Transitioning Away from Smog Check Tailpipe Emission Testing in California for OBD II Equipped Vehicles

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Executive Summary

California's Smog Check program currently includes two overlapping inspection procedures for 1996 and newer model year vehicles. Each vehicle is subjected to a tailpipe emission test and also to an inspection of its On-Board Diagnostic II (OBD II) system, which independently monitors the performance of the vehicle's emission control systems and related components during everyday driving. The USEPA and state authorities have generally found that OBD II systems are more effective in detecting emission-related malfunctions on in-use vehicles compared to existing Inspection and Maintenance (I/M) tailpipe testing procedures. Current Smog Check data indicates that vehicles are more than twice as likely to fail an OBD II-based inspection than the required tailpipe emissions test. Nearly every state besides California that has an I/M program currently relies exclusively on vehicle OBD II system inspections as the basis for its emission inspections of 1996 and newer vehicles.

Available data and information indicate that Smog Check tailpipe testing of OBD II equipped vehicles significantly increases testing costs and inconvenience to California motorists, but provides only minimal emission benefits that are above and beyond those that can be realized through OBD II-based inspections. The procedure for conducting an OBD-based inspection can be completed in 5 minutes or less, compared to 20 minutes for a tailpipe test, and the equipment required for the inspection can be purchased for as little as 10% of the cost for the analyzer and dynamometer needed for tailpipe testing.

However, because the use of a second independent inspection procedure will almost always lead to higher overall failure rates, relatively minor emission benefits would likely be lost by eliminating tailpipe testing for all or a strategic subset of OBD II equipped vehicles in California. ARB staff has analyzed available data to quantify any such losses. Emission estimates were prepared for calendar years 2010, 2015, and 2020 to show how the emission impact will change as the percentage of the fleet that is OBD II equipped continues to increase. The analysis indicates that in the most likely implementation scenario, which excludes the early model years of OBD II implementation where some OBD systems on some vehicles were not fully operational, emission losses would amount to no more than approximately one ton per day of hydrocarbons (HC) and oxides of nitrogen (NOx), statewide in 2020, which is less than one-half of one percent of the total program benefits. Losses would be lower in earlier calendar years.

Corresponding cost savings to California motorists would be achieved as reduced testing times and equipment costs translate into lower inspection prices. Although prices are ultimately dependent on market forces, ARB staff estimates that cost reductions between $15 and $35 per test would occur, resulting in cumulative cost savings between $60 million and $350 million per year. Even at the most conservative ends of the estimates, the cost effectiveness of continuing tailpipe emission testing is estimated at more than $120,000 per ton of HC+NOx reduced, which is on the order of ten times higher than commonly accepted cost effectiveness thresholds for motor vehicle emission control measures. Therefore, the data indicate that relying solely on an OBD II-based inspection for newer model year vehicles would greatly increase the efficiency of the

Smog Check program and reduce its cost without jeopardizing attainment of California's air quality goals.

Moving forward with an OBD-based inspection strategy would require legislative changes to California's Health and Safety Code because current law specifically requires tailpipe testing to be a part of the Smog Check inspection process for gasoline powered vehicles. As with any inspection procedure, once authorized, safeguards to ensure that inspections are carried out accurately and completely are necessary to ensure the effectiveness of the program. Current experience with OBD II-based inspections indicates that further enhancements to existing safeguards are important to minimize any potential for lost emission reductions as the result of discontinuing tailpipe testing. These enhancements include increasing protections against the clearing of OBD II-detected fault information and the use of surrogate vehicle information to circumvent the inspection process.

For pre-1996 model year vehicles, some form of tailpipe testing will need to continue, as it is the best inspection tool available for that portion of the vehicle fleet. Although diminishing over time, the emission benefits from that older fleet currently make up a substantial portion of the total Smog Check benefits. The availability of a tailpipe testing structure also provides more options for implementation of an OBD only inspection on a subset of the 1996 and newer model year vehicles, provides more flexibility in dealing with problematic vehicles, and can also be used for data collection and program auditing purposes for newer model year vehicles. Tailpipe testing will, however, likely need to undergo changes to ensure continued efficiency as the number of vehicles that would be subject to it would continue to decrease through normal attrition.

Introduction

OBD II, California's second generation of OBD requirements, is a diagnostic system incorporated into the vehicle's powertrain computer. The purpose of OBD II systems is to detect high emission levels caused by emission-related malfunctions, reduce the time between the occurrence of a malfunction and its detection and repair, and also to assist in the diagnosis and repair of the malfunction. OBD II systems activate their monitoring strategies during normal on-road vehicle driving. When a malfunction is detected, the system illuminates the Malfunction Indicator Light (MIL) on the instrument panel of the vehicle, and stores data related to the detected malfunction in the on-board computer so that it will be available to the technician for downloading when the vehicle is serviced. In most cases, an initial malfunction detection must be confirmed by the OBD II system on the next trip before the MIL is illuminated.

OBD II systems are designed to monitor nearly every component and system that can impact emissions when malfunctioning. Studies have found that OBD II based inspections catch a greater percentage of vehicles that are in need of emission-related repairs compared to tailpipe emissions tests that have been traditionally used for state Inspection and Maintenance (I/M) programs.

The USEPA acknowledges the viability of OBD II inspections by providing full emission credits to state I/M programs that are based on OBD II only inspections. Nearly every I/M program in the United States relies solely on OBD II systems for vehicles so equipped. The exceptions, California and Colorado, still use tailpipe testing (Colorado relies on tailpipe testing exclusively). This paper examines the benefits and challenges associated with eliminating the tailpipe test from California's Smog Check program for OBD II equipped vehicles, options for implementing such a program, and factors that will maximize benefits and cost effectiveness.

OBD II Requirements

All 1996 and newer model year gasoline powered passenger cars, light-duty trucks, and medium-duty vehicles are equipped from the factory with an OBD II system. USEPA developed its own set of OBD requirements that apply to federally certified vehicles in the same timeframe; however, its regulation accepts the more stringent OBD II systems as satisfying the federal rules. Although USEPA has less stringent OBD requirements for new vehicles sold outside of California, in practice, manufacturers have, in the vast majority of cases, equipped their vehicles sold nationwide with OBD II systems that meet California requirements. Therefore, even used federal vehicles operating in California are equipped with systems meeting OBD II design requirements in nearly all cases[1].

[1] In addition to the rare instances where a manufacturer has chosen to certify Federal cars to the EPA's rules, it should be noted that prior to ~2007, Federal OBD requirements only covered vehicles below 8,500 lbs GVWR while OBD II covered vehicles below 14,000 lbs GVWR. 1996 through ~2007 model year Federal vehicles between 8,500 and 14,000 lbs (primarily large pick-ups, vans, and small delivery vehicles) do not have a certified Federal OBD or California OBD II system. Inspection of these vehicles would continue to rely on a tailpipe emission test.

ARB's goal in developing its OBD II requirements was for vehicles to be equipped with diagnostic systems that can detect virtually every component or system failure that can lead to high emissions. Therefore, the regulation requires monitoring of all emission-control devices, such as the catalytic converter, oxygen sensors, and exhaust gas recirculation (EGR) system, and most other components and systems that can affect emissions when malfunctioning. The on-board computer software is designed to use information from sensors and other components that are already part of the vehicle's powertrain to carry out the monitoring, and the system will also indicate a malfunction if one of these parts should fail. Below is a general list of the components and systems typically monitored by a vehicle's OBD II system.

Table 1: Components and Systems Monitored by OBD II[2]

Major Emission Controls	**Emission Related Inputs**	**Emission Related Outputs**	**Other Components/ Systems**
Fuel System	Intake Air Temperature Sensor	Idle speed control	Thermostat
Ignition System	Manifold Absolute Pressure Sensor	Transmission shift solenoids	Fast Warm Up Strategies
Exhaust Gas Recirculation	Mass Air Flow Sensor	Variable valve timing	Powertrain Control Module
Secondary Air Injection	Crankshaft Position Sensor	Variable length intake systems	Transmission Control Module
Catalytic Converters	Camshaft Position Sensor	Cooling system fans	
Oxygen, Air/Fuel Ratio Sensors	Engine Coolant Temperature Sensor	Throttle Actuator	
Oxygen Sensor Heaters	Ambient Temperature Sensor		
Fuel Vapor Control	Barometric Pressure Sensor		
Crankcase Ventilation	Transmission Temperature Sensor		
Evaporative System Integrity	Fuel Level Sensor		
	Transmission Range Switch		
	Transmission Speed Sensors		

In addition to detecting malfunctions, OBD II systems also provide valuable system information. When a malfunction is detected, a failure-specific fault code is stored in the on-board computer along with vehicle operating information that is recorded at the time the problem was found. On the order of 175 different fault codes can be set. The

[2] This list represents monitoring strategies typically included in an OBD II system design for gasoline powered vehicles. However, variations are common based on emission control designs, powertrain features, and vehicle model year.

system can also report real time information for several powertrain parameters to off-board diagnostic equipment. This information helps technicians to effectively diagnose and repair detected problems so they can get vehicles back on the road with proper emission performance. OBD II systems additionally store information that is useful for emissions inspections and ARB's efforts to ensure that the systems are working as expected in-use.

From the time that the OBD II requirements were originally adopted by the ARB, staff has worked to ensure that the requirements are effective in detecting problems that occur in-use. The staff has reported back to the Board approximately every two years to provide an update on manufacturers' progress towards meeting the requirements and to propose necessary regulatory amendments. These updates typically include proposed regulatory amendments to address issues encountered by manufacturers in designing OBD II systems or those identified from in-use vehicles. The amendments have also included new monitoring strategies, such as monitoring of variable valve timing systems and cold start emission reduction strategies, to keep up with new vehicle powertrain and emission control technologies. More discussion on the improvements made to the OBD II requirements over the years and their impact on the performance of OBD II systems as an effective inspection and maintenance program tool is included in Appendix B.

OBD II Based Emissions Inspections

The basic process for conducting an OBD II inspection is to examine whether or not the vehicle's MIL is illuminated, indicating the presence of one or more emission-related malfunctions. Owners of vehicles with detected malfunctions need to have them repaired before passing, and those with no malfunctions are determined to have acceptable emission performance. Falsely passing a vehicle because of a burned out or disconnected MIL lamp is avoided by electronically checking the OBD II system information to see if it has commanded the light to be on.

Illumination of the MIL and related fault code information can typically be cleared from a vehicle using commonly available diagnostic equipment or by disconnection of the battery. Therefore, additional OBD information needs to be examined during the inspection to make sure that a recent clearing of the memory isn't hiding the fact that an emission-related fault has occurred. OBD II systems store a set of "readiness indicators" that tell a technician or inspector whether or not critical monitoring strategies have had a chance to operate since the last time the OBD fault memory was cleared. By requiring most or all of the indicators to be set to ready as a condition for conducting an inspection, faults that are present are likely to be redetected by the time the vehicle is inspected. A more extensive analysis and discussion of the impact of memory clearing on OBD inspection effectiveness can be found later in this report, and in Appendix A.

Implementing an OBD-only Smog Check inspection procedure would likely require legislative changes. Health and Safety Code section 44012 specifically calls for loaded mode (emission) testing for gasoline powered vehicles. Legislative changes that specifically permit OBD only based inspections or inspection methods that are at least as effective as loaded mode tailpipe testing would provide a more clear basis for discontinuing tailpipe testing for OBD II equipped vehicles.

Benefits of OBD II Only Inspections

The primary benefits of eliminating Smog Check tailpipe testing for OBD II equipped vehicles are the consumer benefits of lower inspection costs and reduced inspection times. Downloading the necessary information from vehicle on-board computers takes fewer than five minutes. A shorter test requires less labor time for inspectors, resulting in lower inspection costs, and greater convenience for motorists. Further, the inspection does not require the use of expensive test equipment such as the chassis dynamometer and emission analyzers that are currently used for Smog Check tailpipe tests. The Bureau of Automotive Repair estimates that the hardware costs for a BAR97 Smog Check analyzer and dynamometer are approximately $28,000 to $33,000. Calibration gases and maintenance also result in significant ongoing operating costs (e.g., dynamometer maintenance contracts often are $1,500 to $2,000 per year). By contrast, equipment necessary to carry out an OBD II inspection can be purchased for as little as $2,000 and requires essentially no maintenance beyond periodic software updates (tailpipe emission analyzers also require software updates). Therefore, the price of an OBD II inspection should be significantly less than the $30 to $60 currently being charged for a Smog Check inspection. The California Inspection and Maintenance Review Committee has reported that OBD only inspection costs in other states are as low as $11 per test.[3] The significance of potential cost savings is discussed further in the report sections on benefits and costs.

Effectiveness of OBD System Inspections

Monitoring the emission control performance of vehicles through the use of OBD II systems offers several advantages over tailpipe testing. Tailpipe tests are conducted when the vehicle is warmed-up even though most emissions from 1996 and newer model year vehicles occur while the engine is still cold. Further, tailpipe testing only measures emissions during limited operating conditions. For California's ASM test procedure, emissions are measured only at two steady-speed points. Moreover, tailpipe tests measure emission levels for less than a few minutes once every two years. OBD II systems, on the other hand, specifically monitor vehicle emission controls that are designed to minimize cold start emissions, such as oxygen sensor heaters and secondary air injection, and are capable of detecting cold start specific misfire problems. OBD II systems also typically monitor emission control system performance under much broader operating conditions that include transient vehicle operation (accelerations and decelerations). OBD II systems monitor emission controls virtually every time the vehicle is operated and, for some components, virtually every second the engine is running.

Another advantage with OBD II systems is that they are capable of detecting malfunctions when emissions have only marginally exceeded the levels the vehicle was designed to meet. The OBD II regulation requires most malfunctions to be detected before the deterioration has led to emissions exceeding new vehicle certification standards by more than 50 percent. The emission inspection standards for ASM tailpipe testing typically correspond to emission levels that are on the order of five to ten times higher than certification standards. Real world evidence of the effectiveness of OBD II systems in detecting emission-related problems can be seen from inspection results from OBD II equipped vehicles in California's Smog Check Database. The data show

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[3] California Inspection and Maintenance Review Committee: Review of the Smog Check Program, November 27, 2007, page 11

that inspected vehicles are more than twice as likely to fail an OBD II inspection compared to an ASM tailpipe test.

Table 2: Smog Check Results for OBD II Equipped Vehicles
(1996MY and Newer)

Smog Check Database Jul-Dec 2007	Total	% of Vehicles Tested
# of Vehicles Failing OBD II Inspection	192,342	6.64%
# of Vehicles Failing ASM Tailpipe Test	78,954	2.73%

Notwithstanding all of the advantages that OBD technology brings to the emissions inspection process, unless a particular vehicle inspection method is near perfect, a second independent test will always be likely to lead to higher failure rates. In this context, California's current practice of conducting a tailpipe test in addition to an OBD II based inspection for 1996 and newer vehicles directionally provides a backstop for any high-emitting vehicles that do not have OBD II detected malfunctions at the time of the inspection. In a program without the tailpipe test, implementing adequate measures to maximize the effectiveness of the OBD II inspection process will be important to minimize potential emission-reduction losses. The section below examines the factors that can negatively influence OBD inspection programs performance and how their impact can be minimized.

Maximizing OBD-Based Inspection Benefits

Code Clearing

Code clearing is a term that refers to the practice or occurrence of extinguishing the MIL and erasing stored information concerning detected malfunctions just prior to an inspection. This can occur by connecting a commonly available diagnostic tool to the vehicle's data port, or in many cases, by disconnecting the battery for a period of time. If, after code clearing, an inspection takes place before the OBD II system has had the opportunity to detect the faults again, malfunctions that still exist could go unnoticed. Code clearing is not always part of a deliberate effort to alter the results of an inspection. It is common practice for fault codes to be cleared after a vehicle has received repairs to correct the malfunctions that caused them to set, or after an initial malfunction detection to confirm that the monitoring results were accurate before seeking repairs. Battery replacement or recharging due to accidental draining are also examples of actions that are not deliberate attempts to alter the results of the inspection but can cause codes to be cleared.

OBD II systems address this problem by also clearing a set of "readiness indicators" when the fault codes are cleared. These indicators, when unset, alert a technician or I/M inspector that the vehicle's monitoring systems have not had the opportunity to check for the presence of a malfunction since the time the memory was cleared. I/M programs examine the readiness indicators from the on-board computer to ensure that the OBD II system is ready for inspection. If a vehicle is not "ready", the owner is instructed that the vehicle needs additional operation to give the OBD II system a chance to run through its monitoring strategies, and then should be brought back so that the inspection can be completed.

One complication, however, in verifying that every readiness indicator is set is the fact that the amount of driving that is necessary for all monitoring to occur varies significantly based on the design of the monitoring algorithms, how the vehicle is operated, and even on the ambient conditions that are present when the vehicle is driven. The total number of readiness indicators that are examined varies from three to six depending on the types of emission control systems that the vehicle is equipped with. In order to balance the need for an effective inspection while not overburdening vehicle owners, state I/M programs typically consider a vehicle to be "ready" even if one to two indicators are not set. The California Smog Check program currently permits up to two indicators to be unset at the time of inspection.

Smog Check data and roadside information gathered from in-use vehicles indicates that clearing of OBD II information is common, and occurs more frequently near the time of a Smog Check inspection. Vehicles that have detected malfunctions are about 20% less likely to have all readiness indicators set when inspected, indicating that codes were likely cleared at least once from the time the problem first appeared. Further, vehicles selected for unannounced roadside inspections were more likely to have all readiness indicators set than those brought in for a Smog Check inspection by a margin of 10 to 20 percent. This suggests that code clearing (be it legitimately following a repair or a deliberate attempt to alter the inspection outcome) is part of the pre-inspection activity for a significant portion of tested vehicles.

A study conducted by the University of California, Riverside's Center for Environmental Research & Technology (CE-CERT) investigated the extent to which circumventing an OBD based inspection is possible through the use of code clearing. In the study, vehicles for which the MIL was illuminated were procured. The MIL was extinguished and code information was cleared using a scan tool. The vehicles were then monitored as they were driven on the road to see which occurred first, re-illumination of the MIL, or setting of sufficient readiness indicators to qualify the vehicle for a Smog Check Inspection (i.e., two or fewer readiness indicators unset).

The results showed that approximately one-half of the vehicles reached the current Smog Check criteria of two or fewer indicators not set for a period of time varying from minutes to days before re-illumination of the MIL. The data therefore indicate that circumventing an inspection through code clearing can frequently be carried out successfully under current circumstances, and suggests that the readiness criteria would need to be strengthened for any OBD-only inspection procedure that is implemented in California. Further analysis of the data shows that reducing the permitted number of unset indicators from two-or-fewer to one-or-fewer would cut the possibility of circumventing an inspection by one half, and requiring all readiness indicators to be set would reduce the possibility by as much as 75 percent. New OBD requirements have been phased in on 2005 through 2010 model year vehicles that restrict code clearing and provide additional information that can be used for readiness determinations. Incorporation of the new features and data into the inspection process would effectively eliminate the potential for code clearing to cause malfunctioning vehicles to be overlooked. Details on the study's design and findings are presented in Appendix A.

Clean Scanning

Maintaining the integrity of the OBD based inspection process also requires protection against “clean scanning”. The practice of clean scanning refers to attempts by technicians to circumvent an OBD only inspection for a given vehicle by collecting data from a surrogate vehicle on which no malfunctions are present. If only fault code and readiness data are downloaded as is currently done in the Smog Check program, the system that processes the information cannot verify that the data came from the vehicle for which the inspection was intended. This practice is analogous to “clean piping” where the tailpipe probe is connected to a vehicle other than the one that is represented by the technician as being tested for tailpipe emission levels.

The extent to which clean scanning occurs within the current Smog Check program is unknown because the program does not currently include an effective mechanism to detect or prevent clean scanning. However, officials with other states that have OBD only I/M programs have indicated that clean scanning is a significant issue that they have had to address to ensure the success of their programs.

Unlike “clean-piping” which essentially requires visual observation of the fraudulent inspection, clean scanning can be drastically reduced or eliminated for OBD II vehicles through strategies that utilize information available from the on-board computer to verify the source of the data. The information (beyond fault code and readiness information) typically varies to some degree by manufacturer and vehicle model. Inspection programs can examine this information to see if it is consistent with the vehicle model being tested. The types of information that are available include:

- The communication protocol that the vehicle uses. This includes SAE J1850, ISO 9141-2, ISO 14230-4 (Key Word Protocol 2000), and ISO 15765-4 (CAN Protocol). Some of these protocols permit the use of options that effectively create distinct sub-protocols.
- The readiness profile of the vehicle. This provides information on which of the 11 readiness indicators are “supported” by the vehicle. The indicator profile is most often affected by whether or not the vehicle is equipped with secondary air or exhaust gas recirculation.
- Module ID’s and addresses. Vehicle computer networks typically connect multiple computer modules together, including the engine control module, the transmission control module, and often times other modules. The manufacturer assigns an ID or address for each of these modules. There is no required convention for how these module ID’s are assigned, so they typically vary between manufacturers and even between models within a manufacturer’s product line.
- Parameter Identification Count (PID count). This value can be calculated by the inspection equipment from information reported by the on-board computer and indicates how many parameters are available for downloading through the vehicle’s data stream. The value varies for different vehicle makes and models.

The data parameters identified above can be compared to known values for each vehicle being inspected. The comparison can take place while the vehicle is being inspected so that discrepancies can be immediately addressed, or it can take place during post-inspection processing of the data. For the latter, discrepancies could trigger enforcement investigations against specific inspection stations or inspectors. Most states performing OBD inspections already collect this data and are successfully using it to identify fraudulent tests and take action against the inspectors and/or stations without the need to do further undercover observations or evidence gathering.

Newer vehicles include additional sources of information, which can go as far as positively confirming whether or not the downloaded data is from the vehicle purportedly being inspected.

- Calibration ID (Cal ID), a number assigned by the manufacturer to identify the software calibration of the vehicle. This ID is usually unique to a particular vehicle model.
- Calibration Verification Number (CVD). This value is computed based on contents of the on-board computer's software. It is typically unique to a specific CAL ID for a particular vehicle model, or even at the sub-model level.
- Vehicle Identification Number (VIN). Newer model year vehicles store the VIN electronically in the on-board computer. This value uniquely identifies the test vehicle, and can be compared to the VIN on the registration renewal form.

Ensuring Expected In-Use Performance of OBD Systems

Ensuring that OBD systems work as effectively as possible is also an important component in maximizing inspection program benefits. From the time OBD II systems were first introduced in 1996, the ARB has employed a stringent certification process that examines both design information and performance data to ensure that production vehicles are in compliance with the regulations. The ARB staff reviews information including the types of sensors and other hardware used to detect malfunctions, the conditions under which monitoring occurs, the criteria by which performance is evaluated, and emission and monitoring system test results when a fault is introduced. Approval of each OBD II system's design is required before production vehicles can be sold in California.

The ARB staff has also evaluated the in-use performance of OBD II equipped vehicles from the time they first appeared on the road. These efforts have yielded multiple benefits for the program as a whole. Initial compliance issues were addressed through manufacturer recalls or other corrective actions. In other cases, issues identified in the field have been addressed for future model year vehicles through continuing improvements to the OBD II requirements. These improvements include new or more specific monitoring requirements for certain emission-related components, and revised performance and reporting requirements that better ensure how frequently monitoring systems operate in use.

<u>Benefits versus Costs</u>

While the measures discussed above would go a long way towards minimizing the number of high emitting vehicles that would be missed with an OBD based inspection strategy, some loss in emission benefits would still likely occur without the backup of a second inspection procedure. The question then becomes how significant would the loss in benefits be, and at what cost are they currently being preserved from continued tailpipe testing. The ARB staff has conducted an analysis of available data to answer this question.

Benefits

ARB staff used historical Smog Check data and information obtained through laboratory testing of OBD II equipped vehicles to calculate estimates regarding the percentage of vehicles failing the ASM tailpipe test that might pass an OBD-only inspection process. The data are presented in Table 3 below in model year groupings for vehicles failing an ASM at either the regular or gross polluter (GP) inspection standards. The model year groupings take into account improvements in OBD II system designs that have been achieved from the initial years of OBD II implementation. The data show that early model year vehicles equipped with OBD II (1996-1999) may not detect up to a quarter of vehicles that fail the tailpipe emission test. However, for 2000 and newer models, the failure to identify a vehicle with high tailpipe emissions drops to 3 to 4 percent. A more detailed discussion on the data and analysis upon which the estimates are based can be found in Appendix B.

Table 3: Estimated Percentages of Vehicles That Would Benefit From Continued Tailpipe Testing

% of ASM Failures "Missed" by OBD II Inspection					
MY1996 through MY1999		MY2000 through MY2008		MY2008 and future MY	
ASM Fail	ASM GP	ASM Fail	ASM GP	ASM Fail	ASM GP
23.90%	12.75%	4.48%	2.39%	2.99%	1.59%

The staff investigated two options that could be included in an OBD II only inspection program that would further minimize the number of high emitting vehicles that might be missed, especially for vehicles produced during the first years of OBD II implementation (i.e., model years 1996-1999). Each is based on excluding certain OBD II equipped vehicle models from the OBD-only inspection program. Such vehicles would still be required to undergo a conventional inspection, including a tailpipe test. These options are described in more detail below.

The Smog Check database shows that certain vehicle models are more likely to fail an ASM test without their OBD II systems detecting malfunctions than are others. Selectively excluding such vehicle models from an OBD-only inspection program would therefore have the effect of maximizing emission benefits in a manner that minimizes the number of vehicles that need to be excluded. As a specific example, excluding (by vehicle model) the top five percent of vehicles most likely to fail an ASM inspection without MIL illumination would account for more than 30 percent of the vehicles that currently fail ASM and pass OBD. The calculation takes into account both the rate of ASM failures and the correlation between ASM failure and MIL illumination for each given vehicle model. Implementing a strategy like this to minimize the loss of emission benefits would likely require tailpipe testing of a sufficient sample of OBD II equipped vehicles on an ongoing basis in order to determine which vehicle models should be excluded from OBD-only inspections.

Table 4: Impact of Excluding Specific Vehicle Models from OBD Only Inspections on Number of Missed High Emitting Vehicles

Number of OBD II Vehicles Excluded from OBD-Only Testing	130,782
Total Number of OBD II Vehicles Tested	2,616,264
Percent of OBD II Vehicles Tested	5.0%
Number of ASM Fail, OBD Pass Events Eliminated	16,388
Total Number of Events	52,681
Percent of Total Events	31.1%

Based on July to December 2007 Smog Check Records

Another option for further minimizing the emission impact of OBD II-only inspections is to exclude altogether 1996 through 1999 model year vehicles. As discussed above, these vehicles, because they represent manufacturers' initial implementations of the regulation, can be more prone to miss certain failure modes that lead to high tailpipe emissions. Implementing this option would be straightforward in that no additional testing or monitoring of the fleet would be necessary to select vehicles for exclusion. However, excluding a much larger volume of vehicles would also eliminate the cost savings for a greater fraction of vehicle owners.

Using ARB's EMFAC emission model and other available data, ARB staff calculated the impact of an OBD-only approach for OBD II equipped vehicles on the emission reduction benefits Smog Check provides. The results are summarized in Table 5 for an implementation that would include all OBD II equipped vehicles and also for the options described above that would exclude some vehicles from OBD-only inspections. Estimates are presented for calendar years 2010, 2015, and 2020. Details of the emission estimates are included in Appendix C.

Table 5: Emission Reduction Implications for Discontinuing Tailpipe Testing for OBD II Vehicles

Scenario	Emission Reductions Lost (tpd HC+NOx)		
	2010	2015	2020
All OBD Vehicles Included	1.80	2.95	2.56
Poorest Performing Vehicles Excluded (5%)	1.25	2.07	1.79
1996-1999 MY Vehicles Excluded (9% - 35%)	0.15	0.76	1.01

For 2010, the staff estimates that fleet HC+NOx emissions would increase by 1.80 tons per day if ASM testing was dropped for all OBD II equipped vehicles. That number would grow to 2.95 tons per day for 2015 as the portion of the California fleet that is OBD II equipped continues to increase. By 2020, the lost emission reductions would drop to 2.56 tons per day as greater attrition of the population of 1996 through 1999 models occurs. Excluding vehicle models based on their expected performance or model years would further reduce any emission consequences associated with discontinuing tailpipe emission testing in Smog Check by as much two-thirds in 2020.

Putting these numbers into perspective, even the worst case emission benefit loss of 2.56 tons per day would constitute less than 1% of the approximately 400 ton per day of emission benefits currently attributable to the Smog Check program. For other scenarios, the impact would amount to substantially less than one-half of a percent of the current benefits.

Costs

As discussed above, the primary benefits of an OBD-based Smog Check program are an inspection process that is significantly less expensive and less time consuming. The fact that an OBD based inspection can be conducted in 5 minutes or less with inexpensive diagnostic equipment has been well established by I/M programs in other states. Programs in other states also provide a basis upon which to estimate the cost savings that would likely occur in California.

The California Inspection and Maintenance Review Committee (IMRC) conducted a survey of other states to determine inspection costs.[4] The survey results show that the cost for an inspection within centralized programs (state run inspection centers) averages $18, and decentralized programs (privately owned inspection stations, like California Smog Check stations) average $27.50 for an inspection. In most cases, these states conduct OBD-only inspections for 1996 and newer model year vehicles, and some form of tailpipe emission testing for older pre-1996 model year vehicles. Overall, prices are considerably lower than California's current average of $47 per inspection. Based on these figures alone, California motorists could expect to save $20 to $30 per inspection. In reality, the savings could be even greater because the cost figures for some of the states used in the study includes services beyond just an OBD system inspection. Inspection prices in New Hampshire, for example, average about $40 per test. However, a relatively labor intensive vehicle safety check is also part of the inspection process. The safety check includes a general visual inspection, a test drive, and removal of all four wheels to inspect the brakes. Therefore, the OBD portion of the inspection likely accounts for less than half of the inspection price.

Because the extent to which competitive forces would reduce inspection costs in the California context cannot be exactly predicted, the analysis below examines cost savings for a range of possibilities independently and in comparison to the emission benefit calculations presented above. The minimum per test savings examined is $15, and the maximum savings is $35. The impact of a cost savings per test within this range are evaluated in Tables 6 through 8 below for calendar years 2010, 2015, and 2020.

Table 6: Calendar year 2010 Cost Savings

	Number of OBD II Only Inspections	Cost Savings per Year			Cost Savings per Ton Lost ($ per ton HC+NOx)		
		$15 Savings per Test	$25 Savings per Test	$35 Savings per Test	$15 Savings per Test	$25 Savings per Test	$35 Savings per Test
All OBD II Equipped Vehicles Included	6,558,984	$98,384,753	$163,974,588	$229,564,423	$149,592	$249,320	$349,048
Poorest Performing Vehicles Excluded (5%)	6,231,034	$93,465,515	$155,775,858	$218,086,201	$205,035	$341,725	$478,415
1996 to 1999 MY Excluded	4,240,314	$63,604,710	$106,007,850	$148,410,990	$1,133,806	$1,889,677	$2,645,548

[4] California Inspection and Maintenance Review Committee: Review of the Smog Check Program, November 27, 2007.

Table 7: Calendar year 2015 Cost Savings

	Number of OBD II Only Inspections	Cost Savings per Year			Cost Savings per Ton Lost ($ per ton HC+NOx)		
		$15 Savings per Test	$25 Savings per Test	$35 Savings per Test	$15 Savings per Test	$25 Savings per Test	$35 Savings per Test
All OBD II Equipped Vehicles Included	8,723,825	$130,857,368	$218,095,613	$305,333,858	$121,346	$202,243	$283,140
Poorest Performing Vehicles Excluded (5%)	8,287,633	$124,314,499	$207,190,832	$290,067,165	$164,683	$274,472	$384,261
1996 to 1999 MY Excluded	7,157,473	$107,362,088	$178,936,813	$250,511,538	$389,364	$648,940	$908,515

Table 8: Calendar year 2020 Cost Savings

	Number of OBD II Only Inspections	Cost Savings per Year			Cost Savings per Ton Lost ($ per ton HC+NOx)		
		$15 Savings per Test	$25 Savings per Test	$35 Savings per Test	$15 Savings per Test	$25 Savings per Test	$35 Savings per Test
All OBD II Equipped Vehicles Included	10,171,020	$152,565,300	$254,275,500	$355,985,700	$163,541	$272,568	$381,596
Poorest Performing Vehicles Excluded (5%)	9,662,469	$144,937,035	$241,561,725	$338,186,415	$221,949	$369,914	$517,880
1996 to 1999 MY Excluded	9,249,224	$138,738,353	$231,230,588	$323,722,823	$374,786	$624,644	$874,502

The values indicate that even if only a $15 per test savings is realized, motorists would collectively save more than $60 million per year by 2010 even if 1996 through 1999 model year vehicles were excluded. The cost savings increase in all other scenarios, up to more than $350 million per year in 2020 if all OBD II equipped vehicles were included in the OBD only inspection program.

The best-case calculated cost effectiveness of continuing tailpipe testing for OBD II equipped vehicles is just over $120,000 per ton of HC+NOx emissions reduced (the calculated cost effectiveness in 2015 if only a $15 per test savings is achieved and all OBD II vehicles are included). For purposes of comparison, this figure is more than 7 times the current limit ($16,000 per ton) for projects funded under the ARB's Carl Moyer Program,[5] 12 times more than the limit ($10,000 per ton) typically used when considering new motor vehicle regulations, and more than 22 times the cost-effectiveness ($5,317 per ton) calculated for the Smog Check program based on 2002 data. The cost effectiveness of preserving the emission reductions provided by continued tailpipe testing is higher for all other scenarios, approaching $1 million or more per ton reduced.

In summary, the data indicate that while lost emission reductions are never desirable, their magnitude would be small in comparison to the benefits of the program overall, and the cost savings associated with OBD only inspections would likely be disproportionately large by comparison.

OBD Inspection Program Options

There are three basic ways in which an OBD-only based inspection program can be implemented. Each option offers a different balance between the emission reductions

[5] THE CARL MOYER PROGRAM GUIDELINES - Approved Revision 2008
http://www.arb.ca.gov/msprog/moyer/guidelines/cmp_guidelines_part1_2.pdf

they provide and expected cost savings, and each would likely warrant significant changes to the design of the Smog Check program, test equipment, and the manner in which inspection stations would operate.

OBD-Only Inspections at Smog Check Stations

All vehicle owners would still bring vehicles to Smog Check stations for an inspection. However, tailpipe testing would not be a part of the inspection procedure. As a result, the inspection process would be much faster and less expensive to the vehicle owner. As quantified above, some emission reductions would likely be lost to the extent that vehicles with high emissions pass the OBD inspection process. Factors that could lead to lost emission reductions include code clearing and poor in-use OBD II performance for particular manufacturer designs. Changes to the current inspection criteria and excluding vehicles with known design problems from an OBD only test could substantially reduce any lost emissions from this option. Visual inspections for tampering, liquid leaks, and other visible emission-related problems could still be conducted under this option

OBD Clean Screening

An OBD clean screen procedure would eliminate tailpipe testing only for vehicles that met the strictest readiness requirements (i.e., all indicators set to ready). For fully ready vehicles without detected faults, the owners would realize the time and cost conveniences of an OBD only inspection. For vehicles that are not fully ready, a tailpipe emission test would be conducted in addition to the OBD inspection (similar to the current Smog Check procedure). Vehicles with known OBD II system issues could also be excluded from the clean screen inspection path. Overall, this approach is more protective of emission benefits by including the ASM testing backstop for vehicles not meeting the clean screen criteria. However, far less cost savings would likely be realized overall because every Smog Check station would need to be equipped and capable of performing tailpipe emission testing.

OBD III (Remote OBD Based Inspection)

Examination of a vehicle’s OBD II system (MIL status, stored fault codes, and readiness) does not necessarily require a physical inspection of the vehicle. Various transmitter technologies (radio-frequency, cellular, or wi-fi) can be installed on vehicles and used to receive OBD information transmissions from vehicles through a network of receivers. When so equipped, vehicles could undergo an OBD based inspection without going to an inspection station at all. Information identifying the vehicle can be programmed into the vehicle’s transmitter, or it can be read from the vehicle’s on-board computer for newer model year applications. Vehicle owners can be made aware of the vehicle’s inspection status at the time of registration renewal based on the most recent OBD II data gathered remotely from the vehicle. The concept of remotely receiving OBD information from vehicles is often referred to as OBD III.

OBD III strategies offer possibly the most cost effective options for OBD-based motor vehicle emission inspections. Although an up front cost of approximately $50 per vehicle would be required to fit vehicles with OBD II information transmitters, the time and cost savings of not having to bring the vehicles in for an inspection would, over the course of a couple inspection cycles, outweigh the initial costs.[6] In fact, over a vehicle's lifetime, it has been estimated that OBD III technology could reduce Smog Check testing costs by about 75% compared to station-based OBD inspection programs.[7] Some potential for lost emission reductions exists for OBD III concepts because both tailpipe testing and visual vehicle inspections would no longer be conducted. Emission control system tampering that does not result in illumination of the MIL, and those vehicles with high emission levels without detected malfunctions would likely be missed in most circumstances. However, lost emission reductions due to code clearing or fraudulent inspections could be virtually eliminated by the continuous nature of a remote OBD system and additional benefits from a reduced time from detection of a fail to repair may outweigh any additional losses.

Impact on Remaining Fleet, Test Equipment, and Smog Check Stations

Eliminating tailpipe testing for the newer fleet would result in changes to the current Smog Check equipment and practices within the industry. Even in 2008, the newer fleet (i.e., OBD II equipped vehicles) made up over 66% of all vehicles inspected, and the percentage is growing every year. The number of older cars in the fleet that need a tailpipe test, on the other hand, will continue to diminish over time. At some point, tailpipe testing volumes may be reduced to the point that it is impractical or cost-ineffective to have tailpipe testing equipment at every Smog Check station, and other infrastructure options would need to be considered (e.g., tailpipe testing at a subset of stations, allowing individual stations to opt in or out of tailpipe testing from a business point of view, etc.). Maintaining a tailpipe testing infrastructure, however, is a vital element to the Smog Check program. The older fleet, which still must be inspected with a tailpipe test, is currently responsible for a substantial portion of the Smog Check program benefits. Further, the presence of a tailpipe testing infrastructure provides additional flexibility for the newer fleet (e.g., to address problematic early implementation vehicles as discussed elsewhere in this report, to inspect a subset of the newer fleet for data collection and program auditing purposes, etc.).

A change to an OBD-only inspection for the newer fleet would also have an impact on future inspection equipment needs. BAR has indicated that the current BAR 97 analyzer cannot be reasonably adapted to adequately perform OBD-only inspections. In fact, the development of a replacement system is already underway to accommodate necessary and desired upgrades in tailpipe testing, OBD testing, and current and future vehicle compatibility. The design of future inspection systems would need to take into account the possibility of an OBD-based inspection program and the extent to which continued tailpipe testing for older vehicles would be necessary.

Lastly, an OBD III based design could drastically reduce the number of newer model year vehicles that show up at Smog Check stations. This change could ultimately result in the need for fewer inspection stations within the state while still maintaining the same demand for repair stations. This too should be considered in future program changes as the current program structure allows for inspection only stations as well as inspection and repair stations, but does not allow for repair only stations.

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[6] USEPA FACA Report, "Transitioning I/M - Options for Inspection and Maintenance in the OBD Dominated Fleet," April 2008, pages 11-12, http://obdclearinghouse.com/

[7] Ibid, page 13

Summary and Conclusions

OBD II systems incorporated into 1996 and later model year vehicles can provide for highly effective and inexpensive emission control system inspections. Experience in California and other states demonstrates that OBD based inspections outperform tailpipe emission testing at a lower cost.

While California's current practice of requiring both an OBD inspection and tailpipe testing works to maximize total emission reductions achieved within the Smog Check program, available data indicates that the additional reductions attributable solely to tailpipe testing are small and are not being achieved in a cost effective manner. Discontinuation of tailpipe testing would greatly reduce costs (which are ultimately passed on to California motorists) with only a minor impact on the program's effectiveness. Transitioning to an OBD-only based Smog Check program would bring California's program into alignment with USEPA recommendations and the I/M programs in other states that have already discontinued tailpipe testing for OBD II vehicles.

Legislative changes, including changes to Health and Safety Code 44012 and 44036, are necessary for California to move forward with an OBD only inspection strategy.

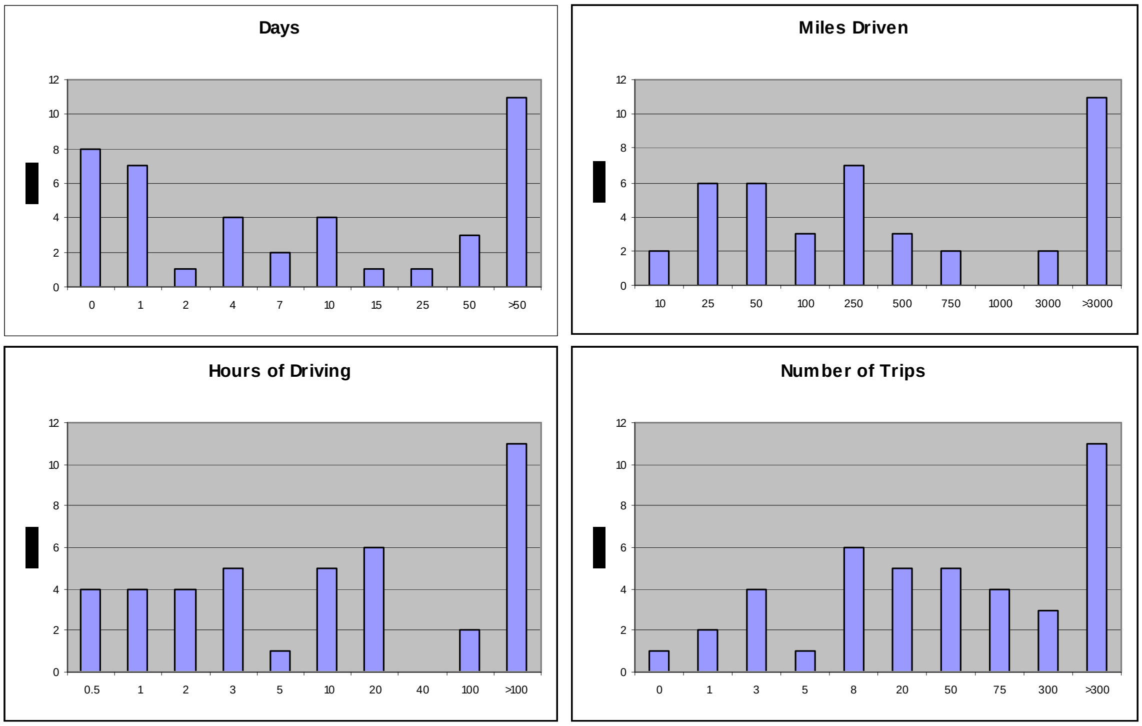
Appendix A
Impact of Code Clearing

In order to investigate the impact of inspecting vehicles with unset readiness indicators, and the potential for the use of code clearing to circumvent the inspection process, the University of California, Riverside's Center for Environmental Research & Technology (CE-CERT) conducted a study under contract with the Air Resources Board (ARB) and the Bureau of Automotive Repair (BAR). CE-CERT installed real time monitoring devices produced by NetworkCar on 74 test vehicles on which the MIL was illuminated for real-world malfunctions. The NetworkCar device can instantaneously transmit data from the vehicle whenever the information stored in the vehicle's on-board computer changes. By collecting the information in a database, monitoring system results and the time it takes for the monitors to run can be studied. Once the NetworkCar devices were installed, the codes were cleared without any repairs being made, and the vehicles were returned to their owners. The information transmitted from these vehicles was collected in a database used to examine how soon the malfunctions were detected again (and the MIL illuminated) in relation to the setting of the readiness indicators. The vehicles were operated for an average of 36 days with the NetworkCar systems installed.

Using California's criterion that a vehicle is "ready" for inspection when no more than 2 readiness indicators are incomplete, 42 of the 74 test vehicles (57%) reached the 2-not-ready condition before the MIL was re-illuminated. For these vehicles, clearing of the codes provided a window of opportunity (referred to hereafter as a code clear window) for the vehicle to pass an OBD only based inspection without having repairs made.

The code clear window closes as soon as the OBD II system reconfirms that a fault is present and illuminates the MIL. The test data show that how long the window was open (based on time or driving) varied considerably from a few minutes to more than 45 days. The distributions are shown in Figure 1. The data was calculated in terms of days, number of miles driven, hours of driving, and number of trips.

Figure A-1: Length of Code Clear Window with Two Indicators Not Ready



For about one third of the vehicles, the window did not stay open long. The MIL was re-illuminated within one day after the on-board computer memory was cleared for 15 vehicles (36%). This corresponds generally to less than 50 miles of vehicle operation, less than 2 hours of driving, and 8 or fewer trips. On the other end, the MIL never did illuminate again within the period of the test program for 11 (26%) of the test vehicles (further discussion of these eleven vehicles is provided later). For the remaining test vehicles for which the window existed, the length of the window was fairly evenly distributed between 2 days and 50 days.

Although on-board computers designed to comply with the OBD II requirements store data for eleven readiness indicators, only three to six of them can be effectively used to determine when the corresponding monitor(s) has operated during in-use driving. The remaining indicators are either not supported because the vehicle is not equipped with the corresponding monitoring strategy (e.g., air conditioning system monitoring, or heated catalytic converter system monitoring), or the indicators are set to ready almost immediately because the monitoring strategies generally operate continually as vehicles are being driven (e.g., misfire detection, or fuel system monitoring). Therefore, considering vehicles to be "ready" even though up to two of these indicators are not set means that 33 to 66 percent of the monitoring systems in question do not have to operate before the inspection takes place.

If the requirements were strengthened so that the number of unset indicators is limited to one or none, the opportunity for faults to be overlooked through code clearing lessens. As shown in Table A-1, if no more than one unset readiness indicator was to be accepted, the number of vehicles within the test set for which a code clear window occurred dropped 11 points to 46%. If the I/M program required all readiness indicators to be set before conducting an inspection, the number of code clear windows would be cut by more than two-thirds, down to 18%.

Another approach to establishing readiness requirements is to focus more individually on the readiness indicators that are typically harder to set. Some OBD monitoring technologies operate only under relatively constrained operating conditions in order to ensure that monitoring results are reliable, while others can operate reliably during a wide range of conditions. For example, evaporative system monitoring and secondary air system monitoring can often take longer to set than other indicators because the monitoring systems typically only operate after a cold start, which only occurs once or twice a day in most circumstances. Permitting any one or two readiness indicators to be unset does not take these circumstances into account.

Analysis of the individual indicators within the test fleet database shows that constraining readiness determinations to the setting of particular indicators yields mixed results. Moving from permitting any two indicators to be unset to permitting the evaporative monitor plus any one additional indicator to be unset did not change the frequency of code clear windows because the evaporative system monitor contributed to the creation of the code clear window in each of the “any two” circumstances. However, permitting only the evaporative system indicator to be unset significantly reduced the code clear opportunities compared to an “any one” unset requirement. Although the number of code clear opportunities would be reduced further by using an “all ready” requirement, permitting only the evaporative indicator to be unset would likely inconvenience significantly fewer motorists during the Smog Check process. For this dataset, permitting the secondary air indicator to be unset did not change the results. Secondary air monitoring was only supported by a few test vehicles, and the indicator never contributed to a code clear opportunity within the test program.

Table A-1: Comparison of Frequency of Code Clear Windows versus Number of Unset Bits Permitted

	Unset Indicators Permitted					
	Any Two	Any One	All Ready	Evap + Any One	Evap + Secondary Air	Evap Only
Number of Vehicles for Which Code Clear Window Occurred	42	34	13	42	22	22
Percent of All Test Vehicles	57%	46%	18%	57%	30%	30%

Within the data set, the MIL never re-illuminated within the timeframe of the test program for eleven of the 74 test vehicles. The analysis assumes up to this point that the MIL did not re-illuminate because the OBD II system did not monitor the failing component or system enough times for redetection. However, other explanations are likely true for at least some of the eleven vehicles. Other explanations include:

- The fault may be intermittent or may occur only when certain conditions are present.
- The fault initially detected may have gone away. For example, if the MIL was illuminated because of a loose fuel cap that was tightened during a later refueling, the MIL should not re-illuminate.
- The initial malfunction detection may have been false, meaning that the malfunction never existed.

For the last two possibilities, the fact that readiness was set without re-illumination of the MIL cannot be accurately attributed to code clearing, because there is no reason that the MIL should re-illuminate. With regards to the first possibility, an intermittent fault could easily result in the setting of readiness without timely re-illumination of the MIL, depending on the amount of time during which the malfunction was dormant. Catching such vehicles during an I/M inspection would be ideal because excess emissions would occur whenever the malfunction is active; however, no inspection technique is likely to detect a problem that is not active at the time of the inspection.

ARB staff reviewed available data concerning these eleven vehicles and determined that for six of the vehicles, it is likely that no malfunction existed after the computer memory was erased. The rationale used for each vehicle is included in Table A-2.

Table A-2: Code Clearing Study Vehicles for Which the MIL Never Illuminated After Being Reset

Veh #	Original Fault	Readiness (hours)	Likely to have active malfunction?	Reasoning
23	Fuel System	8.14	yes	Pending fault code is present
31	Evap System	never for Evap	yes	Pending evap fault code, and lack of evap readiness
35	Evap System	30.98	no	no pending codes, evap readiness set, vehicle driven 30 days after evap readiness set
36	Evap System	6.66	no	no pending codes, evap readiness set, vehicle driven 20+days after evap readiness set
45	Misfire, Evap System	never for Evap	yes	misfire code may have returned, readiness never set for evap.
49	Fuel System	3.58	no	No pendind code after about 40 days
56	Comprehensive Comp	Never for Cat	no	Camshaft position fault would have been re-detected very quickly
64	Evap System	2.31	no	Although intermittent misfire fault may be developing, evap readiness set early with no malfunction detection after more than a month
65	No Code Initially	Never for Cat	yes	Database provides insufficient information to make reasoned guess. Treat as likely to have active malfunction by default.
71	Misfire	6.9	yes	Misfire problem is likely intermittent, but pending code indicates it hasn't gone away
74	Misfire	1.33	no	No evidence of misfire fault after more than a month

As indicated in Table A-3, removing the vehicles not likely to be malfunctioning from the list of those that experienced code clear windows would further reduce the percentage of vehicles for which a code clear occurred by 7 to 8 percentage points.

Table A-3: Comparison of Readiness Criteria Performance in Minimizing Code Clearing Opportunities

	Unset Indicators Permitted					
	Any Two	Any One	All Ready	Evap + One	Evap + Secondary Air	Evap Only
Number of Vehicles for Which Code Clear Window Occurred	36	28	8	36	17	17
Percent of All Test Vehicles	49%	38%	11%	49%	23%	23%

For this test program, 32% of the vehicles tested were 1996 model year vehicles and 57% were from the 1996 through 1998 model year. The OBD II requirements have evolved significantly since the 1996 model year. One of the results of this evolution is that more information is being stored in the on-board computer of newer vehicles. Some of this information can be used to detect and further prevent the occurrence of code clearing.

- Number of warm-up cycles since last code clear
- Distance traveled since codes cleared

The I/M program can be set up to require a minimum number of warm up cycles and miles driven before considering a vehicle with unset indicators to be ready for inspection. This would have the effect of reducing the impact of code clearing while also limiting or capping the amount of inconvenience to the motorist.

Improvements to the OBD II regulations also significantly address the frequency with which the monitors operate in-use. Manufacturers must now design OBD II systems to record how frequently the monitors run on the road, and the regulation also sets standards for minimum acceptable frequencies. Monitors that operate more frequently during in-use driving will help to minimize the occurrence of code clear windows and will also shorten the length of the window.

A further improvement to address code clearing is being phased-in on future model year vehicles. It is the use of permanent fault codes. Unlike today's vehicles where all fault code and MIL status information can be erased by a scan tool (or sometimes a battery disconnect), permanent fault codes will be stored in a specific type of media in the on-board computer that is not erasable by a scan tool or by disconnecting power. These fault codes are stored upon MIL illumination and can only be erased by the OBD system itself and only when the OBD system has the opportunity to re-run the exact diagnostics that had previously failed and confirm that a fault was no longer present. In both a valid repair scenario and a case where somebody simply cleared codes, the permanent fault code would still be present (even though the MIL is off) and would stay there until the exact monitor that was previously failing had subsequently run and determined the system was passing. With such a feature, OBD inspections could be configured to reject/fail any vehicle with a permanent fault code stored, regardless of readiness status. This could virtually eliminate the possibility of a vehicle with a fault getting through the inspection simply by clearing codes (except in the case where an intermittent fault was the original cause and the fault is now dormant, a case that every inspection type of test is unable to detect).

In summary, the study results indicate that ensuring OBD readiness is important to minimizing the number of emission-related faults that might be missed by an OBD only I/M program. Within the test fleet after fault information was cleared, 49-57% of the test vehicles achieved current Smog Check program “readiness” before the OBD II system redetected the faults that were present, based on readiness being defined as two or fewer indicators not being set. The percentages drop to 38-46% and 11-18%, respectively, when readiness is defined as one or no indicators that are unset. Permitting only the evaporative system indicator to be unset reduced the percentage of vehicles that were “ready” before redetection of the faults to 23-30%. Using one of the more stringent readiness criteria discussed above in combination with the OBD II requirement improvements that apply to later model year vehicles will work to minimize the chances of missing malfunctioning vehicles during an inspection because of code clearing.

Appendix B

Estimating the Impact of Eliminating TailpipeTesting on Smog Check Failure Rates

A simple comparison of ASM tailpipe and OBD II inspection results within the Smog Check database would suggest that OBD II systems only catch a small fraction of the high emitting vehicles (as determined by tailpipe testing) that are inspected. For example, as shown in Table B-1, Smog Check data from the first six months of 2008 indicate that 79,273 OBD II equipped vehicles failed the tailpipe test portion of their inspections, but only 22,227 (28.0%) of these vehicles failed the OBD II portion of the emissions inspection. Although the correlation for vehicles failing at the gross polluter level nearly doubled, nearly 50 percent of the vehicles (45.2%) received passing OBD inspection results. However, despite these statistics, when other factors are taken into account, available data and information suggest that tailpipe testing can be eliminated for OBD II equipped vehicles without increasing the number of high emitting vehicles that are missed by the program to the point that emission benefits are significantly impacted. These factors are examined and quantified below.

Table B-1: ASM versus OBD Results (Up to two readiness indicators incomplete) Smog Check Database – January to June 2008

	OBD Pass	OBD Fail	% OBD Fail
ASM Fail	57,046	22,227	28.0%
ASM Gross Polluter	7,144	8,644	54.8%

Improved Readiness Criteria

As detailed in Appendix A, the current Smog Check practice of considering vehicles ready for an OBD II inspection even if up to two readiness indicators are set to incomplete has the effect of causing some previously detected OBD II faults to be missed if OBD II information is cleared prior to the inspection. Analysis of the Smog Check database indicates that tightening of the readiness criteria would significantly reduce the number of ASM failing vehicles that pass the OBD inspection. Table B-1, above, presents the correlation between the two tests based on the current Smog Check criterion for readiness indicators (i.e., no more than 2 incomplete). Table B-2 recalculates the ASM/OBD inspection correlation data when all readiness indicators, with the exception of that for the evaporative system, are required to be set to complete.

Table B-2: ASM versus OBD Results (All indicators except evaporative system required to be set) – Smog Check Database – January to June 2008

	OBD Pass	OBD Fail	% OBD Fail
ASM Fail	36,707	42,566	53.7%
ASM Gross Polluter	3,906	11,882	75.3%

The data reflect a 35.7% reduction in the number of ASM failing vehicles “missed” by the OBD II inspection and a 45.4% reduction for ASM gross polluters.[8] The data show that

[8] 72.0% of ASM failures passed the OBD inspection when two or more indicators could be incomplete versus 46.3% when only the evaporative system indicator could be incomplete (a 35.7% difference).

revising the criteria for vehicle readiness would provide a much more solid foundation upon which to base an OBD II only inspection procedure.

More stringent readiness criteria directionally increases the chances for a properly operating vehicle to fail the OBD inspection in cases where OBD information was cleared (because of emission-related repairs or a battery replacement), or if the vehicle model being tested contains one or more monitoring strategies that operate with a particularly low frequency in-use. However, roadside vehicle inspection data collected by the Bureau of Automotive Repair suggests that the vast majority of properly operating vehicles would meet the tighter criteria. The data show that for 2,919 OBD II equipped vehicles that passed a roadside ASM test and had no detected malfunctions, 2,721 (93.2%) of them met the evaporative only readiness criteria.[9] Based on the data, it appears that the more stringent readiness criteria could be implemented without significantly further burdening owners of passing vehicles.

Permitting the evaporative system indicator to be incomplete was included in the analysis because evaporative system monitors typically include more restrictive monitoring conditions to ensure accuracy. These conditions include monitoring within a relatively narrow range of ambient temperatures, and monitoring only on driving cycles that begin with a cold start. Therefore, purposefully operating the vehicle such that the necessary conditions are encountered can sometimes be prevented by conditions outside of the control of the vehicle operator. For most other monitoring strategies, readiness can be set by a technician or the vehicle owner simply by driving the vehicle under the correct monitoring conditions for a specified length of time.

<u>Applying Findings from ARB's Study of Gross Polluting OBD II Equipped Vehicles</u>
In 2003 and 2004, the ARB, BAR, and the University of California, Riverside (UCR) conducted a study of vehicles that failed a Smog Check inspection at gross polluter levels, but passed the OBD II inspection portion of the test. The vehicles were procured from their owners, and tested at either the ARB or UCR laboratories. Vehicles were given confirmatory ASM tests and FTP emission tests in their as-received condition. Vehicles with confirmed high emission levels were studied to determine what malfunctions caused the elevated emission levels and reasons why the malfunctions were not detected by the vehicles' OBD II systems. In total, 31 of the procured vehicles failed the ASM test at a Smog Check station but passed the OBD II inspection with all readiness indicators (other than the indicator for the evaporative system) set to complete. ARB staff used the study to estimate the impact of three additional factors on the correlation of OBD and ASM test results.

Likewise, 45.2% of vehicles failing as gross polluter levels passed the OBD inspection versus 24.7% (a 45.4% difference) under the same criteria.

[9] The data were not sorted to remove vehicle models with known readiness indicator setting problems or other problems related to setting of the indicators. Such vehicles would likely be excluded from an OBD only inspection program (continuing instead to be subject to tailpipe testing) because code clearing issues could not be reasonably addressed. Although they are relatively few in number, excluding them from the analysis would directionally increase the percentage of vehicles in the roadside data that met the more stringent readiness requirements. A list of vehicles identified by BAR as having such problems are included in Appendix J of California's Smog Check Inspection Manual.

Inaccurate ASM Results

The ASM test procedure was designed to be a relatively inexpensive tailpipe emission screening procedure, and a number of factors exist that influence the accuracy and repeatability of its measurements. These factors include the time-varying nature of vehicle emissions, the limited operating conditions under which testing occurs, ASM instrument errors, vehicle operational variability during an ASM test, and issues related to Smog Check station performance.[10] As a result, not every vehicle that fails an ASM tailpipe test is in fact a high emitter.

Within the 31 vehicle dataset, ARB staff determined that 4 of the vehicles (12.9%) were not high emitters. These vehicles passed an ASM, IM240, and an FTP test in their as-received condition upon arriving at the laboratory, showing no sign of having elevated emission levels or emission-related malfunctions. Considering that these vehicles failed at gross polluter levels at the Smog Check stations, the frequency of properly operating vehicles that inaccurately receive failing ASM test results at the standard cutpoints is likely higher.

Vehicles Unlikely to Benefit from Failure Determination

For 7 of the test vehicles (22.6%), ARB staff confirmed that an emission-related problem existed under at least some conditions, but further determined that emissions from the vehicles would not have been significantly reduced as a result of the failing test result. For example, two Ford Econoline vans were tested that exhibited highly intermittent oxygen sensor problems. After the initial ASM failures at the Smog Check stations, both vehicles passed follow up ASM tests before any diagnostic or repair work was conducted. Diagnosis and repair of the vehicles required the use of a transient chassis dynamometer (typically not available to service technicians) as well engineering support from Ford. ARB staff believes, therefore, that it is highly likely that the vehicle problems would not have been diagnosed in the field, and the vehicles would have instead been simply retested with passing results and given a Smog Check certificate.

In two other cases, Honda vehicles were tested that had an incorrect fan temperature switch. The malfunction caused the vehicles to intermittently overheat when subjected to repeated ASM dynamometer testing because airflow to the radiator is very minimal. The overheating caused the vehicle to invoke default fuel strategies to attempt to cool the engine which led to high emission levels during the ASM tests. However, on-the road, the vehicles would experience sufficient airflow to prevent overheating, and in-use emissions would not be significantly impacted. This point was confirmed by the fact that the vehicles were in compliance with emission standards when subjected to an FTP test in the laboratory. OBD II regulatory changes were made in 1995 to prohibit manufacturers from invoking such default fuel strategies for overheating after the 1996 model year.

OBD II System Improvements

Most (about 81%) of the ASM-failing OBD II-equipped vehicles captured in the 2008 Smog Check database are 1996 through 1999 model year vehicles.[11] These model years represent the initial years of OBD II implementation. Although OBD II

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[10] "Evaluation of Remote Sensing for Improving California's Smog Check Program", page May 3, 2008, Eastern Research Group

[11] Based on Smog Check data for January through June, 2008

implementation has generally been successful from the beginning, significant improvements both in manufacturers' OBD II system designs and the OBD II regulation itself have been made with respect to future model year vehicles. These improvements will have the effect of further reducing the chances for emission-related malfunctions to occur without OBD II system detection.

Early in-use experience with OBD II systems revealed that some OBD II system designs missed certain emission-related failures either because of errors in the OBD II system's design or software, or because certain types of component failures weren't sufficiently contemplated. For example, it has been determined that some early OBD II system designs, although generally capable of detecting catalytic converter degradation, may lack the capability to detect when the substrate is missing altogether from the converter. Empty catalytic converters can exist in-use when poorly matted ceramic substrates physically break apart and are blown out the tailpipe, or through tampering (removal of the substrate) aimed at increasing vehicle power by reducing tailpipe backpressures. Once this malfunction detection limitation was discovered, vehicle manufacturers took time to evaluate the performance of their OBD II systems in this regard, and worked quickly to make improvements to their designs for future model years as necessary.

The OBD II regulation has also undergone many revisions over the last several years to include new monitoring requirements for emission-related components that were not covered under the original regulation, and to increase the effectiveness of existing requirements. The improvements cover not only the requirements for component and system monitoring, but also cover fault code setting and issues related to system security. Table B-3 lists the major revisions that have been made along with the model years from which they apply.

Table B-3: Important OBD II Revisions

Revised OBD II Requirements	**Phase-in Period**
Misfire monitoring under expanded operating conditions	1997-1999
Improved Catalyst Efficiency Thresholds	1998-2002
Thermostat monitoring	2000-2002
Storage of software calibration identification number	2000-2002
Calculation and storage of calibration verification number	2000-2002
0.020 inch evaporative system leak detection	2000-2003
Positive crankcase ventilation monitoring	2002-2004
Minimum in-use monitoring frequency requirements	2005-2007
NOx malfunction criteria for catalyst monitoring	2005-2009
Monitoring cold-start emission reduction strategies	2006-2008
Post catalyst oxygen sensor monitoring improvements	1999-2011
Primary oxygen sensor monitoring improvements	2010-2012
Permanent fault code storage protocol	2010-2012
Monitoring for air/fuel ratio imbalances between cylinders	2011-2014

ARB staff believes that these improvements will have the effect of greatly reducing the number and types of emission-related malfunctions that some early OBD II implementations had trouble detecting. In the OBD II study for vehicles failing tailpipe testing but passing the OBD inspection, the catalytic converter was malfunctioning in 11 of 16 cases. Through the manufacturers' efforts described above to improve catalytic converter monitoring and the strengthening of the requirements in the 1998-2002 timeframe, the staff estimates that the same malfunctions would be detected in post-2000 model year OBD II equipped vehicles. Other malfunctions that were found during the study, including a bad thermostat and a poorly performing rear oxygen sensor, would also be detected, in ARB staff's opinion, by the improved OBD II system designs that are now in place.

Overall, the staff estimates that for 13 of the 16 problem vehicles, 2000 and later model-year OBD II systems would detect the malfunctions in question, and for one of the three remaining vehicles, the malfunction will be detected in 2009 and later model year vehicles. A listing of the test vehicles in the study are presented in Table B-5 at the end of this appendix

<u>Impact of Factors on Smog Check Failure Rates</u>
A summary of the impact of the findings discussed above on the number of truly high emitting vehicles that might be missed using an OBD only inspection strategy is presented in Table B-4 below. The table estimates the percentages of failing and gross polluting OBD II equipped vehicles that might be missed if tailpipe testing was discontinued. The values are presented in model year groupings consistent with the staff's analysis of the impacts of OBD system improvements that have occurred since 1996.

Table B-4: Estimated Percentages of ASM Failing Vehicles Missed by OBD II Only Inspection Program

	Adjustment Amount (% improvement)	% of ASM Failures "Missed" by OBD II Inspection					
		MY1996 through MY1999		MY2000 through MY2008		MY2009 and future MY	
		ASM Fail	ASM GP	ASM Fail	ASM GP	ASM Fail	ASM GP
Baseline: Jan to June 2008 Smog Check Data. All readiness required except evap		46.30%	24.70%	46.30%	24.70%	46.30%	24.70%
Adjustment 1: fraction of vehicles that would not benefit from failure determination, or malfunction detection should occur for most 1996-1999 my vehicles	15/31 (48.39%)	23.90%	12.75%				
Adjustment 2: Adjustment 1 + OBD II improvements MY 2000 through 2008	28/31 (90.32%)			4.48%	2.39%		
Adjustment 3: Adjustment 2 + OBD II improvements MY 2008 and beyond	29/31 (93.55%)					2.99%	1.59%
Adjustment 4 (Optional) Removing 5% of worst performing OBD II vehicles	30%	16.73%	8.92%	3.14%	1.67%	2.09%	1.12%

The staff's analysis estimates that 1996 through 1999 model year OBD II systems may not detect a malfunction in about one out of every four vehicles (23.90%) that accurately fails an ASM test because of a malfunction that could be readily diagnosed and repaired under the rules of the Smog Check program. About one out of every eight vehicles (12.75%) that fail at gross polluter levels would also be missed. The values decrease to less than 1 out of 20 (4.48% down to 1.59%) for 2000 and later model year vehicles as a result of the numerous OBD II improvements that have occurred.

Table B-5: Summary of ARB's Gross Polluter Study for OBD II Equipped Vehicles

Veh#	year	make	model	Root Cause	Emission benefit from repair?	Would OBD catch in the future?	Loss of benefits without ASM?			Why or why not?
							1996-1999	2000-2008	2009+	
0	1997	Toyota	Camry	no problem	no	n/a	no	no	no	no problem with car - initial ASM false fail
1	1998	Ford	Mustang	intermittent O2	yes	yes	no	no	no	strengthened readiness criteria would result in vehicle failing OBD inspection
2	1999	Ford	Mustang	tampered catalytic converters - empty cans	yes	no	yes	yes	yes	tampered catalyst system escaped detection
3	1997	Ford	Ranger	Plugged EGR cylinder ports plus non-OEM catalyst partially failing	yes	yes	yes	no	no	strengthened readiness criteria would result in vehicle failing OBD inspection for EGR fault. New rules would limit availability of non-OBD II compatible catalytic converters
5	1997	Dodge	Ram	Bad catalytic converter	yes	yes	no	no	no	strengthened readiness criteria would result in vehicle failing OBD inspection
6	1998	Mazda	Protégé	no problem	no	n/a	no	no	no	no problem with car
7	1999	Hyundai	Sonata	intermittent O2	yes	yes	no	no	no	revised software TSB already out there to fix O2 monitor frequency, model contains readiness clearing error
8	1996	Plymouth	Voyager	Bad catalytic converter	yes	yes	yes	no	no	Catalyst monitoring has improved with more experience
9	1996	Honda	Accord	overheat on dyno	no	yes	no	no	no	required to illuminate MIL for 1997+ for this default mode
10	1999	Toyota	Camry	multiple partials	no	no	no	no	no	Car had several partially deteriorated but none bad by itself. Would not be fixed in context of Smog Check Program
11	1999	Toyota	Sienna	no problem	no	n/a	no	no	no	no problem with car
12	1997	Ford	Expedition	no problem	no	n/a	no	no	no	no problem with car
13	1997	Chevy	Astro	multiple problems (rear O2, slipping trans, bad cat)	yes	yes	no	no	no	Problems would be caught in OBD II only inspection with more stringent readiness criteria
14	1997	Dodge	Stratus	aftermarket cat	yes	yes	no	no	no	changes to illegal a/m cats would make them compatible with OBDII
15	1996	Honda	Accord	overheat on dyno	no	yes	no	no	no	required to illuminate MIL for 1997+ for this default mode
16	2000	Nissan	Frontier	plugged EGR cylinder ports plus partially bad catalyst	yes	yes	yes	yes	no	EGR monitor doesn't catch EGR mal-distribution. Cat would be caught by NOx cat mon (2006+MY)
17	1996	Acura	Integra	empty can	yes	no	yes	no	no	Catalyst monitoring has improved with more experience
18	1996	Chevy	Astro	bad cat and bad thermostat	yes	yes	yes	no	no	Thermostat monitored from 2000+, cat mon worked with new t-stat (was disabled and incomplete with old t-stat)
19	2000	Toyota	Tundra	intermittent O2	yes	yes	no	no	no	Would have been detected by OBD II check with more stringent readiness criteria. More frequent O2 monitoring for newer model years.
20	1997	Plymouth	Breeze	empty can	yes	no	yes	no	no	Catalyst monitoring has improved with more experience
21	2000	Toyota	Avalon	bad rear O2	yes	yes	yes	no	no	2001+ Avalon had improved rear O2 monitor for exact problem
23	1996	Ford	E350 Econoline	intermittent O2	no	yes	no	no	no	Failure was highly intermittent. Would have likely passed subsequent ASM tests. Would be caught in future model years with more frequent O2 monitoring plus fuel control/OBD linked
25	1997	Nissan	Altima	plugged EGR cylinder ports plus partially bad catalyst	yes	yes	no	no	no	Multiple, hard to diagnose problems. Would likely hit repair cost limits or receive waiver
26	1996	Dodge	Ram	empty can	yes	yes	yes	no	no	Catalyst monitoring has improved with more experience
27	1998	Dodge	Ram	readiness loophole let bad cat through	yes	yes	no	no	no	Would have been detected by OBD II check with more stringent readiness criteria.
28	2000	Chevy	Metro	readiness loophole let bad cat through	yes	yes	no	no	no	cat monitor turned MIL on as soon as it ran
29	1998	Ford	Taurus	intermittent ECM glitch?	no	no	no	no	no	Never could fix anything on car--too intermittent and Ford engineers couldn't find problem. Would not have been fixed in context of Smog Check
30	1996	Jeep	Grand Cherokee	empty can	yes	yes	yes	no	no	Catalyst monitoring has improved with more experience
32	1996	Chevy	S-10	empty can not detected because aged rear O2 sensor	yes	yes	yes	no	no	Deficiency for 1996. 1997+ idle cat monitor tolerates aged rear O2 better
UCR1	1999	Dodge	Durango	empty can	yes	yes	yes	no	no	enforcement case
UCR2	1996	Nissan	Maxima	aftermarket cat	yes	yes*	no	no	no	changes to illegal a/m cats would make them compatible with OBDII
UCR3	1996	Honda	Civic	illegal exhaust header (O2 in a single cylinder exhaust pipe)	yes	no	yes	yes	yes	Tampered/illegally modified
UCR5	1996	Chevy	Monte Carlo	overheat on dyno	no	yes	no	no	no	Clean on FTP. No air flow during ASM test caused overheating. Overheating required to illuminate MIL for 1997+ (default mode of operation)
UCR6	1997	Ford	Econoline	intermittent O2	no	yes	no	no	no	Intermittent failure would likely result in ASM pass without repairs
1Q0401-5	1997	Jeep	Wrangler	empty can	yes	yes	yes	no	no	Catalyst monitoring has improved with more experience
1Q0401-8	1998	Jeep	Wrangler	empty can	yes	yes	yes	no	no	Catalyst monitoring has improved with more experience
1Q0401-15	1997	Jeep	Wrangler	empty can	yes	yes	yes	no	no	Catalyst monitoring has improved with more experience

Appendix C
Emission Benefit Calculations

ARB's EMFAC model, historic Smog Check failure rate data, and data from ARB's in-use surveillance programs were used to estimate the emission impact of discontinuing tailpipe testing for OBD II equipped vehicles. The overall approach to the analysis calculates a statewide impact on a tons per day basis by estimating the population of high emitting vehicles that might be missed by an OBD only inspection procedure multiplied by an estimate of the corresponding emissions impact per vehicle per day. Estimates were calculated for calendar years 2010, 2015, and 2020. For each calendar year scenario, the staff calculated the emission impact with all OBD II equipped vehicles included, with the 5% of the vehicles most likely to fail an ASM test without MIL illumination excluded, and with 1996 through 1999 model years excluded. Results for these three scenarios are presented in Table 5 in the body of this report.

Smog Check failure rates for the three future calendar year scenarios studied were estimated by correlating 2007 Smog Check failure rate data on the basis of vehicle age. For example, 2005 model year vehicles within the CY2007 Smog Check database are on average approximately 3 years old. Therefore, the 2005 model year failure rate data was used to estimate the failure rate of 2008 model year vehicles under the CY2010 scenario, and 2013 model year vehicles under the CY2015 scenario. The table below presents the correlations on a model year basis.

Table C-1: Estimated Smog Check Failure Rates

CY2007 Smog Check Data				Model Year Represented for Future CY Analyses		
Model Year	Vehicle Age	% Fail Emissions	% Fail GP Limit	CY2010	CY2015	CY2020
2007	1	0.46%	0.15%	2010	2015	2020
2006	2	0.24%	0.06%	2009	2014	2019
2005	3	0.33%	0.05%	2008	2013	2018
2004	4	0.22%	0.06%	2007	2012	2017
2003	5	0.32%	0.08%	2006	2011	2016
2002	6	0.45%	0.11%	2005	2010	2015
2001	7	0.58%	0.14%	2004	2009	2014
2000	8	1.32%	0.30%	2003	2008	2013
1999	9	1.53%	0.28%	2002	2007	2012
1998	10	3.18%	0.56%	2001	2006	2011
1997	11	4.16%	0.71%	2000	2005	2010
1996	12	6.88%	1.10%	1999	2004	2009
1995	13	8.64%	1.76%	1998	2003	2008
1994	14	11.28%	2.41%	1997	2002	2007
1993	15	14.37%	3.28%	1996	2001	2006
1992	16	12.66%	3.98%		2000	2005
1991	17	13.79%	4.45%		1999	2004
1990	18	15.21%	5.17%		1998	2003

1989	19	16.28%	5.85%		1997	2002
1988	20	18.84%	7.27%		1996	2001
1987	21	21.90%	8.86%			2000
1986	22	20.32%	9.13%			1999
1985	23	23.21%	11.07%			1998
1984	24	24.59%	12.27%			1997
1983	25	23.42%	10.95%			1996

The failure rate data was then used to determine the number of high emitting vehicles that would pass an OBD based inspection within the range of percentages presented in Appendix B. The total number of vehicles that would fail under current Smog Check procedures was obtained on a model year basis by multiplying the failure rates indicated above with vehicle population and attrition estimates provided by EMFAC. Values were calculated separately for vehicles failing at the standard and gross polluter cutpoints. The fraction of these vehicles that would pass an OBD II based inspection was then determined by simply factoring in the estimated percentage that would be "missed," as estimated in Table B-4 in Appendix B. The example below is for calendar year 2015. Vehicles less than 6 years old were not included in the analysis because they are not subject to biennial Smog Check inspections.

Table C-2: Estimated Number of ASM Failing Vehicles "Missed" by OBD II Inspection Program – CY 2015

Model Year	Initial Tests based on Vehicle Pop	Total # ASM Failures	Total # ASM GP Failures	# ASM Failures Missed	# ASM GP Failures Missed
1996	282,014	53,131	32,714	12,696	4,170
1997	362,253	58,975	37,674	14,092	4,803
1998	417,595	63,516	38,419	15,177	4,897
1999	504,492	69,569	41,368	16,624	5,273
2000	629,684	79,718	45,337	3,573	1,084
2001	685,541	98,512	47,302	4,415	1,131
2002	691,076	77,953	40,773	3,494	975
2003	718,757	62,101	35,219	2,783	842
2004	721,636	49,649	12,268	2,225	293
2005	709,406	29,511	8,513	1,323	204
2006	725,813	23,081	6,532	1,034	156
2007	736,341	11,266	3,682	505	88
2008	752,711	9,936	4,516	445	108
2009	786,510	4,562	4,719	136	75
Total	8,723,825	691,480	359,037	78,523	24,100

Data from ARB's In-Use Surveillance testing programs was used to estimate the emission impact on a per vehicle basis of high emitting vehicles missed through discontinuation of tailpipe testing. Within the testing programs, in-use vehicles are procured from California motorists and tested at the ARB's Haagen-Smit Laboratory. Vehicles are typically subjected to both an FTP and ASM test in their as received conditions. The data were used to separately calculate average FTP emission rates for vehicles passing the ASM test and those that failed. The difference between the two emission rates was used to represent the emission reductions that would be lost on a per vehicle basis. Data going back to model year 1990 was included in order to increase the number of data points for vehicles failing the ASM test. The baseline (as received) emission rates for these vehicles are summarized below. Although the sample size of ASM failing vehicles is not large, the data provide a direct comparison of ASM and real world emission levels, and appears to be the best available dataset upon which an estimate can be built.

Table C-3: ARB In-Use Surveillance Data (1990+ Model Year)

	Ave. FTP Emission Levels			Difference From ASM Passing			Sample Size
	HC	CO	NOx	HC	CO	NOx	
Pass ASM	0.22	2.68	0.38	N/A	N/A	N/A	250
Fail or GP ASM	0.70	6.59	0.99	0.48	3.92	0.61	19
Fail ASM only	0.55	4.24	0.92	0.33	1.57	0.54	15
GP ASM only	1.26	15.40	1.26	1.04	12.72	0.88	4

The emission rates were then combined with the vehicle population figures and vehicle activity rates provided by EMFAC to calculate the statewide tons per day impact. An example calculation for the calendar year 2015 scenario is show in the table below. In this scenario all OBD II equipped vehicles were included.

Table C-4: Emission Impact - Calendar Year 2015

Model Year	# ASM Failures Missed	# ASM GP Failures Missed	Vehicle Miles Travelled (per day)	Statewide Emissions Impact (tons per day HC+NOx)
1996	12,696	4,170	22	0.46
1997	14,092	4,803	22	0.53
1998	15,177	4,897	23	0.57
1999	16,624	5,273	23	0.64
2000	3,573	1,084	24	0.14
2001	4,415	1,131	25	0.16
2002	3,494	975	25	0.14
2003	2,783	842	26	0.11
2004	2,225	293	27	0.07
2005	1,323	204	27	0.05
2006	1,034	156	28	0.04
2007	505	88	29	0.02
2008	445	108	30	0.02
2009	136	75	31	0.01
			Total	**2.95**