DEPARTMENT OF CONSUMER AFFAIRS

BAR

Bureau of Automotive Repair

Smog Check Performance Report 2022

July 1, 2022

Introduction and Summary

This report provides an update on California's Smog Check Program (Program) pursuant to Assembly Bill (AB) 2289 (Eng, Chapter 258, Statutes of 2010), which requires an annual evaluation of the Program and the performance of Smog Check stations. This legislation directed the California Bureau of Automotive Repair (BAR) to implement both inspection-based performance standards for stations inspecting directed vehicles[1] and On-Board Diagnostics (OBD II) focused inspections for newer vehicles. It also enhanced BAR's ability to identify and take action against stations performing improper inspections. The 2022 Smog Check Performance Report (SCPR) satisfies the statutory reporting requirement for 2021.

AB 2289 requires that BAR, in cooperation with the California Air Resources Board (CARB), perform certain analyses of Smog Check-related data and annually report the results of these analyses to the public. Specific information required to be presented in this report include:

- The percentage of vehicles initially passing a Smog Check that subsequently fail a roadside inspection.
- The percentage of vehicles that initially fail (and later pass) Smog Check that fail a subsequent roadside inspection.
- An estimate of the excess emissions associated with these vehicles.
- A best-effort explanation of the reasons why these vehicles may have been inappropriately passed or failed within Smog Check.
- A comparison of current findings to those included in the 2009 report entitled "*Evaluation of the California Smog Check Program Using Random Roadside Data*" (the "2009 Report").

In addition to the above, AB 2289 requires BAR to offer recommendations for modifications to the existing program geared toward reducing "excess emissions" to a minimum and to consider those best practices implemented by other states or provinces. The term "excess emissions" is traditionally used to describe levels of pollutants that are over and above those to which a vehicle has been certified, however the term is used in this report to describe those additional benefits that could be realized if all vehicles were inspected at "high-performing" Smog Check stations.

The Smog Check Program is a biennial program requiring the inspection of vehicles' emission control components and systems every other year. The analyses included in this report are based upon data collected during calendar years (CY) 2020 and 2021, representing the latest complete test cycle for the entire fleet. For purposes of these analyses, the fleet was subdivided into two broad groups; pre-2000 model year (MY) vehicles that receive an Acceleration Simulation Mode (ASM) or Two Speed Idle (TSI) exhaust emissions test, and those 2000 and newer MY vehicles equipped with OBD II that receive an On-Board Diagnostic Inspection using the BAR OBD Inspection System or OBD Inspection System (OIS).

---

[1] "Directed vehicles" include all 1976-1999 MY vehicles, and those newer vehicles identified as having the greatest likelihood of failing their next inspection. These vehicles are required ("directed") to be certified at STAR-certified stations.

A summary of the test results for 1976 to 2021 MY vehicles inspected in CYs 2019-2020 and 2020-2021 is presented in Table 1 below. Separate results are shown for vehicles that initially failed Smog Check and subsequently received certification (FAIL), and those which initially passed Smog Check (PASS). Overall, vehicles failed at roadside at a statewide fleet-weighted rate[2] of about 16%, which can be compared to the 17% overall failure rate found in the CY 2019-2020 roadside sample. For reasons explained later in this report, sufficient data was not available to present separate results for tailpipe and OIS tested vehicles.

Table 1
Roadside Failure Rates of Tested Gasoline-Powered Vehicles, MY 1976-2021*

Initial Smog Check Results	Roadside Failure Rates Within One Year after Smog Check (CY 2019-2020)	Roadside Failure Rates Within One Year after Smog Check (CY 2020-2021)
FAIL	23% (684)	22% (263)
PASS	16% (5858)	15% (2497)
Overall	**17% (6542)**	**16% (2760)**

* Sample sizes are shown in parentheses beneath the failure rate percentages.

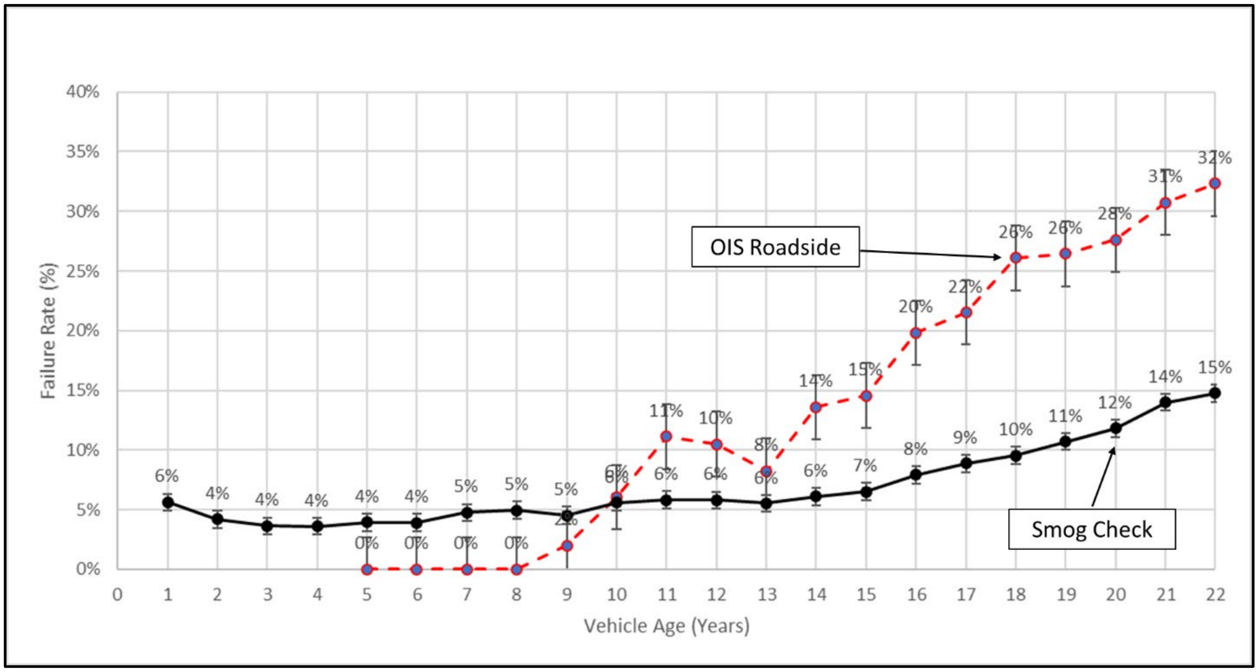
Figure 1 presents the age specific initial failure rates for the OIS tested fleet in addition to the results of roadside inspections. Vehicle age is determined by subtracting model year from calendar year (Vehicle Age=CY-MY). It is important to note that vehicles eight years old and newer are currently exempt from biennial inspection. However, these vehicles are required to undergo inspection upon initial registration in California and upon change of ownership (COO). Both the roadside and Smog Check datasets reflect a strong relationship between vehicle age and failure rate. However, as can be seen in Figure 1, the Smog Check failure rate increased by a factor of 2.5 from age 10 to 22 years (going from 6% to 15%), while the roadside failure rate increased by a factor of 5.3, more than twice as much, over the same period (going from about 6% to 32%). It is reasonable to ask why this difference exists.

As vehicles age, emission control components become less effective or fail outright and it is the objective of the Smog Check Program to identify these vehicles for repair. However, the observed difference between the age specific Smog Check and roadside failure rates suggests that at least a portion of the difference can be attributed to some Smog Check stations passing vehicles that would have failed if properly inspected. If all Smog Check stations performed proper inspections and made effective and lasting repairs, the failure rates observed at roadside would more closely match the overall Smog Check results.

---

[2] Roadside failure rate percentages are weighted to match the numbers of initial Smog Check tests performed in the State.

Figure 1
OIS Fail Rates by Vehicle Age using Smog Check and Roadside Testing Data
(CY 2020-2021, MY 2021 and Older Gasoline-Powered Vehicles)*

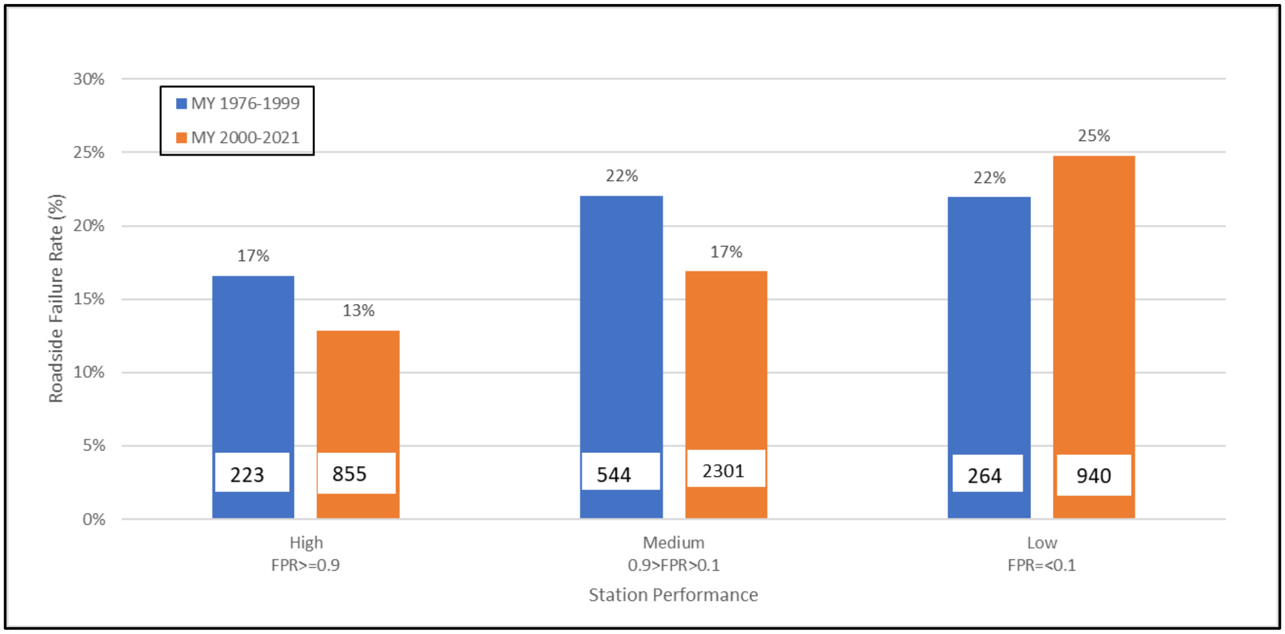


*Error bars reflect the 95% confidence intervals

BAR has taken steps to improve station and technician performance through effective education and administrative discipline. These individuals and entities are subject to a process of progressive discipline that typically begins with reminders and warnings but will, in the extreme case of fraudulent testing, result in license revocation as required by State law. Supporting evidence for the efficacy of BAR's enforcement approach can be seen in the roadside data shown in Figure 2 (below). It is of particular interest that vehicles in both MY ranges certified by the "high performing" Smog Check stations, those with a Follow-up Pass Rate (FPR)[3] score of 0.9 or above, were found to have consistently lower roadside failures compared to those certified by both categories of lower-performing stations.

[3] "Follow-up Pass Rate" (FPR) is, in brief, "…a performance measure that evaluates whether vehicles previously certified by each station or technician are passing, in their current cycle, at higher-than-expected rates." CCR, Title 16, Division 33, Chapter 1, Article 5.5, §3340.1, "Follow-up Pass Rate."

Figure 2
Performance of Certifying Smog Check Station vs. Roadside Failure Rates
CY 2020-2021 Roadside Data*



*Where the terms "Low,"" Medium," and "High" represent the station performance based on FPR score. The numbers within the bars reflect the number of stations included in the analysis.

Summary of Findings

Analysis of the CY 2020-2021 roadside test data, Smog Check inspection data, and related information presented, discussed, and/or cited in this report lead BAR to conclude the following:

1. MY 1976-2021 vehicles included in the CY 2020-2021 roadside sample failed at a MY weighted rate of about 16% compared to 17% observed in the CY 2019-2020 roadside sample.
2. Vehicles certified by "high performing" Smog Check stations failed at a lower rate during roadside inspections compared to vehicles certified by Smog Check Stations with lower FPR scores.
3. Incremental improvements to the Smog Check Program are evidenced through declining differences between roadside and Smog Check failure rates, and an increase in enforcement actions against stations and technicians engaging in fraudulent practices.
4. BAR and CARB staff estimate that in CY 2021, Smog Checks could have provided approximately 53 additional tons per day (tpd) of exhaust emission reductions of reactive organic gases (ROG) and oxides of nitrogen (NOx) from gasoline-powered vehicles subject to Smog Check if all stations operated as effectively as high-performing stations.

After a review of BAR's Roadside Inspection Program data collection efforts conducted in support of the 2022 SCPR, this report discusses the following:

- BAR's efforts to improve station performance in the Smog Check Program;

- Information about the relationships between vehicle age, Smog Check station performance, and other factors that affect on-road emissions;
- Excess emissions associated with sub-optimal station performance
- An update on what other states are doing to reduce emissions through inspection and maintenance (I/M).

Background

A comprehensive program evaluation report[4] prepared for CARB and BAR ("2009 Report"), Austin, *et. al.,* examined the differences between failure rates at the roadside and the initial test results from Smog Check. The significantly higher failure rates observed during roadside inspections led the authors to conclude that:

"…many of the vehicles that initially failed during the previous Smog Check cycle were not actually repaired or were repaired only temporarily."

Further investigation into prior Smog Check histories showed that many of the excess and premature failures seen at roadside were due to vehicles that had previously failed Smog Check that were subsequently certified, presumably having been repaired. The authors estimated that the Smog Check Program could have achieved an additional reduction of 70 tons per day (tpd) of excess emissions of hydrocarbon (HC) and oxides of nitrogen (NOx) had these vehicles been properly inspected and repaired.

To address this issue, the authors suggested that BAR:

- Further refine the station performance algorithm for increased enforcement
- Create incentives for more stations to become high performing
- Perform inspections of vehicles immediately following certification at Smog Check stations through either roadside or on-site testing
- Continue roadside inspections to provide data for Smog Check performance assessment and to target low performing stations for additional enforcement

BAR, with the assistance of the California Highway Patrol (CHP), conducts roadside inspections in "enhanced areas" of the state, those urbanized areas experiencing serious, severe, or extreme air quality problems. During these inspections, vehicles are directed by a CHP officer to a roadside inspection area where they are tested in a manner similar to what is required as part of Smog Check.

To minimize inconvenience, participation in roadside inspection is voluntary, and participation does not affect the Smog Check pass/fail status of any of the vehicles tested. The only objective of this program is to gather data that can be used to independently audit the performance of the Smog Check Program as a whole.

[4] Austin, T., McClement, D., and Roeschen, J.D., 2009, "Evaluation of the California Smog Check Program Using Random Roadside Data, Report No. SR09-03-01, March 12, 2009, Sierra Research,
http: www.calautoteachers.com/PDF/Final_RoadsideReport_O31209.pdf

The voluntary nature of the roadside testing program coupled with the impacts of the pandemic, and a shift in the CHP priorities, has resulted in fewer tests being performed for the current assessment compared to earlier years. Approximately 6,800 vehicles, roughly divided into 90% 2000 and newer MY OIS tested vehicles, and 10% 1999 and older tailpipe tested vehicles were used to support the findings in this report (See Table 2). The relative scarcity of test data for pre-2000 MY vehicles preclude the presentation of separate results for OIS and tailpipe tested vehicles as has been done in previous reports.

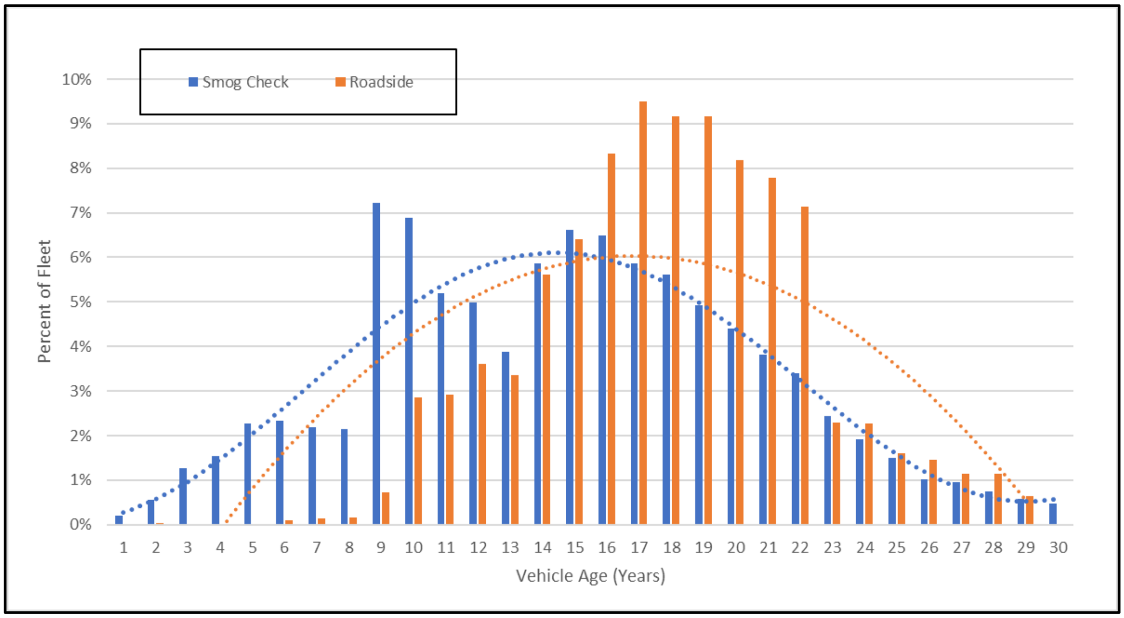
Table 2
Roadside Inspection Datasets

Vehicles Tested

Model Year Group	**CY 2019**	**CY 2020**	**CY 2021**
1976-1995	877	124	175
1996-1999	1,576	264	446
2000-2003	3,152	538	1,080
2004-2006	2,310	452	1,015
2007+	2,925	712	2,038
Total	**10,840**	**2,090**	**4,754**

Figure 3 presents the MY distribution of the CY 2020-2021 roadside dataset, as well as the distribution of initial tests performed within Smog Check for the same period. Given that newer vehicles are exempt from biennial inspection and understanding that older vehicles are more likely to develop problems with their emission control systems, older vehicles are purposefully oversampled at roadside compared to Smog Check. As can be seen in Figure 3, the resulting fleet weighted average age of the roadside dataset is two MYs older (16.3 yrs.) compared to Smog Check (14.3 yrs.) To account for the difference in the average age of the stratified random roadside sample, BAR weights the sample results by the number of initial Smog Check tests, i.e., the number of unique vehicles of each MY or MY group in the overall California fleet before computing the actual statistics for the fleet.

Figure 3
Population Distributions by MY for Roadside and Smog Check Tested Vehicles



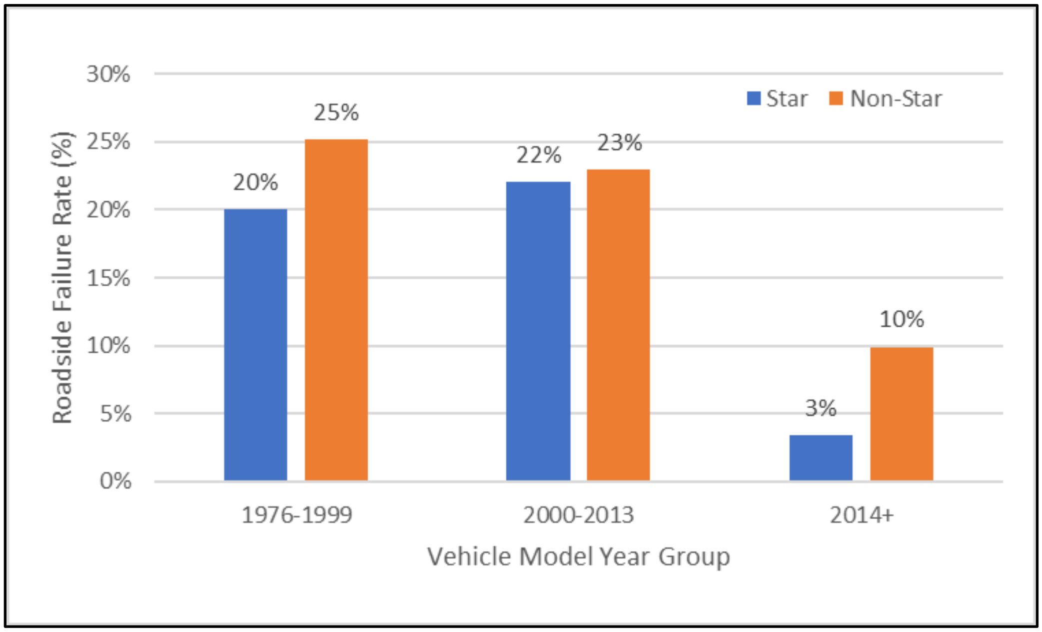
Efforts to Improve Station Performance

The voluntary STAR program was established by BAR in 2013 for Smog Check stations seeking to test directed vehicles. Stations and inspectors participating in the STAR program have their performance assessed against other stations and inspectors within the Smog Check Program. As an incentive for improvement, each year BAR directs a portion of the enhanced area fleet, including vehicles designated as “gross polluters,”[5] to those stations that meet all STAR requirements. The effectiveness of the STAR program is evidenced by the consistently lower roadside failure rate of STAR stations’ certified vehicles compared to the failure rate of vehicles certified by non-STAR stations (See Figure 4 below).

BAR has also acted aggressively to identify and take corrective action against those suspected of fraudulently certifying vehicles. Individuals and entities suspected of performing fraudulent Smog Checks risk revocation of their license(s) if found guilty. This process involves formal accusations that are filed by BAR against the licensees who committed the alleged fraud, and due process is afforded to them through hearings conducted by the Office of Administrative Hearings (OAH) or, when appropriate, through civil or even criminal proceedings in other courts.

[5] “Gross Polluters” pollute much more than typical vehicles that fail a Smog Check. The emission levels associated with Gross Polluters varies according to vehicle type and year, however they typically exceed at least one or more of the gross polluter standards (twice the minimum emissions limit).

Figure 4
Roadside Failure Rate as a Function of Station Type Where Vehicle was Last Certified



The most prevalent fraudulent techniques used by Smog Check stations are:

- Clean Piping
- Clean Gassing
- Clean Plugging
- Clean Tanking, and
- Registration-based fraud

"Clean piping" involves fraudulently obtaining an emissions sample from a vehicle that is known to pass a Smog Check and representing the results as having been taken from a vehicle that is the actual subject of the test. "Clean gassing" is a method by which a surrogate gas is introduced into an Emission Inspection System (EIS)[6], so that the EIS will measure the surrogate gas or a mixture of surrogate gas and exhaust emissions and issue a passing test result based upon those readings rather than the actual vehicle emissions.

Newer vehicles (MY 2000+) are not subject to tailpipe testing, instead the vehicles' OBD systems are queried electronically to determine compliance with Smog Check requirements. The practice of "clean plugging" then, is the modern equivalent to clean piping in that the electronic data reportedly collected from the vehicle being inspected is obtained from a completely different vehicle or from a device designed to generate passing readings.

[6] The BAR 97 Emission Inspection System (EIS) inspects vehicles under simulated driving conditions to detect HC, CO, and NOx.

“Clean Tanking” involves reporting fraudulent evaporative control system test results that are actually derived from a tank other than the fuel tank of the vehicle supposedly being tested.

Finally, Registration-based fraud involves providing false information to Department of Motor Vehicles (DMV) in order to obtain registration without a required Smog Check. Using this mechanism, some vehicle owners have obtained repeated vehicle registration renewals.

In response to these and other highly improper and/or illegal acts, BAR has developed and continues to refine its ability to identify suspicious activities and to gather data and other related evidence to support administrative and legal actions to combat and deter fraud and other illegal Smog Check related activities. Table 3 provides a summary by year of BAR’s case filings with the California Office of the Attorney General (OAG), along with case outcomes for each year.[7] It should be noted that filings may take more than a year to resolve, therefore the number of outcomes may not match those of case filings on a year-to-year basis. Table 3 reflects case filings that were based on assessment of Smog Check data only and excludes other Smog Check case filings that were based on more traditional BAR investigations or investigations and actions by DMV[8].

Table 3
Summary by Year of BAR Smog Check Data-Only Case Filings and Outcomes
(Outcomes Still Pending on Some Filings as of this Writing)

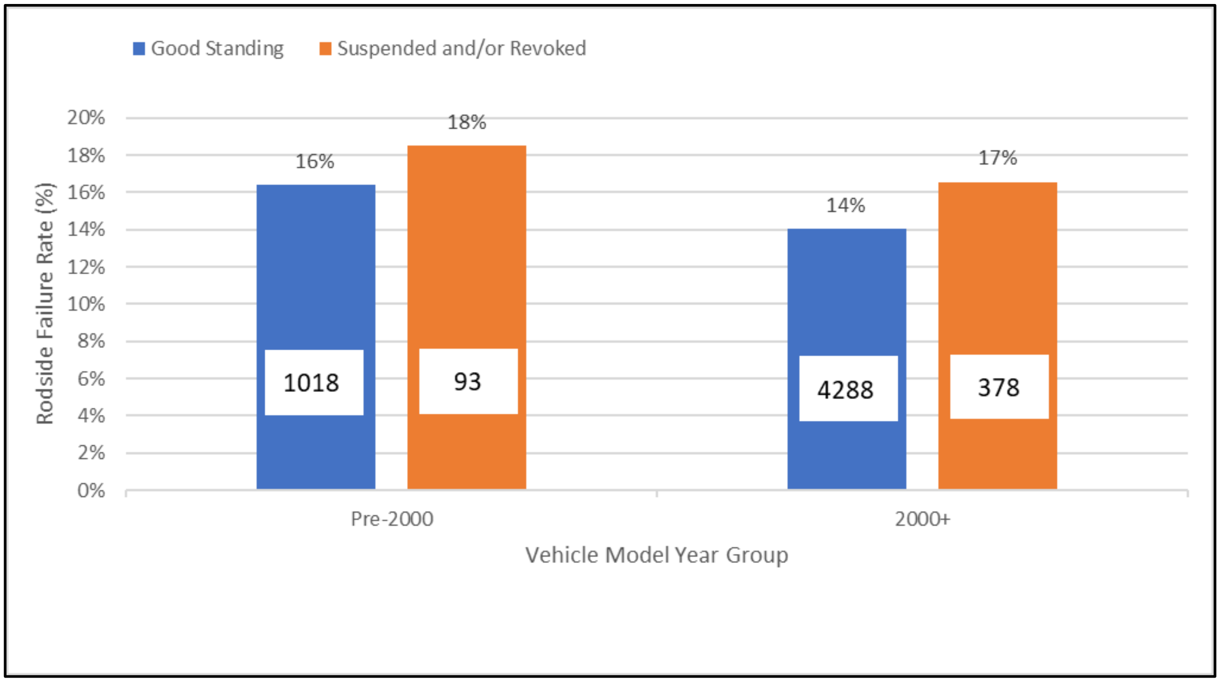
Year	Case Filings to AGO	Outcome: Revocation	Outcome: Suspension	Outcome: Probation
2016	117	2	0	0
2017	555	39	0	3
2018	252	280	9	9
2019	63	342	30	48
2020	96	249	24	69
2021	99	124	36	47
Total	**1182**	**1036**	**99**	**176**

[7] Enforcement actions are published on BAR’s website in a searchable format at Enforcement Actions - Bureau of Automotive Repair (ca.gov)

[8] “Traditional” investigations conducted by BAR include, but are not limited to, the use of undercover vehicles with implanted defects and surveillance.

Figure 5 illustrates the superior performance of stations in good standing compared to those that have had their licenses suspended or revoked, again using the roadside failure rates as a metric of station performance. Figure 5 clearly shows the benefit of reduced roadside fail rates when stations that commit fraud have their licenses suspended and/or revoked.

Figure 5
Roadside Failure Rate by MY Group and Station License Status Where Vehicle was Last Certified



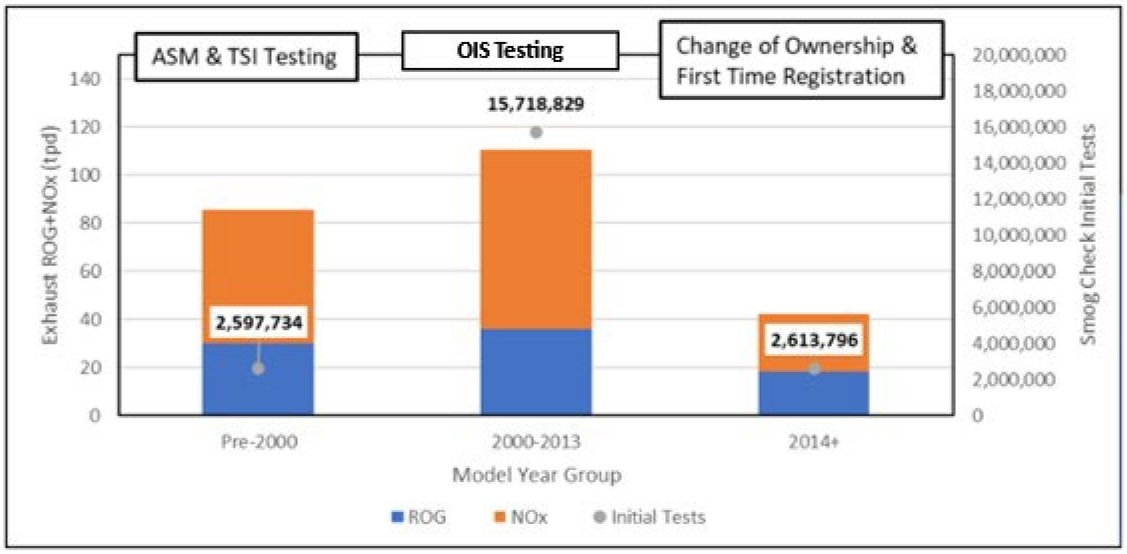
Current Estimate of Excess Emissions

The authors of the 2009 Report used roadside ASM test results in order to estimate the excess emissions that could have been reduced if all Smog Check stations were high performing. Because emissions are not measured for 2000 and newer MY vehicles in Smog Check (approximately 90% of the on-road fleet), differences in emission levels of vehicles certified by high and low performing stations could not be estimated reliably for this report. Alternatively, CARB's official on-road vehicle emissions inventory model, EMFAC (Emission Factor) Model, supplemented with Smog Check and roadside fail rate data was used to estimate the excess emissions of the CY 2021 fleet.

CARB developed, maintains, and routinely updates their EMFAC computer model, which is designed to estimate the emissions of the on-road fleet. The latest version of the model, EMFAC2021 (v1.0.1), was used to estimate the excess emission associated with the Smog Check program which can also be viewed as the additional benefits that might be obtained through programmatic improvements.

According to the results from EMFAC, gasoline-powered light-duty autos, light, medium, and light-heavy-duty trucks with a gross vehicle weight rating (GVWR) of less than 14,001 pounds contribute a total of 256 tpd of ROG+NOx to the CY 2021 statewide emissions inventory. A breakdown of the emissions inventory by MY group and pollutant is shown in Figure 6 below.

Figure 6
Exhaust ROG + NOx Emissions by Model Year Group and Number of Smog Check Inspections for CY 2020-2021

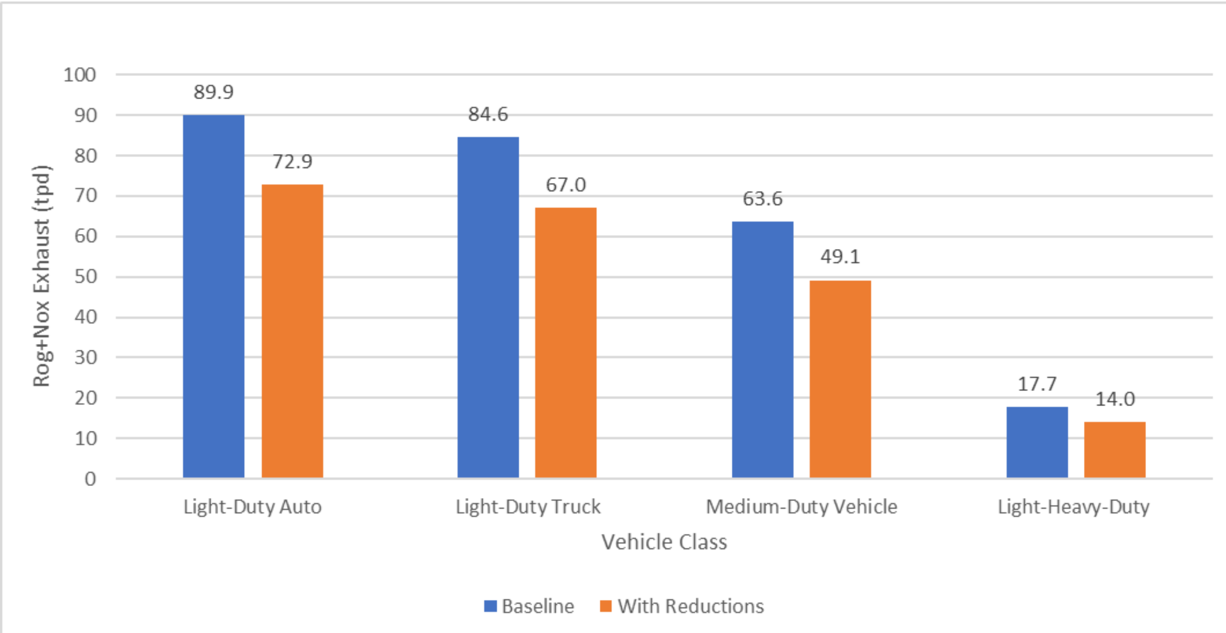


It is important to note that EMFAC does not explicitly model the impact of the Smog Check Program on the emissions inventory. Like roadside inspections, the benefits of the Program are assumed to be implicitly reflected within the baseline. Further, it is assumed within CARB's model that increases in fleet emissions are directly attributable to the degradation in effectiveness, or the complete failure of emission control components and systems.

Under these assumptions, a one-to-one relationship was established between the age specific failure rates as observed during roadside and initial Smog Check inspection, with the age specific emissions rates as estimated by EMFAC. The potential benefit was determined by lowering the roadside failures to a level equal to Smog Check failures and recalculating emissions. Using this methodology, it is estimated that approximately 53 tpd of additional benefit (reduction in emission of ROG+NOx) could be achieved if all Smog Check stations were to perform at the level of high performing stations (See Figure 7 below). That is, if roadside failure rates were the same as Smog Check failure rates, the resulting reduction in emissions would be equivalent to removing close to eight million gasoline-powered passenger cars from daily operation.[9]

[9] A sample calculation of potential emission reduction is included in this report as Appendix C.

Figure 7
Contribution of Model Year Groups of Exhaust ROG + NOx and Smog Check Inspections for CY 2020-2021*



Evaluation of Best Practices of Vehicle Inspection Programs

The following is a summary of the current techniques, practices, and procedures utilized within I/M programs conducted in 30 US states, the District of Columbia, and Ontario, Canada. It is important to note that Ontario rescinded its requirement for the emissions testing of light-duty vehicles in 2019. The state of Washington soon followed suit ending its vehicle emission testing program in 2020. Also in 2020, the state of Ohio suspended all tailpipe emission testing of non-OBD equipped vehicles.

Each of the programs evaluated here were found to utilize at least one, but more typically some combination of two or more of the test procedures described below.

OBD Tests

OBD tests are typically administered to 1996 and newer MY gasoline-powered vehicles and 1998 and newer MY diesel-powered vehicles equipped with OBD systems. The test is performed while the vehicle is stationary. After contact is made with the OBD system, the vehicle's on-board computer system is queried to access readiness and fault codes that are relevant to determining the functioning of components and systems that are critical to emissions control.

Loaded Mode Tests

Typically administered to 1995 and older MY (pre-OBD) vehicles weighing less than 14,001 lbs. GVWR, loaded mode tests require vehicles to be operated under load on a treadmill-like device called a dynamometer. Emissions are measured while the vehicle is in motion. Several different driving cycles (vehicle speed / time / load traces) are used throughout the states including the I/M 97, I/M 147, I/M 240, the ASM 25/25, and the ASM 50/15. (The number following “I/M” in the name of the test denotes the length of the test cycle in seconds. The numbers in the numerator and denominator that follow “ASM” in the name of the test denote the load on the vehicle and the vehicle speed, respectively).

Idle Tests

Although best practices dictate that a loaded mode tests be performed, idle tests are cheaper to perform and are typically administered to older vehicles (pre-catalyst equipped) or vehicles that cannot easily or safely be tested on a dynamometer (including most all-wheel drive vehicles, some vehicles with anti-lock braking systems and vehicles weighing more than 14,000 lbs. GVWR). During an idle test, tailpipe emissions of HC and carbon monoxide (CO) are collected from a stationary vehicle operating at one or more engine speeds (low and/or high idle). The vehicle must be under load in order to test for emissions of NOx.

Gas Cap/Evaporative System Tests

A properly sealing gas cap is essential in limiting evaporative emissions from escaping the fuel tanks of gasoline-powered vehicles. During the gas cap test, a technician may perform a visual examination to see that the cap fits tightly to the fuel filler neck or a functional check to ensure that the cap can hold pressure without leaking. Some states including California also perform a test of the vehicle’s evaporative emission control system. Using an adaptor in place of the gas cap, and temporarily sealing a vapor line, a small amount of pressure is applied to test for leaks.

Opacity Tests

Typically administered to diesel-powered vehicles, opacity tests are performed to determine the amount of light absorbed by the vehicle’s exhaust as a proxy for emission levels of particulate matter. The exhaust plume is evaluated while the vehicle is in operation. Various test procedures are used to determine opacity including:

- The **snap-idle** or **snap-acceleration** test calls for the engine speed to be raised from idle to the maximum speed as rapidly as possible with the vehicle in park, followed by fully releasing the throttle allowing the engine to return to idle.
- The **Lug-Down** is a loaded test performed either on-road or on a dynamometer. At wide open throttle (WOT) the engine is slowly loaded using the service brakes. Loading is applied linearly throughout an engine rpm range from maximum to seventy percent in no less than seven seconds.
- The **Stall Test** Procedure is a full-load stationary test designed for vehicles equipped with automatic transmissions. With the vehicle brakes applied, engine speed is increased until the transmission’s stall speed is attained.[10] Stall speed is maintained for approximately five seconds to allow for stabilization.

[10] Stall speed is the maximum engine RPM achieved with the transmission in a forward operating gear without generating any driveshaft motion (i.e., the vehicle remains stationary).

- The **High Idle** Test Procedure is performed with the vehicle's transmission in neutral. The engine speed is slowly increased to the maximum governed no-load rpm and the plume is evaluated when the rpm stabilizes.

Visual inspections

Technicians may perform a visual inspection of the vehicle to determine the presence and condition of the of the following components:

Visually Inspected Components

- Crankcase Emission Controls
- Fuel Evaporative System
- Exhaust Gas Recirculation
- Fuel Metering System
- Computers, Sensors, and Switches
- Liquid Fuel Leaks
- Thermostatic Air Cleaner
- Exhaust Gas After Treatment System
- Ignition Spark Controls
- Air Injection System
- Other Emission Related Components
- Visible Smoke

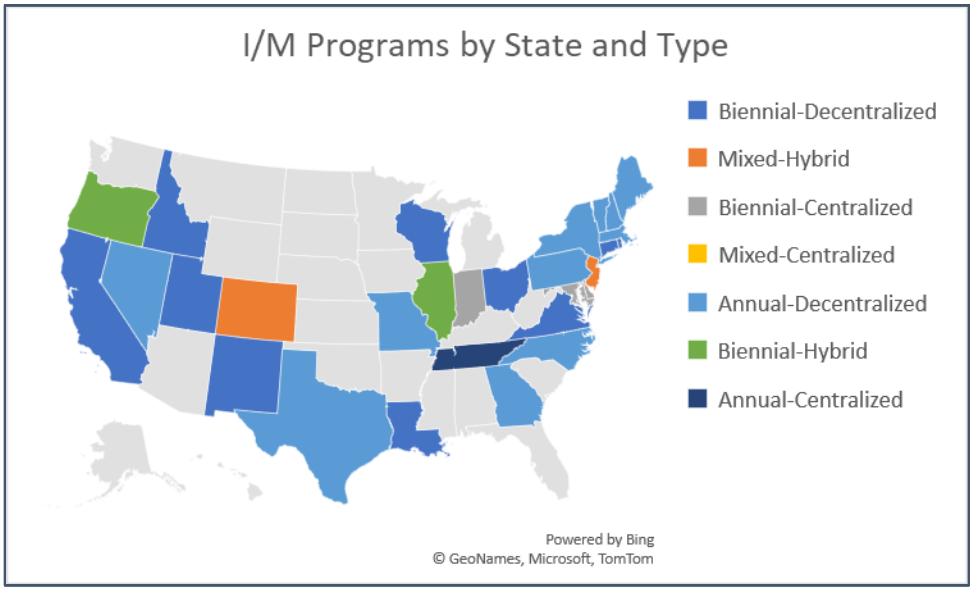
I/M Program Summary

The programs evaluated in this summary can be divided into broad categories by:

- **Program Administration** (i.e., who holds primarily responsibility for vehicle testing)
    - Centralized (test performed by government or their contractor)
    - Decentralized (test performed by entities licensed by the state) or
    - Hybrid, which is a mixture of both centralized and decentralized testing
- **Frequency of testing**
    - Annually – every year
    - Biennially – every other year

The majority of states were found to operate decentralized programs with an annual inspection requirement (11 states). The second most frequently occurring program structure is decentralized biennial. which is utilized in California and nine other states including Connecticut, Idaho, Louisiana, New Mexico, Ohio, Rhode Island, Utah, Virginia, and Wisconsin. Three states, Maryland, Indiana, and Delaware, employ centralized-biennial programs, two administer centralized-mixed programs. Arizona and the District of Columbia. Illinois and Oregon utilize a hybrid-biennial approach, while Colorado and New Jersey run a hybrid-mixed program. Tennessee alone has adopted a centralized-annual program.

Figure 8
I/M Program Administration and Inspection Frequency by Area



- There are currently five contractors supporting state I/M programs. Opus/Gordon Darby now administers I/M programs in 19 states and the District of Columbia. Applus+ Technologies supports seven states, Worldwide Environmental Products (WEP) holds contracts in four states, Parsons Engineering Science operates in three states, and OnCore Consulting supports a single program (California).
- In October 2020, Opus/Gordon Darby was awarded a four-year contact to perform the emission testing in Cache County, Utah, with an option for an additional four-year extension. That program was formerly administered by WEP.
- Fourteen states and the District of Columbia conduct safety inspections in addition to emissions testing. These states tend to conduct annual inspections and require the acquisition and display of window stickers as proof of compliance. The remaining states tie compliance with periodic emissions inspection directly to registration renewal.
- Eleven states and the District of Columbia require vehicles to be tested upon change of ownership. Two additional states, North Carolina and Rhode Island, require testing upon change of ownership only when the vehicle is sold by a dealer.
- California's program is conducted statewide, as are the programs in eight other states. The remaining states require testing only in those areas deemed to have air quality significantly and adversely impacted by on-road vehicles.
- The overall number of emissions testing stations has fallen over the past year. Some of the attrition can be attributed the pandemic and some to the steadily diminishing population of pre-OBD vehicles.
- California had 7,600 licensed stations by year-end 2020, which is third in network size behind Pennsylvania (8,000 stations) and New York (10,000 stations). Other states

range from as few as two stations in the District of Columbia, to as many as 5,700 in Texas.

- The average cost of inspection varies widely from state to state and by test type. The cost associated with annual inspection ranges from as little as $9.00 in Tennessee, to as much as $52.50 in Missouri. For those biennial programs that charge an inspection fee, costs range from a low of $12.25 in Tucson, Arizona, to a high of $75.00 in New Jersey. Delaware, Indiana, Ohio, and Wisconsin do not charge inspection fees.
- Except for Idaho, all states and the District of Columbia require the periodic testing of hybrid-electric vehicles.
- Given the low failure rate among the newest vehicles in the fleet, most I/M programs exempt new vehicles from testing. Maine, Massachusetts, and New Hampshire do not allow test exemptions based on vehicle age.

Supplemental Programmatic Elements

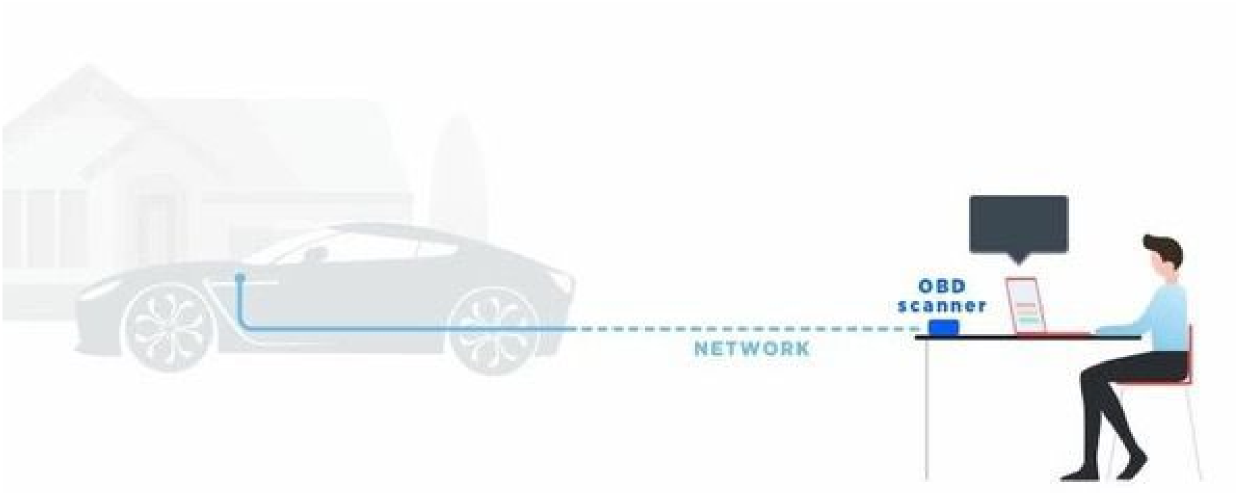
In addition to the features described above, several states have implemented supplemental test procedures designed to either better identify those vehicles most likely to benefit from inspection or provide greater convenience to consumers.

- **Remote Sensing**

Remote Sensing Devices (RSD) are capable of measuring emissions as vehicles pass the device deployed on the roadside and are an integral part of the I/M programs in Colorado, Ohio, and Rhode Island. The advantage of using RSD is that a large number of vehicles can be measured in a relatively inexpensive and time efficient manner. However, because RSD captures only a "snapshot" of the vehicle's emission under either uncontrolled or loosely controlled driving conditions, RSD is typically used to make coarse determinations of either very low emitting vehicles for exemption from conventional testing, a practice referred to as "clean screening," or detection of very high emitting vehicles referred to as "dirty screening." It is important to note that dirty screened vehicles are not failed according to their RSD readings, rather these vehicles are identified for inclusion in conventional programs for more comprehensive testing.

- **Remote OBD**

In California, Oregon, Nevada, and Utah's Davis County, portions of the light-duty fleet that are subject to periodic testing are allowed to opt into a remote OBD monitoring program. Participating vehicles are fitted with devices that allow the on-board computers to be queried remotely and relevant data are retrieved through telematics. The main advantage of this approach is the capability to continuously monitor the vehicle's emission control components and systems as compared to testing once per year or once every other year. Although currently more expensive than conventional testing, this approach has been shown to be



convenient for subscribers and has the potential of achieving surplus emission reductions in two ways. Although failures among the newest vehicles in the fleet tend to be rare, they are known to occur. According to BAR's 2020 annual report, five percent of vehicles normally exempted for age but tested for various reasons failed the OIS test. It is likely that these vehicles would have been identified and brought into compliance had they been equipped with Remote OBD. The second source of surplus emission reductions is associated with minimizing the time between malfunction and repair, which could be a year or more in a biennial program.

- **OBD Kiosks**

Maryland, Ohio, Oregon, and the District of Columbia offer a self-testing option to owners of OBD-equipped vehicles. Much like an ATM, motorists use a touch-screen computer and cable to plug-in to their vehicles' on-board computer. OBD kiosks are conveniently located and are available for testing 24 hours per day, seven days per week. Although this approach appears promising, several states have expressed reluctance to adopt this unsupervised form of testing given the prevalence of the use of surrogate vehicles and OBD defeat devices.

- **Mobile/On-Site OBD Testing**

Rather than have dealerships or fleets bring cars in one by one for testing at a licensed station, the states of Oregon and Tennessee offer on-site testing by appointment. The availability of Oregon's Mobile on-site testing (MOST) units, and Tennessee's fleet of test vans save participating consumers both time and travel costs. The same concerns

expressed regarding the use of OBD kiosks also exist with mobile testing unless the inspections are conducted by the state or their contractor.

Summary of Best Practices of I/M Programs

The following are considered best practices for I/M programs in the U.S. A summary of the different testing practices by the State is provided in Table 5.

Test Frequency:

BAR's data has shown that up to 20% of vehicles that initially pass Smog Check fail at roadside within one year on initial inspection. These data strongly suggest that significant benefits could be obtained through annual inspection. Even greater benefit might be achieved through continuous monitoring of the fleet; however, compliance would need to be decoupled from registration.

OBD-equipped vehicles:

- Perform a scan of the vehicle's on-board computer to verify that monitors have run and that no diagnostic trouble codes (DTCs) are present.
- Clearance of permanent DTC codes by running the vehicle's self-check rather than clearing codes with a scan tool or disconnecting the battery.
- Incorporation of a comprehensive system to detect fraud in decentralized programs.
- Supplemental programs have been adopted that either expand coverage, lower costs, and/or increase consumer convenience including adoption of remote OBD, the use of OBD kiosks and mobile testing.

Non OBD-equipped vehicles:

- Performance of loaded-mode dynamometer emissions testing using established cycles such as the I/M 240, I/M 147, or ASM test.
- Perform two-speed Idle emissions tests for vehicles that cannot safely or reliably tested on a dynamometer.
- The use of RSD as a quick emissions pass determinant.
- As pre-1996, non-OBD equipped vehicles continue to comprise a smaller and smaller portion of the fleet, the cost of maintaining dynamometers and systems to test these vehicles is becoming less and less practical. Requiring the dynamometer testing of this small portion of the fleet to be centralized through either the expansion of the Referee network or through a contractor would allow for better control over the testing environment and the potential to significantly reduce both fraud and the excess emissions that it causes.

Evaporative system checks:

- Low-pressure evaporative system tests to check for leaks for pre-OBD vehicles.
- Separate leak check of the fuel cap.

Visual inspection of the emission control system:

- Performance of a visual inspection for the presence and outward appearance of the catalyst, EGR system, air injection, positive crankcase ventilation, etc.

Table 4
I/M Test Requirements by State

State	Fuel	GVWR	Model Year(s)	Steady State	Loaded Mode	OBD	Gas Cap	Opacity	Visual
Arizona	Gas	-	1996+	-	-	X	-	-	X
Arizona	Gas	<8501	1967-1995	-	I/M 147	-	-	-	X
Arizona	Gas	<26001	-	-	-	-	-	Dyno	X
Arizona	Diesel	>26000	-	-	-	-	-	Snap Idle	X
California	Gas	<14001	2000+	-	-	X	-	-	X
California	Gas	-	<2000	-	ASM25/25	-	-	-	-
California	Gas	-	<2000	-	ASM50/15	-	X	-	X
California	Diesel	<14001	1998+	-	-	X	-	-	X
Colorado	Gas	-	Age 8 to 11	-	-	X	-	-	-
Colorado	Gas	-	Age 12+(>1981)	-	I/M 240	-	-	-	-
Colorado	Gas	-	<1982	TSI	-	-	-	-	-
Colorado	Diesel	-	-	-	-	-	-	X	-
Connecticut	Gas	<8500	1996+	-	-	X	X	-	-
Connecticut	Gas	8500-10000	All	PC TSI	-	-	X	-	-
Connecticut	Gas	-	1995	-	ASM25/25	-	X	-	Catalyst
Connecticut	Diesel	<8501	1997+	-	-	X	-	X	-
Connecticut	Diesel	8501-10000	-	-	-	-	-	X	-
Delaware	Gas	<8501	1996+	-	-	X	X	-	Catalyst
Delaware	Gas	-	1981-1995	TSI	-	-	X	-	Catalyst
Delaware	Diesel	-	1968-1990	Curbside	-	-	X	-	Catalyst
Delaware	Diesel	-	1997+	-	-	X	-	-	-
D.C.	Gas	<8501	1996+	-	-	X	-	-	-

State	Fuel	GVWR	Model Year(s)	Steady State	Loaded Mode	OBD	Gas Cap	Opacity	Visual
D.C.	Gas	-	1984-1995	-	I/M 240	-	-	-	-
D.C.	Gas	-	1968-1983	TSI	-	-	-	-	-
D.C.	Gas	-	1975+	-	-	-	X	-	Catalyst
Georgia	Gas	<8501	1996+	-	-	X	X	-	Catalyst
Idaho	Gas	<14001	1996+	-	-	X	X	-	X
Idaho	Gas	-	1981-1995	TSI	-	-	X	-	X
Idaho	Diesel	-	1997+	-	-	-	-	-	-
Idaho	Diesel	-	<1997	-	-	-	-	Snap Idle	-
Illinois	Gas	<8501	1996+	-	-	X	-	-	-
Illinois	Gas	8501-14,000	2007+	-	-	X	-	-	-
Indiana	Gas	<9001	1996+	-	-	X	X	-	-
Indiana	Gas	-	1981-1995	-	I/M 93	-	X	-	-
Indiana	Gas	-	1976-1980	SSI	-	-	X	-	-
Louisiana	Gas	<10001	996+	-	-	X	X	-	Catalyst
Maine	Gas	-	1996+	-	-	X	X	-	Catalyst
Maine	Gas	-	1983-1995	-	-	-	X	-	Catalyst
Maine	Gas	-	1974-1982	-	-	-	X	-	-
Maine	Diesel	>18000	-	-	-	-	-	X	-
Maryland	Gas	<8501	1996+	-	-	X	-	-	Catalyst
Maryland	Diesel	<14001	-	-	-	X	-	-	Catalyst
Maryland	Diesel	8501-26,000	-	SSI	-	-	X	-	Catalyst
Massachusetts	Gas	-	2005+	-	-	X	-	-	-
Massachusetts	Diesel	>10000	-	-	-	-	-	X	-
Missouri	Gas	<8501	1996+	-	-	X	-	-	-
Missouri	Diesel	-	1997+	-	-	X	-	-	-
Nevada	Gas	<14001	1996+	-	-	X	-	-	-

State	Fuel	GVWR	Model Year(s)	Steady State	Loaded Mode	OBD	Gas Cap	Opacity	Visual
Nevada	Diesel	-	1968-1995	TSI	-	-	-	-	-
New Hampshire	Gas	<8501	1996+	-	-	X	-	-	-
New Hampshire	Diesel	-	-	-	-	-	-	-	-
New Jersey	Gas	-	1996+	-	-	X	-	-	-
New Mexico	Gas	<10001	1996+	-	-	X	X	Smoke	-
New York	Gas	<8501	1996+	-	-	X	X	Smoke	X
New York	Gas	<18000	<25 To 1995	-	-	-	-	-	Comp
New York	Diesel	<8501	1997+	-	-	X	-	-	-
New York	Diesel	<18000	<1997	-	-	-	-	X	Comp
North Carolina	Gas	<8501	1996+	-	-	X	-	-	-
Ohio	Gas	-	1996+	-	-	X	X	-	-
Ohio	Diesel	-	1997+	-	-	X	-	-	-
Oregon	Gas	-	1996+	-	-	X	-	-	-
Oregon	Gas	-	<1996	SSI	-	-	-	-	-
Pennsylvania	Gas	<8501	1996+	-	-	X	X	-	-
Pennsylvania	Gas	-	<1996	-	-	-	X	-	Comp
Rhode Island	Gas	<8501	1996+	-	-	X	-	-	-
Rhode Island	Diesel	-	1997+	-	-	X	-	-	-
Rhode Island	Diesel	-	<1997	-	-	-	-	-	X
Tennessee	Gas	-	1996+	-	-	X	Visual	-	-
Tennessee	Gas	-	<1996	TSI	-	-	Visual	-	-
Tennessee	Diesel	-	2002+	-	-	X	-	X	-
Tennessee	Diesel	-	<2002	Curbside	-	-	Visual	-	X
Texas	Gas	-	1996+	-	-	X	-	-	-
Texas	Gas	-	<1996	TSI	-	-	-	-	-
Utah	Gas	All Weights	1969-1995	TSI	-	-	-	-	-
Utah	Gas	<8501	1996-2007	-	-	X	-	-	-

State	Fuel	GVWR	Model Year(s)	Steady State	Loaded Mode	OBD	Gas Cap	Opacity	Visual
Utah	Gas	8501+	1996-2007	TSI	-	-	-	-	-
Utah	Gas	<14001	2008-2018	-	-	X	-	-	-
Utah	Gas	>14000	2008-2018	TSI	-	-	-	-	-
Utah	Diesel	<14001	1998-2006	-	-	-	-	-	X
Utah	Diesel	<14001	2007-2018	-	-	X	-	-	-
Vermont	Gas	-	2005+	-	-	X	Visual	-	Catalyst
Vermont	Diesel	-	2005+	-	-	X	-	-	-
Virginia	Gas	<10001	1996+	-	-	X	Visual	-	-
Virginia	Diesel	<8501	1997+	-	-	X	-	-	-
Wisconsin	Gas	<8501	1996-2018	-	-	X	-	-	-
Wisconsin	Gas	8501-14000	2007-2018	-	-	X	-	-	-
Wisconsin	Diesel	8501-14000	2007-2018	-	-	X	-	-	-

Attachments

Attachment A - Specific Comments from University of California, Riverside, Bourns College of Engineering – Center for Environmental Research and Technology (CE-CERT) and Saint Malo Solutions “Review of the 2021 Smog Check Performance Report” and BAR Responses

Attachment B - List of Acronyms

Attachment C - Example calculation of excess emissions

Attachment A
Specific Comments from CE-CERT and Saint Malo's "Review of the 2021 Smog Check Performance Report" and BAR Responses

This attachment consists of specific comments from the *Review of the 2021 Smog Check Performance Report* conducted by the CE-CERT and Saint Malo Solutions, LLC, (SMS) in May 2021, with annotations (*in italics*) by BAR. Comments by CE-CERT and SMS on specific statements, tables, and page numbers refer to BAR's 2021 SCPR.

CE-CERT/SMS: On page 1 (1st paragraph) it is stated that "This report provides an update on California's Smog Check Program pursuant to Assembly Bill (AB) 2289" and refers the reader to footnote "a" (Eng, Chapter 258, Statutes of 2010.)

- What does "Eng." refer to in the footnote?

BAR Response: *"Eng" is Mike Eng the author of the legislation.*

CE-CERT/SMS: On page 1 (2nd paragraph) the authors state: "As in past SCPRs, vehicles whose most recent Smog Check is not a certification are excluded from the analyses."

- Would these be unregistered vehicles?
- How many vehicles were excluded from analysis for this purpose?
- What were the FPR scores associated with these excluded vehicles?

BAR Response: *Approximately 11% of the available sample of vehicles were excluded from analysis because they were in the process of, but had not yet received certification at the time of roadside inspection. These vehicles were not necessarily unregistered. These vehicles were excluded because their smog check status at the time of roadside inspection (PASS of FAIL) could not be determined. The average FRP for these vehicles was 0.56 which was close to the average for the remainder of the fleet.*

CE-CERT/SMS: On page 1 (2nd paragraph) the authors state: "Model year 1996 and newer vehicles are roadside tested using the OBD Inspection System (OIS)." However, footnote "h" states that: "OIS is the Emission Inspection System for OBD tests of model year 2000 and newer gasoline-powered vehicles, all hybrids, and for model year 1998 and newer diesels."

- Is OIS used for 1996 and newer vehicles or for model year 2000 and newer vehicles?

BAR Response: *The OBD-II specification became mandatory for all cars sold in the U.S. in 1996, however BAR requires OIS testing for all 2000 and newer model year vehicles as the footnote states.*

CE-CERT/SMS: Page 1 (2nd paragraph): "In addition, supplemental tailpipe tests have been collected for select vehicles, including model year 2000 and newer vehicles, to better quantify emissions deterioration as the OBD vehicle fleet ages and to help evaluate excess emissions estimates."

- Are the authors referring to ASMs or RSD tests as supplement tailpipe tests?
- Were OIS and tailpipe tests compared for this subset of vehicles?

<u>BAR Response</u>: *A small sample of OBD equipped vehicles receive both an OIS and ASM test at the roadside allowing the quantification of emissions for 2000 and newer model year vehicles. The size of the 2020 sample is too small to draw meaningful conclusions in comparing the results of the two test procedures, however, such comparison has been performed and the results are available in published literature.*

<u>CE-CERT/SMS</u>: Page 3 (1st paragraph): “Two of the most important factors are vehicle age and the performance of the Smog Check station and inspector that certified each vehicle prior to roadside testing”

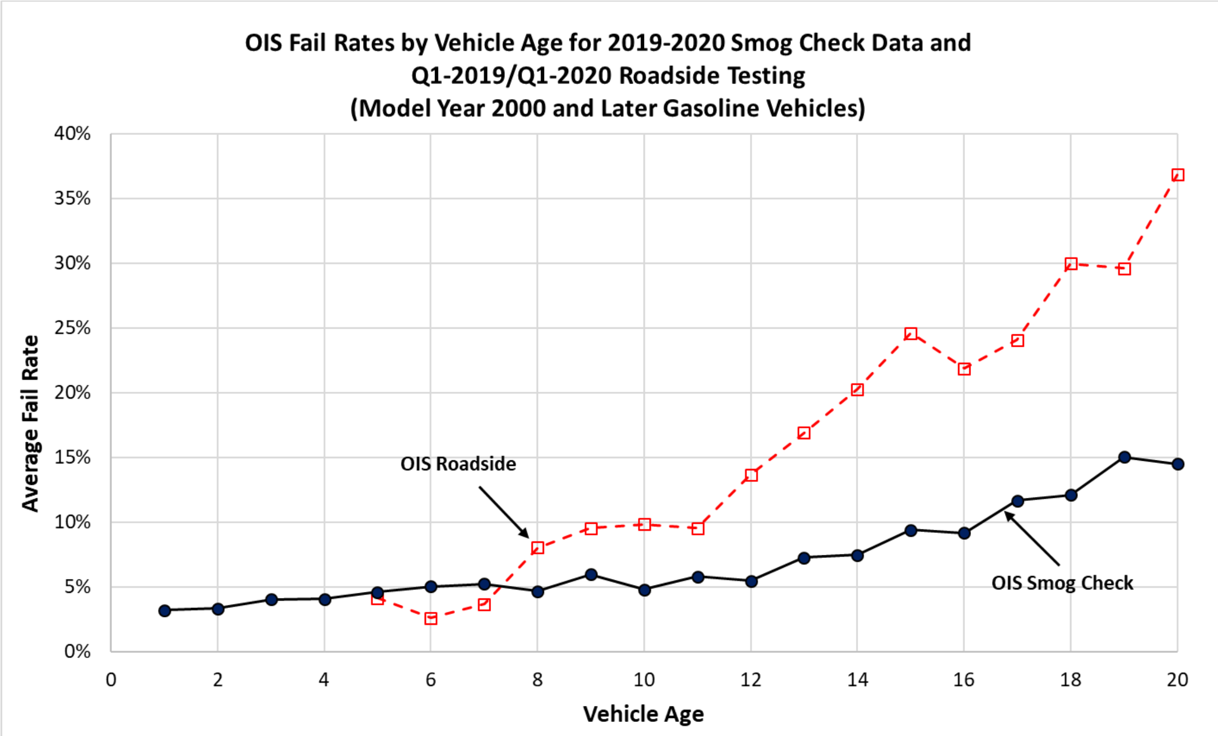
- This sentence implies that there are other “important factors” used in identifying and quantifying the causes of excessive failures at roadside inspection. The same statement appears on page 6 in the 3rd full paragraph of the report. What are the other important factors?

<u>BAR Response</u>: *To address the requirement of AB 2289 to explain roadside failure rates and what influences them, BAR performed a quantitative modeling analysis and reported the results in the 2018 SCPR. That study identified five factors that significantly influence the roadside ASM tailpipe failure rate for 1976-99 MY vehicles. The factors that increased roadside failure rates were 1) vehicle age, 2) reduced FPR of the certifying station, 3) lack of STAR-certification of each station, 4) increasing time between Smog Check certification and the roadside test, and 5) whether each vehicle failed its initial Smog Check before getting certified and then retested at roadside (See Attachment A of BAR’s 2018 SCPR).*

<u>CE-CERT/SMS</u>: Page 4 (Figure 1)

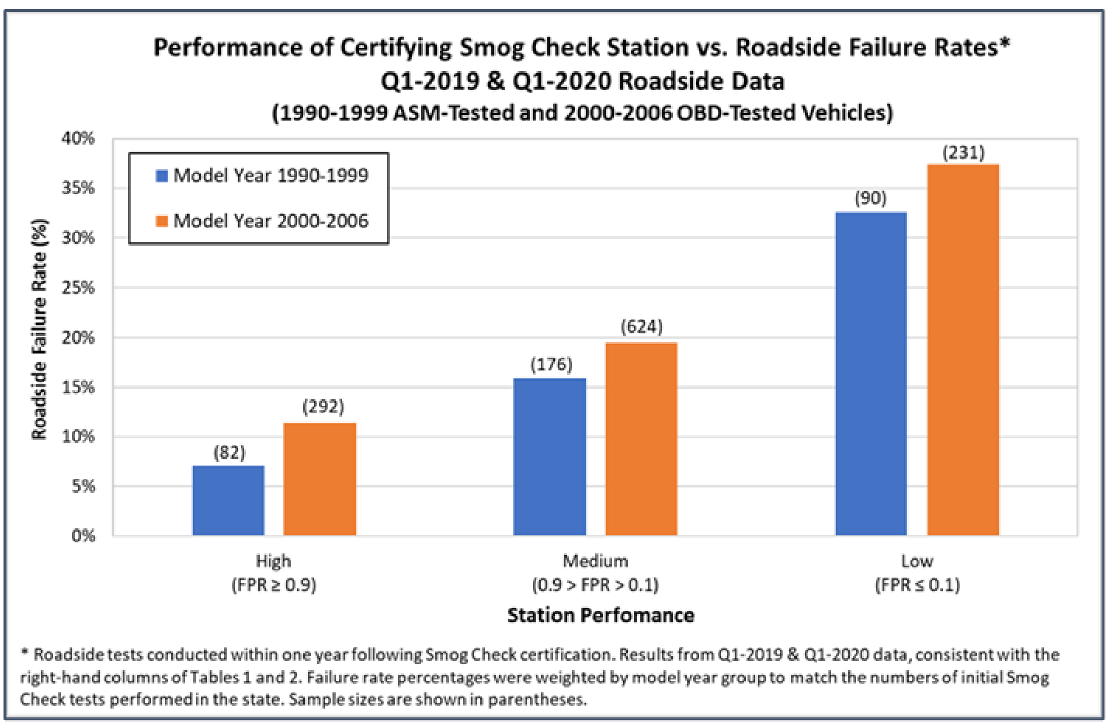
- The roadside failure rates appear to be lower than Smog Check failure rates for vehicles ages 5 to 7. Are these differences statistically significant? If so, why do you believe this occurs?

<u>BAR Response</u>: Figure 1 is *reproduced below including error bars at the 95% confidence level for the roadside failures. As can be seen the roadside estimates overlap the Smog Check averages failures for newer vehicles. That is, the differences in these averages are not statistically significant. It is important to note that newer vehicles are exempt from periodic inspection except upon initial registration in California or upon change of ownership. Therefore, the sample of newer vehicles, both in the Smog Check and roadside dataset presented in the Figure are relatively small.*



CE-CERT/SMS: Page 4 (Figure 2)

In Figure 2 it appears that a higher percentage of newer vehicles, model years 2000-2006, fail at roadside compared to older vehicles, model years 1990-1999 which seems counterintuitive. Is this interpretation correct?



BAR Response: *Newer vehicles (MY 2000-2006) fail initial Smog Check at lower rate (12%) compared to older vehicles (20% for MY 1990-1999). The differences presented in Figure 2 while statistically significant in comparing station performance within a MY group, because of the small sample sizes (especially for the 1990-1999 MY group) are not significant between MY groups.*

CE-CERT/SMS: On Page 7 (1st paragraph), the use of RSD is discussed as a means of supplementing roadside data collection efforts.

- If RSD has proven useful, why not replace traditional testing with RSD?

BAR Response: *As stated on page one of the report, because of the COVID-19 pandemic Roadside Inspections were suspended in mid-March of 2020. As a result, the 2021 SCPR data set was supplemented with RSD data out of necessity rather than preference. Although RSD has been proven as a means of quickly amassing large amounts of on-road data, only a snapshot of each vehicles' exhaust emissions is collected during each test making RSD more suitable for qualitative rather than quantitative analyses.*

CE-CERT/SMS: Also on Page 7 (2nd paragraph), the authors state that: "… the RSD methodology computes pollutant concentration ratios (CO/CO2, HC/CO2, NO/CO2, etc.), which can be related to fuel-specific emission factors in grams of pollutant emitted per kilogram or gallon of fuel burned.

- Why discuss the capability to estimate emissions of CO when your estimate of excess emissions is limited to hydrocarbons (HC or ROG) and NOx?

BAR Response: *The statement was included to inform the reader of the capabilities of RSD rather than the methodology for estimating excess emissions associated with Smog Check.*

CE-CERT/SMS: On page 8, in referring to Table 3, the authors state that: "The table reflects case filings that were based on assessment of Smog Check data only and excludes other Smog Check case filings that were based on more traditional BAR investigations."

- What would be considered "more traditional" BAR investigations?

BAR Response: **"***Typical" BAR investigative methods include, but are not limited to, the use of undercover vehicles with implanted defects and surveillance.*

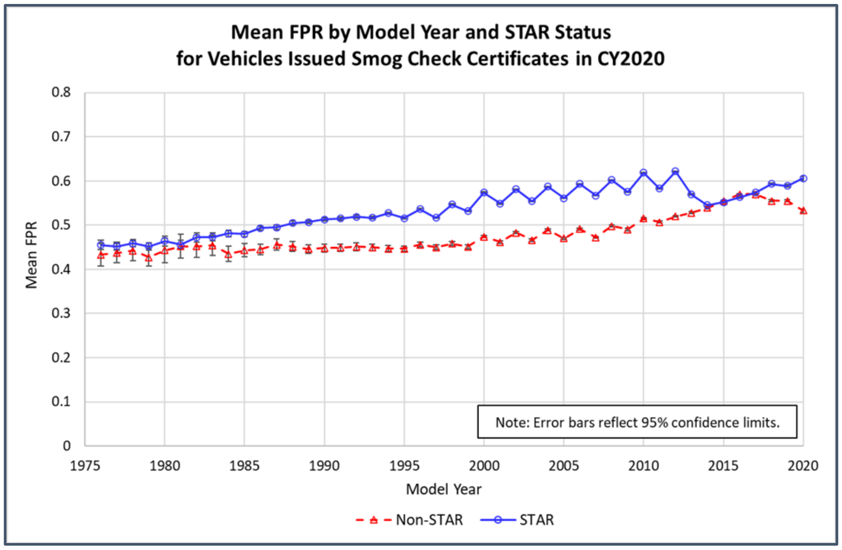
CE-CERT/SMS: On page 12 in reference to Figure 5

- There appears to be little or no discernable difference between station performance and emission rates for 2007 and newer vehicles. Why might that be?

BAR Response: *Figure 5 displays the average emissions along with the standard error for each model year group by station performance. Although the differences may appear small for 2007 and newer vehicles, they are significant. The differences become more apparent for older vehicles in that as vehicles age, both the average emissions and the variability within a model year group tend to increase. As these older vehicles contribute disproportionately to excess emissions the relative performance of high and low performing stations is best evidenced in older model year groups.*

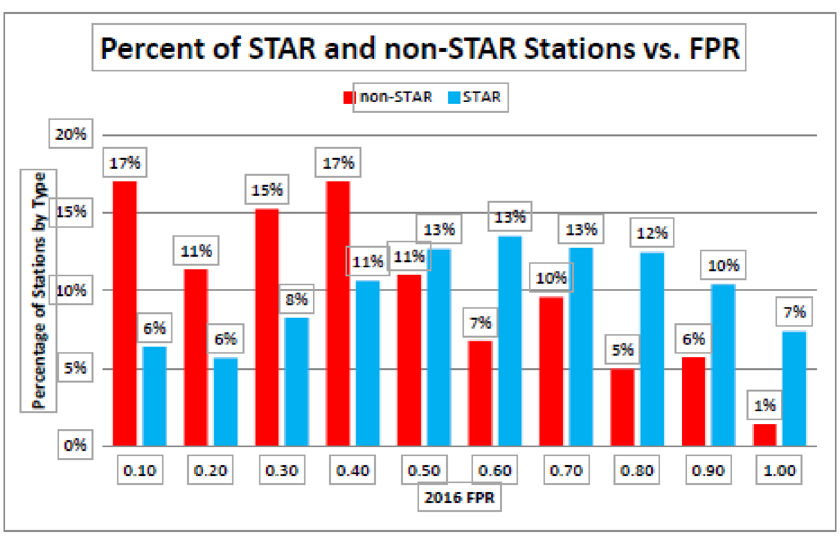
CE-CERT/SMS: On page 15 in reference to Figure 7

- Why would average FPR decline as a function of vehicle model year (vehicle age)?
- Why would STAR and Non-STAR FRPs converge at the extremes of vehicle age?



<u>BAR Response</u>: *Figure A-1 of BAR's 2017 SCPR (reproduced below) showed that most STAR stations were in the upper half of the distribution and most non-STAR stations were in the lower half. As noted in the 2017 SCPR, "The mean FPR score for STAR stations is significantly higher than for non-STAR stations (even though the more failure-prone older vehicles are directed exclusively to STAR stations)." This key feature of higher FPR for STAR stations, even for the older MY vehicles, is highlighted in Figure 7 of the current SCPR, which shows the additional detail of the breakdown by MY. Finally, Figure A-1 also shows the important point that FPR scores overlap with a small percentage of STAR stations in the lowest range (0<FPR<0.10) and an even smaller percentage non-STAR stations in the highest range (0.90<FPR<1.00).*

Figure A-1



CE-CERT/SMS: On page 16 (bullet point 2): "STAR inspection privileges for stations found to be out-of-compliance with STAR regulations would be maintained until the effective date of an informal hearing decision to suspend the privileges."

- It is unclear how this might speed up the process of suspending a station's license. Is It because the station can now be suspended after a more informal hearing as opposed to a full suspension inquiry?

BAR Response: *This option offers an advantage in that the required hearing and outcome would not be delayed by lack of available courtrooms. Judges, publication of formal notices, and scheduling demands on the OAH from agencies other than BAR, thus potentially expediting the process.*

CE-CERT/SMS: On page 16, referring to the inset under the heading "Current Excess Emissions", the authors state that: "The estimated additional achievable emission reductions for model year 1976 to 2016 light- and medium-duty gasoline-powered vehicles in the Smog Check Program is on the order of 20 to 40 tons per day of reactive organic gases and oxides of nitrogen (ROG + NOx) for 2020."

- Is this a large or small reduction? That is, what is the assumed baseline?

- Twenty to forty tpd represents a large range in the estimate. Why this level of uncertainty? How were the upper and lower limits of the estimate established?

BAR Response: *The estimation of excess emissions was made by BAR in consultation with CARB. A baseline inventory of 245 tpd ROG+NOx in CY 2020 was estimated using CARB's on-road emissions inventory estimation model EMFAC. Therefore, a reduction of 20 to 40 tpd represents an 8% to 16% reduction in baseline emissions. The range in potential benefits reflects the inclusion or exclusion of vehicular starting emission in the estimate.*

Attachment B
List of Acronyms

2009 Report, Evaluation of the California Smog Check Program Using Random Roadside Data

AB, Assembly Bill

ASM, Acceleration Simulation Mode

BAR, Bureau of Automotive Repair

BER, Basic Emission Rate

CARB, California Air Resources Board

CCR, California Code of Regulations

CE-CERT, Center for Environmental Research and Technology

CHP, California Highway Patrol

CO, Carbon Monoxide

Comp, Comprehensive

COO, Change of Ownership

CY, Calendar Year

Directed Vehicles, these vehicles can only receive Smog Check certification from STAR test only or STAR test and repair stations.

DTC, Diagnostic Trouble Code

DR, Deterioration Rate

DMV, California Department of Motor Vehicles

Eng, State Assemblyman Mike Eng

EGR, Exhaust Gas Recirculation

EIS, Emissions Inspection System

EMFAC, **Em**ission **Fac**tor – CARB's official on-road motor vehicle emissions inventory estimation model

ER, Emission Rate

FPR, Follow-up Pass Rate

gms, grams

gpm, grams per mile

Gross Polluter, a vehicle with tailpipe emissions exceeding the gross polluter exhaust emission standards prescribed in CCR Section 3340.42

GVWR, Gross Vehicle Weight Rating

HC, Hydrocarbon

I/M, Inspection and Maintenance

Mi, mile

LDA, Light-Duty Auto

LDT, Light-Duty Truck

LHD, Light-Heavy-Duty

MDV, Medium-Duty

MOST, Mobile On-Site Testing

MY, Model Year

NOx, Oxides of Nitrogen

OAG, Office of the Attorney General

OBD II, On-Board Diagnostics, 2nd generation, generally required on 1996 and newer MY, gasoline-powered light-duty vehicles

OIS, OBD II Inspection System for testing OBD-equipped vehicles including, MY 2000 and newer gasoline-powered vehicles and 1998 and newer MY diesel-powered vehicles.

PC, Passenger Car

RFR, Roadside Failure Rate

RPM, Revolutions per Minute

ROG, Reactive Organic Gases, the portion of hydrocarbon emissions that are reactive in the atmosphere and participate in reactions that form ozone

SCFR, Smog Check Failure Rate

SCPR, Smog Check Performance Report

SMS, Saint Malo Solutions, LLC.

SSI, Single Speed Idle

STAR, Classification of stations that can certify directed vehicles

tpd, Tons per day

TSI, Two-Speed Idle

VMT, Vehicle Miles of Travel

WEP, Worldwide Environmental Products

WOT, Wide Oper Throttle

Attachment C
Excess Emissions Example Calculation

The following presents a detailed explanation of how the estimate of excess emissions was derived for the 2022 SCPR.

Figure C-1 (below) displays both the roadside inspection and initial Smog Check failure rates as a function of vehicle age for OIS tested vehicles. As this data reflects the characteristics of the fleet in CY 2021, MY 2021 vehicles are represented in the graphic as age zero and MY 2000 vehicles as being 21 years of age. Note that 14% of MY 2000 vehicles would be expected fail based on Smog Check, however 31% were actually found to fail at roadside. For purposes of this analysis, the differences between the roadside failure rate (RFR) and the Smog Check failure rate (SCFR) were used to estimate excess emissions. No additional benefit is assumed when the SCFR is greater than the RFR.

Figure C-1
OIS Fail Rates by Vehicle Age using Smog Check and Roadside Testing Data
(CY 2020-2021, MY 2020 and Older Gasoline-Powered Vehicles)

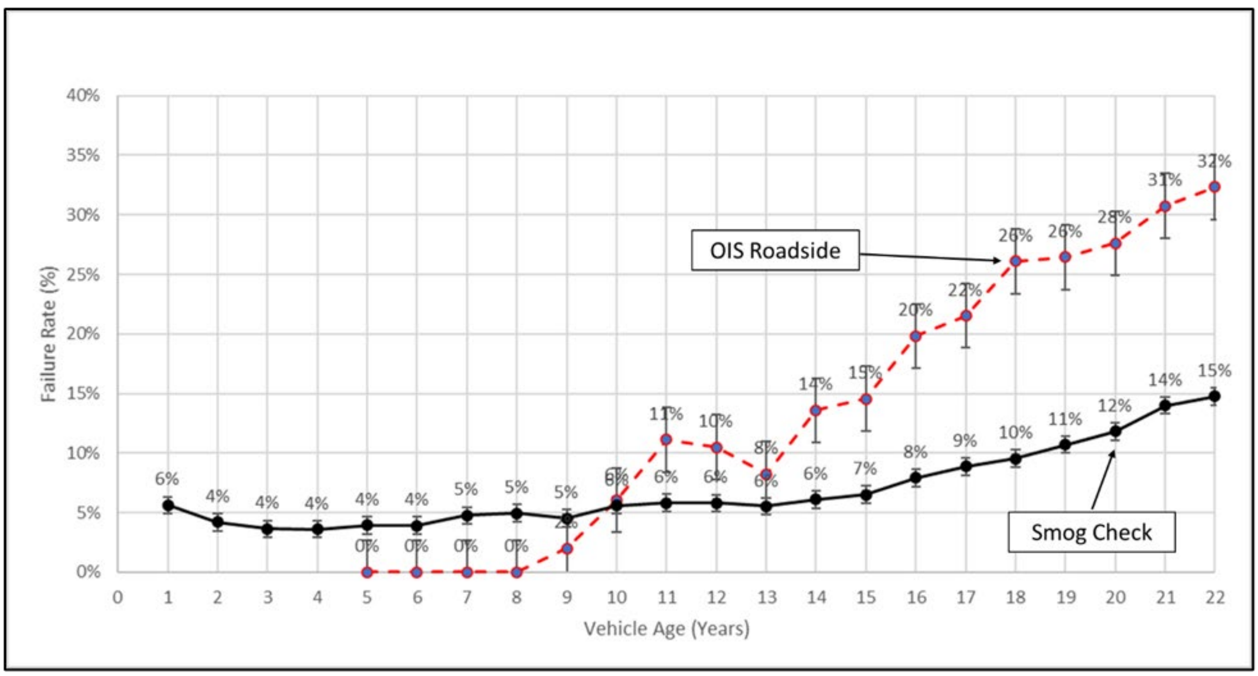
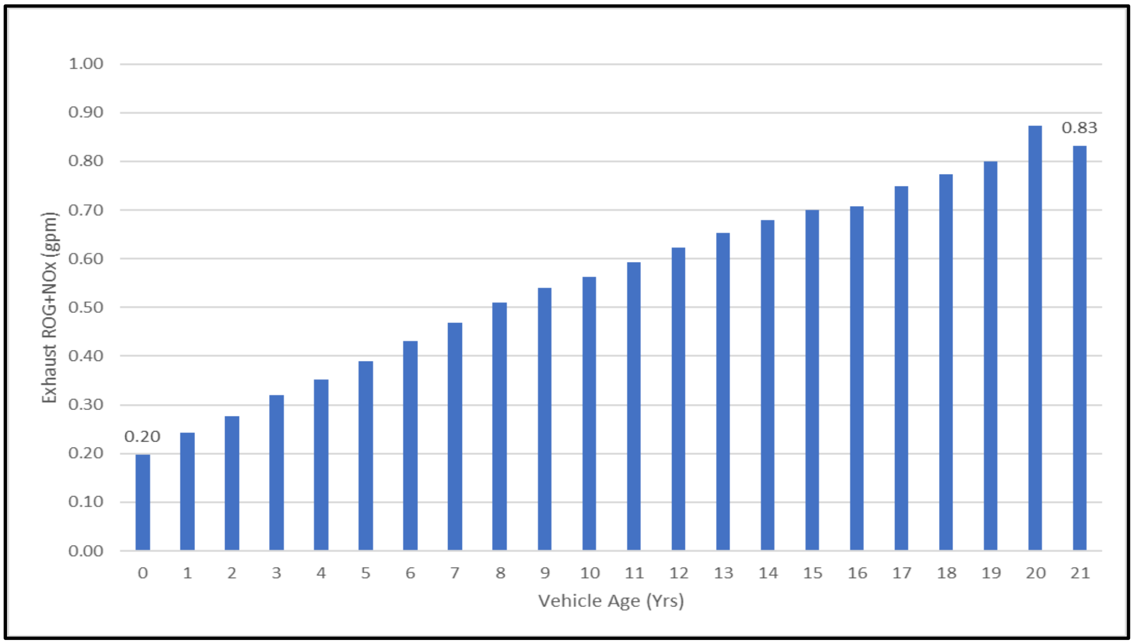


Figure C-2 (below) presents the age specific gram per mile (gpm) ROG+NOx exhaust emission rates for MY 2000 gasoline-powered Light Duty Autos (LDAs) as estimated by CARB's EMFAC2021 (v1.01) on-road emissions inventory model. The statewide, annual average, age specific emissions rates were derived by dividing the CY and MY tpd estimates from the model by the corresponding vehicle miles of travel (VMT). For example, the basic emission rate (BER), the emissions at zero miles are 0.2 gpm for MY 2000 vehicles, which increases to 0.83 gpm at age 21 (See Equation 1 below).

Equation 1:

Emissions (gpm) = (Emissions tpd)*(453.59 gms/lb. X 2000 lbs./ton))/VMT
BER MY 2000 (gpm) = (8.91 tpd X 907180 gms/ton)/ 40955507 mi/day = 0.20 gpm

Figure C-2
Grams/Mile Exhaust Emissions of ROG + NOx by Age
(MY 2000 Gasoline-Powered LDAs – EMFAC2021 Statewide/Annual)



Assuming that loss of efficiency or failure of emission control components are responsible for increases in emissions as the fleet ages, the gpm emission rates presented in Figure C-2 can be broken down into two components; 1) the BER and 2) the incremental increase in emissions as a function of age referred to as the deterioration rate (DR). In the example presented in Figure C-3, the deterioration is zero at age zero, increasing to 0.63 gpm at age 21 (See Equation 2 below).

The benefits of Smog Check are assumed to be intrinsically reflected in the emission rates estimated by EMFAC and the failure rates observed during roadside inspection are assumed to accurately reflect the current state of the Smog Check program. As such, the 0.83 gpm emission rate for 21-year-old vehicles from EMFAC can be associated with a 31% Smog Check Failure Rate (SCFR) (See Figures C-1 and C-3). Ultimately, excess emissions for 21-year-old vehicles were calculated by comparing the emission rate implied by a 31% roadside failure rate (RFR) to the emissions associated with a 14% SCFR assuming linear deterioration (See Figure C-4 below).

The total potential benefits associated with program improvement was estimated using Equation 3 and the vehicles class contribution to the total potential benefit is illustrated in Figure C-5.

Equation 2:

Emissions (gpm) = (BER gpm X DR gpm/yr X Vehicle Age (yrs))
Emissions (gpm) = 0.2 gpm + .03 X 21 = 0.83 gpm

Figure C-3
Basic Emission Rate and Deterioration Rate
MY 2000 Gasoline-Powered LDAs (Exhaust ROG + NOx)

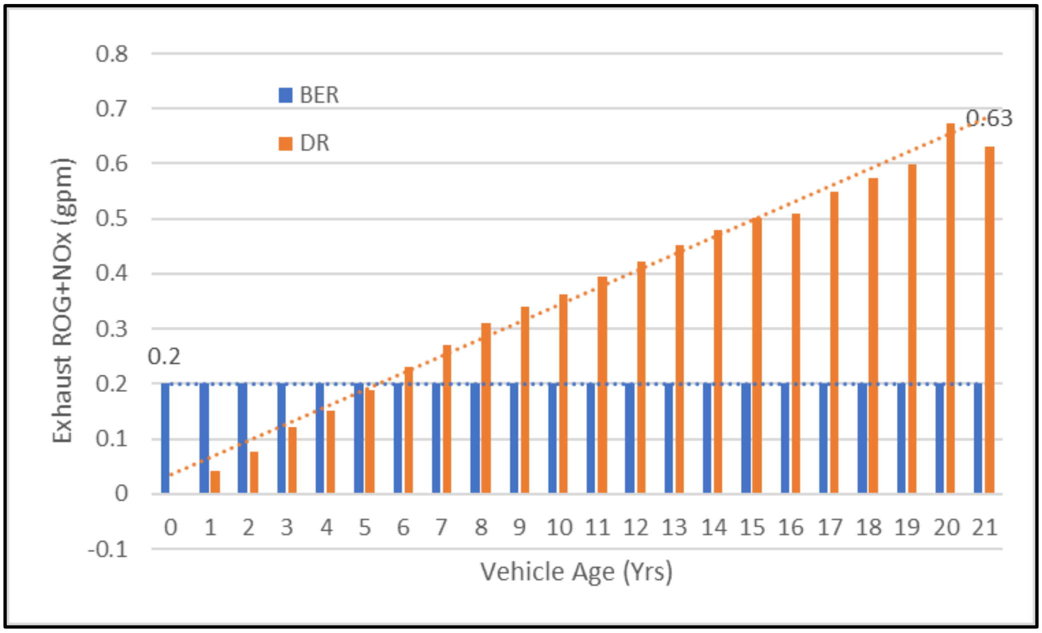
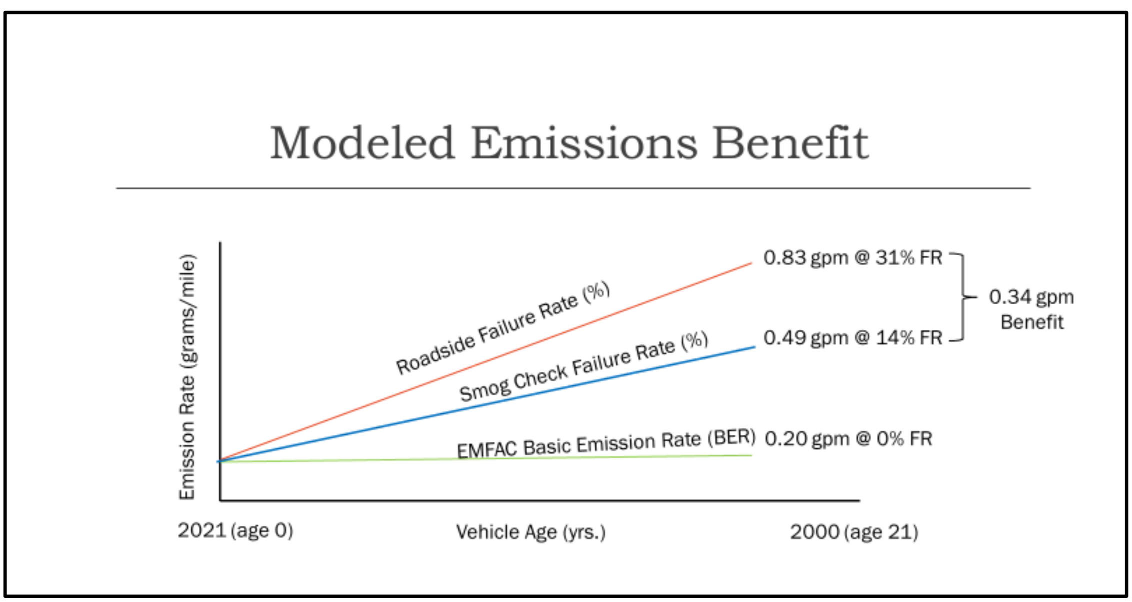


Figure C-4
Basic Emission Rate and Deterioration Rate
MY 2000 Gasoline-Powered LDAs (Exhaust ROG + NOx)



Equation 3:

Potential Benefit (tpd) =$\sum 0to45$(ER-BER)/RFR*(RFR-SCFR)*VMT/(gms./lb.*lbs./ton)

Example:

For MY 2000 LDA in CY 2021
=(0.83$_{gpm}$ -0.20$_{gpm}$) / 31% X 100 X (31%-14%) X 4,518,738$_{mi./day}$ /(453.59 $_{gms/lb}$ X 2000 $_{lbs/ton}$)
= 0.63 $_{gpm}$ / 31 * 17 = (0.345 $_{gpm}$ X 4,518,738 $_{mi/day}$) / 907,180 $_{gms/ton}$ = 1.72 tpd

Equation 4:

Vehicle Displacement = Total Benefit (tons/day) / LDA Fleet Emission Rate (tons/vehicle-day)
53 tpd / 0.000006 tons/vehicle-day = 7,819,110 vehicles

Figure C-5
Estimate of Excess Exhaust Emissions of ROG+NOx
by Model Year and Vehicle Class