cycles. The manufacturer shall use an engine with no malfunctions on the system (engine, engine emission controls, aftertreatment). Manufacturers shall determine the “calculated net brake torque” using data stream parameters “engine reference torque,” “engine friction – percent torque,” and “actual engine – percent torque,” and the following equation:

“Calculated net brake torque” = (engine reference torque) x [(actual engine – percent torque) – (engine friction – percent torque)]

(2.24) A written description of all parameters and conditions that are technically necessary for each NOx sensor to begin reporting NOx concentration data after engine start and, if technically necessary, all parameters and conditions that cause each NOx sensor to subsequently cease or pause reporting NOx concentration data.

(2.25) For 2024 and subsequent model year diesel engines, data identifying the NOx sensor status (e.g., if the NOx sensor is actively reporting NOx concentration data, not reporting NOx concentration data due to low exhaust temperature, not reporting NOx concentration data due to sensor instability, etc.) for each NOx sensor during the FTP cycle and the SET cycle. The data shall also identify specifically which parameters and conditions documented in the certification application caused the NOx sensor to transition from one status to another (e.g., from not reporting NOx concentration data to actively reporting and from actively reporting to not reporting). The manufacturer shall use an engine with no malfunctions on the system (engine, engine emission controls, aftertreatment).

(2.26) For 2022 and subsequent model year diesel engines, data showing the instantaneous NOx mass emission rate determined using the test facility's instrumentation and the instantaneous NOx mass emission rate determined by the electronic control unit that is responsible for NOx tracking (as required in section (h)(5.3)) during an FTP emissions test as described below. The manufacturer shall use an engine with no malfunctions on the system (engine, engine emission controls, aftertreatment). Data from the electronic control unit must include both engine-out and system-out (i.e., tailpipe) NOx mass emission rates and engine output energy. Data from the test facility must include the engine speed, torque, net brake work, and system-out NOx mass emission rate. The test facility's NOx mass emission rate data must not include a humidity correction. The FTP test must be immediately preceded by a hot or cold-start FTP cycle (i.e., a preparatory FTP cycle) without cycling the ignition in between the two cycles to warm up the engine and ensure that all sensors are reporting NOx data throughout the entire FTP test. All data must be provided over the preparatory FTP cycle and the FTP test~~,~~ at a frequency of at least 1 Hertz in a CSV file. The FTP test data (not the preparatory FTP cycle data) must be summed to show the total values determined by the electronic control unit (engine-out NOx mass, system-out NOx mass, and engine output energy) and the total values determined by the test facility (system-out NOx mass and net brake work). The electronic control unit system-out NOx mass and test facility system-out NOx mass emission rate data must be plotted together in a graph versus time over the preparatory FTP cycle and the FTP test. A manufacturer may alternatively provide these data with vehicle-based testing using the EPA Urban Dynamometer Driving Schedule (UDDS) for Heavy-Duty Vehicles specified in 40 CFR Part 86, Appendix I (d) as it existed on July 1, 2012, and incorporated by reference herein. For this option, the requirements and procedures described above for the engine-dynamometer testing option apply (e.g., the UDDS cycle must be preceded by another UDDS cycle without cycling the ignition in between) with the exception that engine speed, torque, and net brake work data from the test facility may be omitted (the net brake work shall be calculated using OBD system parameters).

(2.27) A description of all inducement strategies, including all inputs to each inducement strategy.

(2.28) For 2024 and subsequent model year engines, a list of comprehensive components that are not OBD monitored due to meeting the criteria under sections (g)(3.1.1) and (3.1.2), and the engineering evaluation analysis or associated data for each component, including all emission data, a description of how the worst case configuration was determined, and test cycles used to stabilize the system and assess the emission impact.

(2.29) A list of electronic powertrain components/systems that are not OBD monitored due to meeting the criteria under section (g)(5.7).

(2.30) A list of monitors that run during conditions that are not encountered during the FTP cycle as allowed under section (d)(3.1.3), and, if applicable, the alternate test cycle during which the monitor runs.

(2.31) For monitors designed to run during the SET cycle under section (d)(3.1.3) on 2024 and subsequent model year engines, the information required under section (d)(3.1.3).

(2.32) For 2022 and subsequent model year engines in vehicles equipped with active technologies, a written description of each technology utilized by the manufacturer including the identification of each technology relative to the data required to be tracked and reported in the standardized format specified in sections (h)(5.4.16) through (h)(5.4.21) (e.g., Active Technology #1 is “haptic-feedback accelerator pedal”), the sensor signals and/or calculated values used to activate each technology (e.g., the tip-in rate of accelerator pedal is greater than a certain value), and the driver action (if any) required to activate the technology (e.g., driver tipped out within 1 second of feedback).

(2.33) For 2022 and subsequent model year engines in vehicles equipped with automatic engine shutdown technologies, start-stop technologies, and waste heat recovery technologies, a written description of the technology, the sensor signals and/or calculated values used to activate the technology (e.g., the temperature of the engine exhaust is greater than a certain value), and the driver action (if any) required to activate the technology (e.g., driver pushes a button).

(2.34) For 2022 and subsequent model year engines, a list of monitors and respective fault codes for malfunctions listed under sections (h)(5.3.6)(B), (h)(5.3.6)(C), (h)(5.7.5), and (h)(5.7.6).

(2.~~21~~35) Any other information determined by the Executive Officer to be necessary to demonstrate compliance with the requirements of this regulation. This includes any of the following:

(2.35.1) Complete software design description documentation, specifications, and source code of the engine control unit and any other on-board electronic powertrain control unit (e.g., transmission control unit, aftertreatment system control unit). The manufacturer shall provide the descriptions and specifications in English.

(2.35.2) A complete list and description of all control unit variables available for real-time display and data logging, as well as all calibration maps, curves, and constants used in the software.

(2.35.3) A data acquisition device with real-time display and data logging capability of any and all control unit variables used in calibration. These variables shall be provided in the same engineering units used during calibration (e.g., the units as documented in the AECD documentation provided to the Executive Officer). The data acquisition device shall include, but may not be limited to, an engineering and calibration tool used during control unit software development and calibration.

(2.35.4) A method to unlock any production or prototype control unit to allow real-time display and data logging of any and all variables used during calibration.

(k) Deficiencies.

(1) The Executive Officer, upon receipt of an application from the manufacturer, may certify OBD systems installed on engines even though the systems do not comply with one or more of the requirements of title 13, CCR section 1971.1. In granting the certification, the Executive Officer shall consider the following factors: the extent to which the requirements of section 1971.1 are satisfied overall based on a review of the engine applications in question, the relative performance of the resultant OBD system compared to systems fully compliant with the requirements of section 1971.1, and a demonstrated good-faith effort on the part of the manufacturer to: (1) meet the requirements in full by evaluating and considering the best available monitoring technology; and (2) come into compliance as expeditiously as possible. The Executive Officer may not grant certification to an engine in which the reported noncompliance for which a deficiency is sought would be subject to ordered recall pursuant to section 1971.5(d)(3)(A).

(2) For 2013 and subsequent model year engines, manufacturers of OBD systems for which deficiencies have been granted are subject to fines pursuant to section 43016 of the California Health and Safety Code. The specified fines apply to: (1) the third and subsequently identified deficiency(ies), ordered according to section (k)(3), and (2) a monitoring system deficiency where a required monitoring strategy is completely absent from the OBD system.

(3) The fines for engines specified in section (k)(2) above shall be as follows below in sections (k)(3.1) and (3.2). ~~are in the amount of $50 per deficiency per engine for non-compliance with any of the monitoring requirements specified in sections (e), (f), and (g)(4), and $25 per deficiency per engine for non-compliance with any other requirement of section 1971,1. In determining the identified order of deficiencies, deficiencies subject to a $50 fine are identified first. Total fines per engine under section (k) may not exceed $500 per engine and~~ Fines are payable to the State Treasurer for deposit in the Air Pollution Control Fund. Except as provided below, a manufacturer shall submit the fines payment not more than 30 calendar days after the close of a calendar quarter. Within 30 days from the end of the calendar quarter, a manufacturer shall report the number of affected engines produced for sale in California during the quarter and submit the total payment for the engines produced for sale during that quarter. A manufacturer may request Executive Officer approval for an alternate payment schedule in lieu of the schedule described above. Executive Officer approval shall be based on the projected sales volume of the entire manufacturer product line, and the appropriateness and effectiveness of the schedule in paying the total fines in a timely manner.

(3.1) For 2010 through 2023 model year engines, the fines are in the amount of $50 per deficiency per engine for non-compliance with any of the monitoring requirements specified in sections (e), (f), and (g)(4), and $25 per deficiency per engine for non-compliance with any other requirement of section 1971.1. In determining the identified order of deficiencies, deficiencies subject to a $50 fine are identified first. Total fines per engine under section (k) may not exceed $500 per engine.

(3.2) For 2024 and subsequent model year engines, except as provided below in section (k)(3.2.1), the fines are in the amount of $100 per deficiency per engine for non-compliance with any of the monitoring requirements specified in sections (e), (f), and (g)(4), and $50 per deficiency per engine for non-compliance with any other requirement of section 1971.1. In determining the identified order of deficiencies, deficiencies specified under section (k)(3.2.1) (except for two Emission Threshold 1 (ET1) deficiencies during the first model year the deficiencies are applied and one ET1 deficiency during the second model year the deficiency is applied) shall not be included, and deficiencies subject to $100 are identified first. Total fines per engine under section (k) may not exceed $600 per engine for 2024 model year engines, $800 per engine for 2025 model year engines, $1000 per engine for 2026 model year engines, and $1250 per engine for 2027 and subsequent model year engines.

(3.2.1) For deficiencies regarding monitors not detecting a malfunction before emissions exceeded the malfunction criteria defined in sections (e) through (g), the fines are in the amount described in Table 1 below. Except for two ET1 deficiencies during the first model year the deficiencies are applied and one ET1 deficiency during the second model year the deficiency is applied, the deficiencies shall not be included in the count of deficiencies used in (k)(2) to determine the number of deficiencies subject to fines.

Table 1

		Applicable Model Year (MY) for Deficiency			
Deficiency Type	**Threshold Exceedance (% of malfunction criteria)**	**1st MY**	**2nd MY (1 MY carryover)**	**3rd MY (2 MY carryover)**	**4th MY (3 MY carryover)**
ET1	100 - 120	Free for 2 ET1, $100 for all other ET1	Free for 1 ET1, $100 for all other ET1	$150	$200
ET2	121-150	$200	$200	$250	$300
ET3	151-200	$300	$300	$350	$400

(4) Manufacturers must re-apply for Executive Officer approval of a deficiency each model year. In considering the request to carry-over a deficiency, the Executive Officer shall consider the factors identified in section (k)(1) including the manufacturer's progress towards correcting the deficiency. Except as provided for in sections (k)(4.1) and (k)(4.2) below, the Executive Officer may not allow manufacturers to carry over monitoring system deficiencies for more than two model years unless ~~it~~ the manufacturer can ~~be~~ demonstrate~~d~~ that substantial engine hardware modifications and additional lead time beyond two years would

be necessary to correct the deficiency, in which case the Executive Officer shall allow the deficiency to be carried over for three model years (e.g., if the deficiency was first certified in the 2013 model year, the deficiency may be carried over up to and including the 2016 model year).

(4.1) For deficiencies first granted in the 2010 model year, the Executive Officer may allow manufacturers to carry over the deficiency into the 2013 model year unless it can be demonstrated that substantial engine hardware modifications and additional lead time beyond the 2013 model year would be necessary to correct the deficiency, in which case the Executive Officer shall allow the deficiency to be carried over into the 2014 model year.

(4.2) For deficiencies first granted in the 2011 model year, the Executive Officer may allow manufacturers to carry over the deficiency into the 2014 model year.

(4.3) For a given engine family, for monitors in section (e) or (f) that are required to indicate a malfunction before emissions exceed an interim emission threshold(s) during specified interim model years and a final emission threshold(s) starting in a later model year (e.g., a monitor that is required to detect a malfunction before emissions exceed 3.0 times the applicable standards during the 2015 through 2017 model years and before emissions exceed 1.5 times the applicable standards during the 2018 and subsequent model years), a deficiency for a monitor that does not meet the required emission threshold in a specific model year is considered a new and different deficiency in another model year when the required emission threshold is different. For example, for a monitor that is required to detect a malfunction before emissions exceed 3.0 times the applicable standards during the 2015 through 2017 model years and before emissions exceed 1.5 times the applicable standards during the 2018 and subsequent model years, a deficiency granted during the 2015 through 2017 model years is separate from a deficiency granted during the 2018 and subsequent model years.

(5) Except as allowed in section (k)(6), deficiencies may not be retroactively granted after certification.

(6) Request for retroactive deficiencies

(6.1) ~~During either the first 6 months after commencement of the start of engine production or the first 6 months after commencement of the start of vehicle production, whichever is later,~~ Up until the date specified in section (k)(6.1.1) below, manufacturers may request that the Executive Officer grant a deficiency and amend an engine's certification to conform to the granting of the deficiencies for each aspect of the monitoring system: (a) identified by the manufacturer (during testing required by section (l)(2) or any other testing) to be functioning different than the certified system or otherwise not meeting the requirements of any aspect of section 1971.1; and (b) reported to the Executive Officer. If the Executive Officer grants the deficiency(ies) and amends the certification, the approval would be retroactive to include all affected engines within the engine family and model year.

(6.1.1) The manufacturer may request a retroactive deficiency until either of the following dates, whichever is later:

(A) When the last affected engine or vehicle is produced, or on December 31 of the calendar year for which the model year is named, whichever is sooner; or

(B) 6 months after commencement of the start of engine production or vehicle production, whichever is later.

(6.2) Executive Officer approval of the request for a retroactive deficiency shall be granted provided that the conditions necessary for a pre-certification deficiency determination are satisfied (see section (k)(1)) and the manufacturer could not have reasonably anticipated the identified problem before commencement of production.

(6.3) In granting the amended certification, the Executive Officer shall include any approved post-production deficiencies together with all previously approved deficiencies in computing fines in accordance with section (k)(2).

(7) For 2013 through 2015 model year engines that utilize PM sensors for PM filter filtering performance monitoring (section (e)(8.2.1)), in cases where the deficiency is for a monitor required to detect malfunctions of the PM filter filtering performance (section (e)(8.2.1)), the PM sensor (section (e)(9.2.2)), or the PM sensor heater (section (e)(9.2.4)), the deficiency shall be exempt from the specified fines of section (k)(3) and the deficiency shall not be included in the count of deficiencies used in (k)(2) to determine the number of deficiencies subject to fines.

(8) For hybrid vehicles:

(8.1) For 2014 model year hybrid vehicles previously certified with deficiencies for the 2013 model year, the 2014 model year shall be considered the first model year for the deficiency with regards to the carry-over provisions in section (k)(4).

(8.2) For deficiencies related to issues with the implementation of the hybrid system or of the hybrid system itself on 2013 through 2015 model year engines, two additional deficiencies shall be exempt from the specified fines of section (k)(3) and the deficiencies shall not be included in the count of deficiencies used in (k)(2) to determine the number of deficiencies subject to fines.

(9) For deficiencies related to issues with the tracking requirements in sections (h)(5.3) through (h)(5.7) on 2022 and 2023 model year engines, two of these deficiencies shall be exempt from the specified fines of section (k)(3) and shall not be included in the count of deficiencies in section (k)(2) to determine the number of deficiencies subject to fines.

(~~9~~10) An~~y~~ OBD system installed on a production engine/vehicle that fails to conform with the certified OBD system for that engine/vehicle or otherwise fails to meet the requirements of section 1971.1 and has not been granted a deficiency pursuant to the provisions of section (k)(1) through (k)(6) ~~are~~ is considered ~~non-compliant~~a nonconforming OBD system subject to enforcement. Additionally, for OBD systems granted with a deficiency, if during testing under title 13, CCR section 1971.5(b), 1971.5(c), or any other testing it is confirmed that the details of the noncompliance for which the deficiency was granted are not the same as those disclosed by the manufacturer at the time the deficiency was granted, the OBD system shall be considered a nonconforming OBD system subject to enforcement. The engines/vehicles are subject to enforcement pursuant to applicable provisions of the Health and Safety Code and title 13, CCR section 1971.5.

(l) *Production Engine/Vehicle Evaluation Testing.*

(1) Verification of Standardized Requirements.

(1.1) Requirement: Manufacturers shall perform testing to verify that 2013 and subsequent model year production engines installed in vehicles meet the requirements of section (h)(3) and (h)(4) relevant to proper communication of required emission-related messages to an SAE J1978/J1939 scan tool.

(1.2) Selection of Test Vehicles:

(1.2.1) Engine manufacturers shall perform this testing every model year on ten unique production vehicles (i.e., engine rating and chassis application combination) per engine family. If there are less than ten unique production vehicles for a certain engine family, the manufacturer shall test each unique production vehicle in that engine family. Manufacturers shall perform this testing no later than either three months after the start of engine production or one month after the start of vehicle production, whichever is later. Manufacturers may request Executive Officer approval to group multiple production vehicles together and test one representative vehicle per group. The Executive Officer shall approve the request upon finding that the software and hardware designed to comply with the standardization requirements of section (h) (e.g., communication protocol message timing, number of supported data stream parameters, engine and vehicle communication network architecture) in the representative vehicle are identical to all others in the group and that any differences in the production vehicles are not relevant with respect to meeting the criteria in section (l)(1.4).

(1.2.2) For 2016 and subsequent model year engines, the Executive Officer shall reduce the maximum required number of vehicles to be tested from ten per engine family to five per engine family for a manufacturer based on the demonstrated previous success of the manufacturer to meet the requirements of section (l)(1). For purposes of this requirement, a manufacturer shall be determined to be successful in meeting the requirements of section (l)(1) if zero vehicles fail the testing required by section (l)(1) for two consecutive years.

(1.2.3) For 2019 and subsequent model year engines, the Executive Officer shall further reduce the maximum required number of vehicles to be tested to three per engine family for a manufacturer based on the demonstrated previous success of the manufacturer to meet the requirements of section (l)(1). For purposes of this requirement, a manufacturer shall be determined to be successful in meeting the requirements of section (l)(1) if zero vehicles fail the testing required by section (l)(1) for three consecutive years.

(1.2.4) The Executive Officer may waive the requirement for submittal of data from one or more of the production vehicles if data have been previously submitted for all of the production vehicles. Manufacturers may request Executive Officer approval to carry over data collected in previous model years. The Executive Officer shall approve the request upon finding that the software and hardware designed to comply with the standardization requirements of section (h) are identical to the previous model year and no other hardware or software changes that affect compliance with the standardization requirements have been made.

(1.3) Test Equipment: For the testing required in section (l)(1), manufacturers shall utilize an off-board device to conduct the testing. Prior to conducting testing, manufacturers are required to request and receive Executive Officer approval of the off-board device that the manufacturer will use to perform the testing.

(1.3.1) For vehicles using the ISO 15765-4 protocol for the standardized functions required in section (h), the Executive Officer shall approve the request upon determining that the manufacturer has submitted data, specifications, and/or engineering analysis that demonstrate that the off-board device meets the minimum requirements to conduct testing according to SAE J1699-3 using the software developed and maintained for the SAE J1699-3 committee and available through www.sourceforge.net and SAE J2534-1 compliant hardware configured specifically for SAE J1699-3 testing.

(1.3.2) For vehicles using the SAE J1939 protocol for the standardized functions required in section (h), the Executive Officer shall approve the request upon determining that the manufacturer has submitted data, specifications, and/or engineering analysis that demonstrate that the off-board device meets the minimum requirements to conduct testing according to SAE J1939/84 using the software developed and maintained for the SAE J1939/84 committee and available through www.sourceforge.net and SAE J2534-1 compliant hardware configured for SAE J1939/84 testing ~~is able to verify that vehicles tested are able to perform all of the required functions in section (l)(1.4) with any other off-board device designed and built in accordance with the SAE J1978/J1939 generic scan tool specifications~~.

(1.4) Required Testing:

(1.4.1) The testing shall verify that communication can be properly established between all emission-related on-board computers and any SAE J1978/J1939 scan tool designed to adhere strictly to the communication protocols allowed in section (h)(3);

(1.4.2) The testing shall verify that all emission-related information is properly communicated between all emission-related on-board computers and any SAE J1978/J1939 scan tool in accordance with the requirements of section (h) and the applicable ISO and SAE specifications including specifications for physical layer, network layer, message structure, and message content.

(1.4.3) The testing shall further verify that the following information can be properly communicated to any SAE J1978/J1939 scan tool:

(A) The current readiness status from all on-board computers required to support readiness status in accordance with SAE J1979/J1939-73 and section (h)(4.1) in the key on, engine off position and while the engine is running;

(B) The MIL command status while the MIL is commanded off and while the MIL is commanded on in accordance with SAE J1979/J1939 and section (h)(4.2) in the key on, engine off position and while the engine is running, and in accordance with SAE J1979/J1939 and sections (d)(2.1.2) during the MIL functional check and, if applicable, (h)(4.1.6) during the MIL readiness status check while the engine is off;

(C) All data stream parameters required in section (h)(4.2) in accordance with SAE J1979/J1939 including, if applicable, the proper identification of each data stream parameter as supported in SAE J1979/J1939 (e.g., Mode/Service $01, PID $00 or SAE J1939/73 Diagnostic Message 24);

(D) The CAL ID, CVN, ESN, ~~and~~ VIN, and ECU Name in accordance with SAE J1979/J1939 and sections (h)(4.6) through (4.8);

(E) An emission-related fault code (permanent, confirmed, pending, MIL-on, and previously MIL-on) in accordance with SAE J1979/J1939-73 (including correctly indicating the number of stored fault codes and MIL command status (e.g., Mode/Service $01, PID $01, Data A for SAE J1979 or J1939/73 Diagnostic Message 1)) and section (h)(4.4) for each diagnostic and emission critical electronic powertrain control unit;

(1.4.4) The testing shall also verify that the on-board computer(s) can properly respond to any SAE J1978/J1939 scan tool request to clear emission-related fault codes and reset readiness status in accordance with section (h)(4.10).

(1.5) Reporting of Results:

(1.5.1) The manufacturer shall submit to the Executive Officer the following, based on the results of testing:

(A) If a variant meets all the requirements of section (l)(1.4), the test results (i.e., the test log file) and a statement specifying that the variant passed all the tests, or

(B) If any variant does not meet the requirements of section (l)(1.4), a written report to the Executive Officer for approval within one month of testing the specific variant. The written report shall include the problem(s) identified and the manufacturer's proposed corrective action (if any) to remedy the problem(s). Factors to be considered by the Executive Officer in approving the proposed corrective action shall include the severity of the problem(s), the ability of the vehicle to be tested in a California inspection program (e.g., roadside inspection, fleet self-inspection program), the ability of service technicians to access the required diagnostic information, the impact on equipment and tool manufacturers, and the amount of time prior to implementation of the proposed corrective action.

(1.5.2) Upon request of the Executive Officer, a manufacturer shall submit a report of the results of any testing conducted pursuant to section (l)(1) to the Executive Officer for review.

(1.5.3) In accordance with section (k)(6), manufacturers may request Executive Officer approval for a retroactive deficiency to be granted for items identified during this testing.

(1.6) Alternative Testing Protocols. Manufacturers may request Executive Officer approval to use other testing protocols. The Executive Officer shall approve the protocol if the manufacturer can demonstrate that the alternate testing methods and equipment provide an equivalent level of verification of compliance with the standardized requirements to the requirements of section (l)(1).

(2) Verification of Monitoring Requirements.

(2.1) No later than either six months after the start of engine production or six months after the start of vehicle production, whichever is later, manufacturers shall conduct a complete evaluation of the OBD system of one or more production vehicles (test vehicles) and submit the results of the evaluation to the Executive Officer.

(2.2) Selection of test vehicles:

(2.2.1) For each engine selected for monitoring system demonstration in section (~~j~~i), the manufacturer shall evaluate one production vehicle equipped with an engine from the same engine family and rating as the demonstration engine. The Executive Officer shall select the specific production vehicle(s) to be tested.

(2.2.2) A manufacturer required to test more than one test vehicle may test an engine in lieu of a vehicle for all but one of the required test vehicles. For the purposes of testing under section (l)(2.3), manufacturers may choose to distribute the tests over more than one vehicle, provided the additional vehicle(s) is identical to the test vehicle selected under section (l)(2.2.1) with respect to the emission control system hardware and OBD system calibrations.

(2.2.3) The Executive Officer may waive the requirements for submittal of evaluation results from one or more of the test vehicles if data have been previously submitted for all of the engine ratings and variants.

(2.3) Evaluation requirements:

(2.3.1) The evaluation shall demonstrate the ability of the OBD system on the selected production vehicle to detect a malfunction, illuminate the MIL, and, where applicable, store an appropriate fault code (confirmed and permanent fault codes) readable by a scan tool conforming to SAE J1978/J1939 when a malfunction is present and the monitoring conditions have been satisfied for each individual diagnostic required by title 13, CCR section 1971.1. During testing under section (l)(2), the manufacturer shall also verify the ability of the OBD system to erase permanent fault codes stored during testing for each unique pathway within the software that manages the erasing of permanent fault codes.

(2.3.2) The evaluation shall verify that malfunctions detected by non-MIL illuminating diagnostics of components used to enable any other OBD system diagnostic (e.g., fuel level sensor) will not inhibit the ability of other OBD system diagnostics to properly detect malfunctions.

(2.3.3) The evaluation shall verify that the software used to track the numerator and denominator for purposes of determining in-use monitoring frequency correctly increments as required in section (d)(4), and shall verify that the readiness status correctly sets to "complete" as required in section (h)(4.1). These shall be verified using the "dynamic" testing portion of SAE J1699-3 and available at www.sourceforge.net for SAE J1979 compliant engines or the software described in SAE J3162 for SAE J1939 compliant engines and available at https://github.com/Equipment-and-Tool-Institute/iumpr.

(2.3.4) Malfunctions may be mechanically implanted or electronically simulated but internal on-board computer hardware or software changes may not be used to simulate malfunctions. For monitors that are required to indicate a malfunction before emissions exceed an emission threshold based on any applicable standard (e.g., 2.0 times any of the applicable standards), manufacturers are not required to use malfunctioning components/systems set exactly at their malfunction criteria limits. Emission testing to confirm that the malfunction is detected before the appropriate emission threshold malfunction criteria (e.g., 2.0 times the standard) are exceeded is not required.

(2.3.5) Manufacturers shall submit a proposed test plan for Executive Officer approval prior to evaluation testing being performed. The test plan shall identify the method used to induce a malfunction for each diagnostic, include the permanent fault code storage/erasure test procedure, and include (if applicable) the 10 additional monitors required to be tested under section (l)(2.3.7) below. ~~If t~~The Executive Officer shall approve the plan upon determining~~es~~ that the requirements of section (l)(2) are satisfied, and that the permanent fault code storage/erasure test procedure meets the following: ~~the proposed test plan shall be approved~~.

(A) The procedure provides comprehensive testing coverage of at least one of each of the different “types” of monitors (fault codes) in each diagnostic or emission critical electronic control unit (e.g., monitors subject to the minimum ratio requirements of section (d)(3.2), monitors not subject to the minimum ratio requirements of section (d)(3.2), monitors that utilize an alternate MIL statistical MIL illumination and fault code storage protocol),

(B) The procedure provides comprehensive testing coverage of every different permanent fault code erasure protocol (e.g., “natural” erasure without a clearing of the fault information in the on-board computer, erasure after a battery disconnect, erasure after a scan tool code clear command, erasure after a reprogramming event),

(C) For diagnostics and permanent fault code erasure protocols covered under section (d)(2.3.1)(C)(ii)b. or (d)(2.3.2)(D)(ii)b. (e.g., erasure after a battery disconnect, erasure after a scan tool code clear command), the procedure verifies that the permanent fault code is not erased if the diagnostic determines the respective component/system is not malfunctioning but the criteria described under section (d)(2.3.1)(C)(ii)b.3. or (d)(2.3.2)(D)(ii)b.3. are not met,

(D) The procedure verifies that after a scan tool code clear command, all monitors can fully execute and determine that the respective components or systems are not malfunctioning, and

(E) The last procedure performed on a vehicle during testing under section (l)(2) verifies that any remaining permanent fault code(s) stored as a result of the previous tests is erased without requiring reprogramming of the diagnostic or emission critical electronic control unit (i.e., erased through “natural” erasure).

(2.3.6) Subject to Executive Officer approval, manufacturers may omit demonstration of specific diagnostics. The Executive Officer shall approve a manufacturer's request if the demonstration cannot be reasonably performed without causing physical damage to the vehicle (e.g., on-board computer internal circuit faults) or jeopardizing the safety of personnel performing the demonstration.

(2.3.7) For evaluation of test vehicles selected in accordance with section (l)(2.2), except as provided below, manufacturers are not required to demonstrate diagnostics that were previously demonstrated prior to certification as required in section (i). For evaluation of test vehicles with 2024 and subsequent model year engines from the same engine family and rating as the demonstration engines selected under section (i), manufacturers shall additionally test 10 diagnostics in accordance to section (l)(2) that were previously demonstrated prior to certification as required in section (i). The manufacturer shall propose for Executive Officer approval the 10 diagnostics to test. The Executive Officer shall approve the monitors upon determining that the manufacturer has provided data that demonstrate that the selected diagnostics have the lowest in-use monitor performance ratios of all the diagnostics demonstrated under section (i).

(2.4) Manufacturers shall submit a report of the results of all testing conducted pursuant to section (l)(2) to the Executive Officer for review. This report shall identify the method used to induce a malfunction in each diagnostic, the MIL illumination status, and the fault code(s) stored. The report shall also include a summary of any problems identified during testing (e.g., a monitor that is unable to detect a fault, a monitor that is unable to store a fault code or illuminate the MIL when a fault is detected).

(2.5) In accordance with section (k)(6), manufacturers may request Executive Officer approval for a retroactive deficiency to be granted for items identified during this testing.

(3) Verification and Reporting of In-use Monitoring Performance.

(3.1) Manufacturers are required to collect and report in-use monitoring performance data representative of production vehicles (i.e., engine rating and chassis application combination). Manufacturers shall collect and report the data to ARB ~~within~~ no later than twelve months after the production vehicles were first introduced into commerce. Additionally, for 2022 and subsequent model year engines, manufacturers are required to collect and report data specified under section (l)(3.4.1) below.

(3.2) Manufacturers shall separate production vehicles into monitoring performance groups, as defined by sections (l)(3.2.1) and (3.2.2) below, and submit data representative of each group:

(3.2.1) Emission architecture. Engines shall be separated by emission architecture. All engines that use the same or similar emission control architecture and monitoring system shall be in the same emission architecture category.

(3.2.2) Monitoring performance group. Within an emission architecture category, engines shall be separated by vehicle application. The separate monitoring performance groups shall be based on three classifications: engines intended primarily for line-haul chassis applications, engines intended primarily for urban delivery chassis applications, and all other engines. The Executive Officer may determine that the manufacturer is required to submit data representative of a subgroup of the monitoring performance group. The Executive Officer shall make this determination based on information indicating that the subgroup of vehicles differs from other vehicles in the monitoring performance group and that a reasonable basis exists to believe that the differences may directly impact the data submitted.

(3.3) Manufacturers may request Executive Officer approval to use an alternate grouping method to collect representative data. Executive Officer approval shall be granted upon determining that the proposed groupings include production vehicles using similar emission controls, OBD strategies, monitoring condition calibrations, and vehicle application driving/usage patterns such that they are expected to have similar in-use monitoring performance. If approved by the Executive Officer, the manufacturer may submit one set of data for each of the approved groupings.

(3.4) For each group, the data must include all of the in-use performance tracking data reported through SAE J1979/J1939 (i.e., all numerators, denominators, the general denominator, and the ignition cycle counter), the engine model year, the engine manufacturer, the engine family, the engine serial number, the engine HP rating (for diesels), the engine torque rating (for diesels), the date the data were collected, the chassis odometer reading, the vehicle/chassis VIN, the monitoring performance group, ~~and~~ the ECM software calibration identification number, and the distance traveled and be in the standardized format detailed in Attachments D and E of ARB Mail-Out #MSC 09-22. The manufacturer shall also submit a report that includes a summary of any problems identified in the data (e.g., a monitor where the average in-use monitor performance ratio is less than the minimum acceptable ratio under section (d)(3.2.2)).

(3.4.1) For 2022 and subsequent model year engines on vehicles from which the manufacturer collects and reports in-use monitoring performance data under section (l)(3), the manufacturer shall also collect the data specified in sections (h)(4.1) through (h)(4.9) and (h)(5), as applicable.

(3.5) Manufacturers shall submit a plan to the Executive Officer for review and approval that details the types of production vehicles in each group, the number of vehicles per group to be sampled, the sampling method, the time line to collect the data, and the reporting format. The Executive Officer shall approve the plan upon determining that it provides for effective collection of data from a sample of vehicles that, at a minimum, is fifteen vehicles per group, will likely result in the collection and submittal of data within the required time frame, will generate data that are representative of California drivers and temperatures, and does not, by design, exclude or include specific vehicles in an attempt to collect data only from vehicles with the highest in-use performance ratios.

(3.6) Upon request of the manufacturer, the Executive Officer may for good cause extend the twelve month time requirement set forth in section (l)(3.1) up to a maximum of eighteen months. In granting additional time, the Executive Officer shall consider, among other things, information submitted by the manufacturer to justify the delay, sales volume of the group(s), and the sampling mechanism utilized by the manufacturer to procure vehicles for data collection. If an extension beyond twelve months is granted, the manufacturer shall additionally be required to submit an interim report within twelve months for data collected up to the time of the interim report.

(4) Verification of In-Use Compliance

(4.1) As a condition for certification, manufacturers are required to perform compliance testing on in-use engines as specified in California Code of Regulations, title 13, section 1971.5(c).

(m) *Running Changes and Field Fixes.*

(1) For purposes of section (m), the following terminology shall be defined as follows:

(1.1) "Running change/field fix document" refers to a document indicating notification of a running change and/or field fix for an engine family. The manufacturer may group more than 1 running change and/or field fix notification into one running change/field fix document. Each running change/field fix document shall include the following:

(1.1.1) A detailed description of the change,

(1.1.2) The reason for the change,

(1.1.3) The portion of the product line that is affected by the change, including information sufficient to identify any given in-use engine that includes or will include the change (i.e., in-use engines that have received or will receive the field fix),

(1.1.4) The effect the change will have on emissions and/or OBD system performance (including if it has no effect); if the running change or field fix affects emissions (e.g., increase or decrease in emission levels at which monitor detects a fault) and/or monitoring capability, the manufacturer is required to specify the details of the effect to the Executive Officer in the cover letter,

(1.1.5) Any test data determined to be necessary to demonstrate compliance with the requirements of title 13, CCR section 1971.1, and

(1.1.6) A summary report for each engine family that describes all running changes and/or field fixes that have been incorporated since certification.

(1.1.7) Copies of all service manuals, technical service bulletins and instructions regarding the use, repair, adjustment, maintenance, or testing of such vehicles relevant to the emission control system, OBD system, as applicable, issued by the manufacturer (in written or electronic form) for use by other manufacturers, assembly plants, distributors, dealers, and ultimate purchasers. These shall be submitted to the Executive Officer when they are made available to the public and must be updated as appropriate throughout the useful life of the corresponding vehicles. For the service manual, the manufacturer shall include only the portions of the manual that were changed due to the running change or field fix, with details highlighting what specifically has been changed. If no changes were made to the service manual due to the running change or field fix, the manufacturer is not required to include the specific service manual as part of the running change/field fix document.

(1.2) "Running change/field fix submission date" refers to the date the manufacturer submitted the running change/field fix document to the

Executive Officer.

(1.3) "Running change/field fix notification" refers to a document indicating a notification of intent to implement a running change and/or a field fix. The running change/field fix notification shall include a general description of the modifications to the system but is not required to include all the information listed under sections (m)(1.1.1) through (m)(1.1.7).

(2) Submission Schedule: The manufacturer shall submit either the running change/field fix document or the running change/field fix notification for an engine family prior to or concurrently with implementing the running change or field fix.

(2.1) Running change/field fix document:

(2.1.1) The manufacturer may not submit to the Executive Officer a running change/field fix document for an engine family within 30 calendar days of the issue date of the OBD system approval for the engine family.

(2.1.2) For an engine family, the manufacturer may not submit to the Executive Officer more than 1 running change/field fix document within a 30-calendar-day period.

(2.2) Running change/field fix notification: In lieu of submitting a running change/field fix document concurrently with implementing a running change or field fix, the manufacturer may submit a running change/field fix notification to the Executive Officer concurrently with implementing a running change or field fix. A manufacturer may submit up to a maximum of one notification per day provided it includes all modifications for the day. If the manufacturer submits a running change/field fix notification, the manufacturer is required to submit the running change/field fix document including that running change and/or field fix according to the submission schedule in section (m)(2.1).

(3) Review Process

(3.1) If the Executive Officer has not requested additional information and/or test data from the manufacturer and has not rejected the running change or field fix within 30 calendar days after the running change/field fix submission date, and if the running change or field fix would not be subject to ordered recall pursuant to title 13, CCR section 1971.5(d)(3)(A), the running change or field fix is deemed "approved".

(3.1.1) After the 30 calendar days and "approved" designation referenced in section (m)(3.1), the Executive Officer may still request additional information and/or test data regarding the running change or field fix and request further modifications to the running change or field fix submission if the running change or field fix does not fulfill the requirements of section 1971.1.

(3.2) If the Executive Officer requests additional information and/or test data regarding a running change or field fix, the manufacturer must provide the information/data within 30 calendar days of the request or the manufacturer must rescind the running change or field fix immediately. The manufacturer may request Executive Officer approval for additional time to obtain the information/data, provided that the time requested does not exceed 60 calendar days from the date the Executive Officer requested the information/data.

(3.3) The Executive Officer shall use the following criteria to approve or reject the running change or field fix based on review of the running change/field fix document, additional information, test data, or any other information:

(3.3.1) If the Executive Officer determines the engines affected by the change fulfill the requirements of section 1971.1 (including changes that would qualify for a deficiency under section (k)), the Executive Officer shall approve the running change or field fix and notify the manufacturer in writing.

(3.3.2) If the Executive Officer determines the engines affected by the change(s) do not fulfill the requirements of section 1971.1, the Executive Officer shall reject the running change or field fix and notify the manufacturer to rescind the change immediately.

(3.3.3) A running change or field fix that would be subject to ordered recall pursuant to title 13, CCR section 1971.5(d)(3)(A) shall be rejected by the Executive Officer.

(3.4) The decision to manufacture engines under this section will be deemed consent to recall all engines that do not fulfill the requirements of section 1971.1; such nonconformity shall be remedied at no expense to the owner. If the Executive Officer rejects the running change or field fix, the manufacturer shall stop implementation of the running change on the production line and shall recall the engines already manufactured with the running change or field fix and rescind the running change or field fix.

NOTE: Authority cited: Sections 39010, 39600, 39601, 39602.5, 43000.5, 43013, ~~43016,~~ 43018, 43100, 43101, 43104, 43105, 43105.5, 43106, 43154, 43211, and 43212, Health and Safety Code. Reference: Sections 39002, 39003, 39010, 39018, 39021.5, 39024, 39024.5, 39027, 39027.3, 39028, 39029, 39031, 39032, 39032.5, 39033, 39035, 39037.05, 39037.5, 39038, 39039, 39040, 39042, 39042.5, 39046, 39047, 39053, 39054, 39058, 39059, 39060, 39515, 39600, 39601, 39602.5, 43000, 43000.5, 43004, 43006, 43013, 43016, 43018, 43100, 43101, 43102, 43104, 43105, 43105.5, 43106, 43150, 43151, 43152, 43153, 43154, 43155, 43156, 43204, 43211, and 43212, Health and Safety Code.