MOBILE SOURCE CERTIFICATION AND COMPLIANCE PROGRAM ANNUAL REPORT

2020-2021CY

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Introduction

Historically, CARB's stringent emission standards for mobile sources have been credited with substantial emission benefits and progress in achieving healthy air quality in California. These benefits have only been achieved, however, with successful implementation of these standards including multi-faceted aspects of verifying initial compliance and in-use performance as well as requiring corrective action when needed. The Mobile Source Certification and Compliance Program at CARB is responsible for carrying out these activities to ensure that vehicles, engines, and emission-related components sold in California meet all applicable emission requirements through the product's useful life. In this role, CARB issues nearly 4,000 Executive Orders annually for certification of all types of on- and off-road vehicles and engines and conducts an extensive suite of audits and testing to confirm proper, robust, and durable emission control during in-use operation.

Our History

Over the last 50 years, California air pollution control efforts have resulted in dramatic improvements in air quality, as well as reductions in a variety of harmful toxic air contaminants in urban and rural areas. A key component of this success is the control of emissions from mobile sources through CARB's Mobile Source Certification and Compliance Program (MSCCP). Only CARB-certified vehicles, engines, and components can be sold in California. Certification is granted when a manufacturer demonstrates that its product complies with CARB's stringent emission requirements throughout the product's useful life. The MSCCP is responsible for ensuring engines, vehicles, and components comply with all California clean air standards.

Regulations to control emissions from vehicles and engines started in 1975. Only simple automotive emission controls were needed to comply with the standards at that time. On-road automobiles are now more than 98% cleaner than they were in the early years and CARB has standards that apply not only to automobiles, but to many types of on-road and off-road vehicles, equipment, and products. Today's standards encompass more pollutants, are more stringent, and require robust and complex emission control hardware and software. Table 1 provides a list of key regulatory actions since 1975 related to mobile source certification and compliance.

Key Regulations	Key Updates
Motor Vehicle Emission Control for Motorcycles, Light-, Medium- and Heavy-Duty Engines and Vehicles adopted in 1975	1987: 1988 and Subsequent Emission standards and test procedures 1991: Low Emission Vehicle standards (LEV) 1999: Updated LEV standards (LEV II); 2001 and subsequent MY Evaporative Standards

	2008: Zero Emission Standards for 2018 and subsequent MY 2012: LEV III with GHG reductions (Advanced Clean Cars Program, ACC) 2022: Advanced Clean Cars II Program
Procedures for Exemption of Add-On and Modified Parts adopted in 1977	1988: Aftermarket Catalytic Converters 1990: Exemption of Add-On and Modified Parts procedure update 1993: Alternative Fuel Retrofit Systems 1999: Aftermarket Catalytic Converters for Off-Road Vehicles, Engines, and Equipment; Systems Designed to Convert Off-Road Vehicles, Engines, and Equipment to Use Alternative Fuels 2000: Add-On and Modified Parts for Off-Road Categories 2007: Aftermarket Catalytic Converters procedure update 2009: Aftermarket Critical Emission Control Parts on Highway Motorcycles; Off-Vehicle Charge Capable Conversion Systems 2014: Updated Alternative Fuel Retrofit Systems for 2004 and Subsequent Model Year On-Road Motor Vehicles and Engines 2017: Aftermarket Diesel Particulate Filters for 2007 Through 2009 Model Year On-Road Heavy-Duty Diesel Engines; Medium and Heavy Duty Hybrid Vehicle Conversion Systems 2021: Procedures for Exemption of Add-On and Modified Parts for On-Road Vehicles/Engines update
Exhaust Emission Standards and Test Procedures for Heavy-Duty Diesel Engines and Vehicles adopted in 1985	1985: 1985 through 2003 MY standards and test procedures 1998: 2004 and subsequent MY standards 2000: Urban bus engine standard and Not-To-Exceed (NTE) 2001: 2007 and Subsequent MY emission standards 2002: 2004 MY and subsequent standards and test procedures 2013: HD GHG Phase 1 2015: CA HD In-Use Testing (NTE) Requirements 2019: HD GHG Phase 2, HD ZEV Program 2020: Omnibus Low NOx regulation for on-road HD

Exhaust Emission Standards and Test Procedures for Heavy-Duty Otto-Cycle Engines and Vehicles adopted in 1986	1986: 1985 through 2003 standards and test procedures 2000: 2004 and subsequent standards and test procedures
On-Board Diagnostic System Requirements for Passenger Cars, Light-Duty Trucks, Medium-Duty Vehicles and Engines, and Heavy-Duty Vehicles and Engines adopted in 1985	1985: OBD I 1989: OBD II 2002: Facilitate incorporation of OBD II systems in the Smog Check program 2005: Heavy-Duty OBD for 2010 MY engines 2012: HD OBD adjustments and future model year requirements 2015: Amendments to address LEV III emission standards 2018: HD OBD emission data logging requirements 2021: Updated OBD II standardization
Small Off-Road Engines (Regulations for Utility and Lawn and Garden Equipment Engines) adopted in 1990	1998: Exhaust emission standards update 2003, 2016: SORE evaporative emission requirements 2008: Zero-emission equipment 2021: Transition to zero-emission equipment
Exhaust Emission Standards for Off-Highway Recreational Vehicles adopted in 1994	1998: Red sticker programs 2006: Expanded OHRV category; evaporative (permeation only) standards 2013: Whole vehicle (SHED) evaporative standards 2019: Updates to exhaust and evaporative standards, end of red sticker program
Nonroad Diesel Engines adopted in 1995	2000: Tier II and Tier III standards 2004, 2012: Tier IV standards
Exhaust Emission Standards for Spark-Ignited Marine Engines adopted in 1998	2006: Inboard/Sterndrive engine standards 2009: Updated Sterndrive/Inboard requirements and standards 2012: Update to certification test fuels
Portable Fuel Container Regulation adopted in 1999	2005: Emission standards and test procedure updates 2016: Updates to improve compliance

Exhaust Emission Standards and Test Procedures for Off-Road Large Spark-Ignition Engines adopted in 1999	2007: Updates to emission standards and related requirements 2012: Updates to certification test fuels 2015: Fleet regulations to transition to zero-emissions
Verification Procedure, Warranty and In-Use Compliance Requirements for In-Use Strategies to Control Emissions from Diesel Engines adopted in 2002	2004: Update effective date for NO_2 standard 2006: Update NO_2 standard 2008: Amend test requirements; add NOx controls 2010: Update and clarify installation, warranty, and data requirements 2012: Add recall provisions and update in-use compliance requirements
Exhaust Emission Standards and Test Procedures for Zero-Emission and Hybrid Electric Vehicles adopted in 1998	2001: Electric vehicle charging requirements 2008: 2009 to 2017 standards and set new criteria for earning zero emission vehicle (ZEV) credits 2012: Adopted 2018+ standards, new test procedures, and adjusted criteria for earning ZEV credits 2022: Adopted 2026+ standards, updated test procedures, minimum criteria to qualify as a ZEV
Portable Outboard Marine Tanks and Components adopted in 2008	
Control Measure for Ocean-Going Vessels At Berth adopted in 2007	2020: Modification to add vessel, port and independent marine terminal requirements.

Table 1: Regulatory Development Since 1975

Over time, the mobile source program has continued to evolve and expand. In 1990, only 430 approvals (Executive Orders or EOs), covering on-road vehicles and engines, were issued. CARB uses EOs to grant certifications and exemptions for specific vehicles, engines, or products. By 2018, CARB issued nearly 4,000 EOs annually for all types of on- and off-road vehicles and engines, including, automobiles, heavy-duty trucks, large off-road equipment, small off-road engines, evaporative systems, and aftermarket components used in automobiles and trucks. Over time, the engine and emission control technology used to meet the requirements has become more complex. Increasing numbers of vehicles and equipment are certified with numerous emission control systems such as on-board

diagnostics, plug-in hybrid technology, and advanced exhaust aftertreatment technology such as three-way catalysts, selective catalytic reduction (SCR) catalysts, and diesel particulate filters. To ensure vehicles and engines are robustly designed to meet the emission standards, CARB's programs have expanded from measuring emissions during traditional laboratory dynamometer testing to the use of Portable Emission Measurement Systems (PEMS) and real-time monitoring systems to determine emission levels during real world operation. These new testing methods help verify that the engine or vehicle continues to operate as approved throughout its useful life.

The Mobile Source Certification and Compliance Program Overview

CARB's Mobile Source Certification and Compliance Program (MSCCP) is responsible for certifying vehicles, engines, and components for compliance with California emission standards. These products are required to be certified to be legally offered for sale in California. In addition, the MSCCP is responsible for ensuring engines, vehicles, and components will comply with all California emission standards not only when new but throughout the applicable useful life by verifying the systems have been designed with sufficient durability.

State law gives CARB broad authority to adopt and implement motor vehicle emission standards, and to certify all new motor vehicles, engines, and components. Certification includes testing and monitoring, before and after retail sale, at several points throughout the vehicle or engine's life including:

- The certification process begins with a manufacturer's application that includes technology and test data demonstrating the vehicle, engine, or component meets applicable emission standards. CARB thoroughly reviews the application and submitted data, including an in-depth review of the on-board diagnostic monitoring system, to verify the product has been designed to meet all of the requirements. CARB may require confirmatory testing to verify manufacturer submitted test results. When the vehicles, engines, or components are confirmed to meet emission standards, CARB issues an Executive Order permitting the vehicles, engines, or component to be sold and operated in California.
- Audit and surveillance activities can occur during or after the certification process, as well as after retail sale, to monitor and verify that a product, when produced or assembled, meets, and continues to meet the certification standards. Audits can take the form of inspections of laboratory and production facilities to verify accuracy of equipment and testing procedures, or inspection of testing or warranty records. Audits can also include obtaining and testing, with specific protocols, engines or vehicles from the production line or a point in the distribution chain. Surveillance activities also monitor products as produced and distributed but may additionally utilize non-standard testing procedures to verify emission performance is robust and not inappropriately designed to operate significantly differently under typical in-use conditions.

- Compliance activities occur after the vehicle or engine is sold. CARB continues to monitor vehicle and engine compliance with emission standards, using a variety of surveillance and audit activities, to verify that vehicles and engines continue to operate as certified. CARB utilizes both prescribed and non-standard testing protocols for in-use vehicles, under both laboratory and real-world operating conditions.

Information gathered through the confirmation testing, useful life ("in-use") testing and product durability (warranty information) is fed back into the initial certification process to ensure the product continues to meet California's requirements. The product development and approval process, in some instances, can take up to one to three years. Follow-up in-use testing and warranty activities can occur up to 15 years after the product is initially sold.

Figure 1 shows the multiple activities that are conducted to ensure an engine, vehicle, or component meets and stays in compliance with California's strict emission standards. Not all product categories have the same requirements or undergo the same workload effort to ensure compliance. Activities range from simple applications for experimental permits or non-complex equipment to complex applications and review, such as for the modern-day vehicle that requires multiple steps to obtain approval and ensure continued compliance.

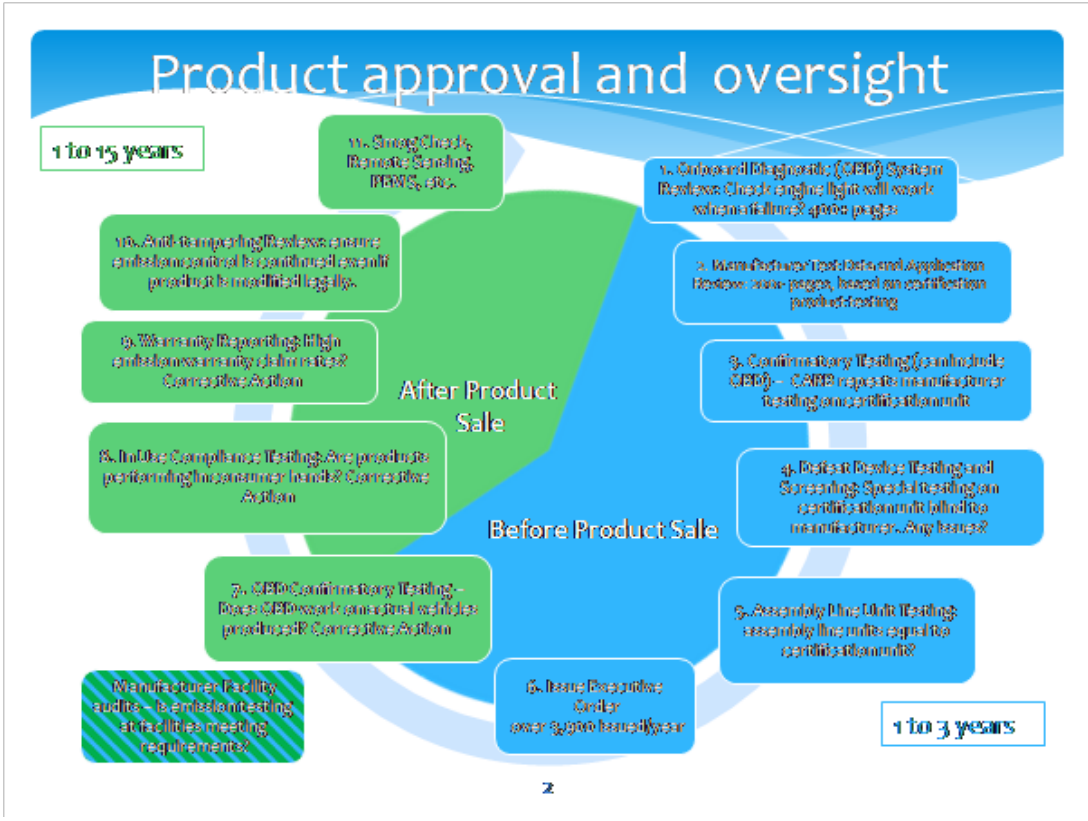

Figure 1: MSCCP Product Approval and Oversight

The activities taken to ensure compliance with California's requirements include certification to stringent standards, approval of on-board diagnostic systems, pre-sale confirmation

testing, post-sale in-use testing, and follow-up warranty and corrective actions. Each step is essential to ensuring compliance and is discussed below.

Certification

Certification is the process by which manufacturers obtain approvals (Executive Order or EO) to legally sell or operate their engine, vehicle, or component in California. Certification is accomplished through pre-application, application, and post-application activities. Before the application is submitted, staff typically meet with manufacturers to discuss and agree upon the type of test information that will be needed for new and existing products. There are multiple applicable emission standards based on the type of engine, vehicle, or component in the application. Prior to certification, manufacturers group their products for approval. Generally, a group include products that share common engine characteristics (e.g., combustion cycle, engine block, number of cylinders, engine displacement), emission control characteristics (e.g., catalyst type, catalyst volume and precious metal loading, exhaust gas recirculation), evaporative emissions characteristics, emission control criteria, or aftermarket exemption coverage. An EO is granted for each individual group and involves review of manufacturers' submissions to show compliance with emissions, on-board diagnostics (OBD) and other requirements per CARB regulations and procedures. The criteria and naming of the group is based on the type of equipment that is under evaluation. For example, light-duty groups are called test groups, heavy-duty engines and vehicles are called engine families and vehicle families, respectively. For some products, two separate EOs are issued for exhaust-related requirements and evaporative-related requirements. CARB evaluates the manufacturer's application for completeness, required emission test results, technical data, descriptions of auxiliary emission control devices[1] (AECD) and on-board diagnostic (OBD) systems, durability data, useful life compliance analysis, and warranty requirements to determine compliance.

On-road, and some off-road, vehicles and engines require review of the operating systems to ensure no non-disclosed AECDs or defeat devices[2] are present. The AECD review process

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[1] *Auxiliary Emission Control Device* (AECD) means any *element of design* which senses temperature, vehicle speed, engine RPM, transmission gear, manifold vacuum, or any other parameter for the purpose of activating, modulating, delaying, or deactivating the operation of any part of the *emission control system*.

[2] *Defeat device* means an AECD that reduces the effectiveness of the *emission control system* under conditions which may reasonably be expected to be encountered in normal vehicle operation and use, unless:

(1) Such conditions are substantially included in the Federal emission test procedure;

(2) The need for the AECD is justified in terms of protecting the vehicle against damage or accident;

(3) The AECD does not go beyond the requirements of engine starting; or

(4) The AECD applies only for ***emergency vehicles*** and the need is justified in terms of preventing the vehicle from losing speed, torque, or power due to abnormal conditions of the *emission control system*, or in terms

can be complex given the extensive amount of software involved in current vehicle and engine controls. Manufacturers provide detailed descriptions of emission control systems and their operation to show compliance with the regulations. CARB verifies and agrees upon the type of test information that will be needed for the future applications to ensure the designs are emission compliant over the typical product operation. As part of the AECD reviews, CARB ensures no defeat devices are present that would cause emission increases in real world operation.

For products which use carburetors, manufacturers are responsible for demonstrating prior to certification that engines and vehicles employ acceptable tamper-resistance measures for all emission-related adjustable parameters to ensure that the emission levels remain as originally certified. The manufacturer submits samples of the adjustable parameters to CARB for evaluation and approval. CARB staff uses only ordinary household tools, such as hammers, screwdrivers, pin punches, needle nose pliers, etc. when performing the tamper resistance test. If the adjustable parameter cannot be accessed, then the carburetor passes the evaluation. Approvals are valid for five years. If the evaluation fails, then the manufacturer needs to re-design the tamper resistance method and submit another carburetor for review.

After the application process has been completed and the EO has been issued, additional requests can be submitted to the agency to modify existing EOs. Changes to the product (e.g., adding new models, new parts due to supplier change, revised calibration) implemented by the manufacturers must be reported to CARB for approval via requests for running change or a field fix. A running change application and approval is required when changes are implemented on vehicles in production. A field fix application and approval is required when the changes are implemented on vehicles post-production. Any application submitted to CARB for running change or field fix for previously certified products requires another review to verify the changes do not adversely affect emissions or compliance with the standards. Depending on the nature of the running change or field fix, the agency may require additional data from the manufacturer as part of the review process. The issuance of a new EO superseding the previous EO issued may be required.

Product EOs for various programs are made available publicly:

Light-, medium- and heavy-duty vehicles, motorcycles, and off-road engines and equipment can be found at *https://ww2.arb.ca.gov/new-vehicle-and-engine-certification-executive-orders*

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of preventing such abnormal conditions from occurring, during operation related to emergency response. Examples of such abnormal conditions may include excessive exhaust backpressure from an overloaded particulate trap, and running out of *diesel exhaust fluid* for engines that rely on urea-based selective catalytic reduction.

Small off-road (SORE) evaporative components: *https://ww2.arb.ca.gov/our-work/programs/small-road-engines-sore/sore-evaporative-component-executive-orders*

Portable fuel containers (PFC): *https://ww2.arb.ca.gov/our-work/programs/portable-fuel-containers-gas-cans/portable-fuel-containers-executive-orders*

Portable outboard marine tanks (OMT): *https://ww2.arb.ca.gov/our-work/programs/outboard-marine-tanks/outboard-marine-tank-executive-orders*

Off-highway recreational vehicles (OHRV): *https://ww2.arb.ca.gov/our-work/programs/highway-recreational-vehicles/ohrv-executive-order-introduction*

Spark-ignition marine watercraft (SIMW): *https://ww2.arb.ca.gov/resources/documents/simw-component-executive-orders*

Manufacturers also submit production and emission reports quarterly or annually after the end of each production model year. Staff audits manufacturer's production reports to verify their compliance with various fleet average standards, averaging/banking/trading (ABT) of credits and deficits, phase-ins, in-use testing, and other requirements. For on-road cars, trucks and motorcycles, the annual production information is also used to determine a per vehicle fee required to be paid by the manufacturer annually. In 2022, a new fee structure will be implemented (See Off-Road Engine, Vehicle and Component Certification and Compliance Program, Program Development and Enforcement Support section for more information).

California's Anti-Tampering Law prohibits any modification of the approved engine or vehicle unless such modification has been approved by CARB. Therefore, manufacturers of aftermarket parts intended to modify or be added on to a certified vehicle or engine must also obtain approval through CARB's exemption programs. These products are reviewed to verify they do not adversely impact the emission control systems or certified emission levels of the vehicle or engine. Some products are approved to modify the fuel type of an existing vehicle or reduce the emissions of an existing or in-use vehicle or engine to meet in-use fleet regulation requirements. Exemption EOs for approved aftermarket parts can be found at *https://ww2.arb.ca.gov/select-type-part-check*.

Executive orders and approval letters for equipment used for product modification to reduce emissions as required for feet and entity control measures or incentive funding are located as followed:

For verified diesel emission control strategies:
https://ww2.arb.ca.gov/diesel/verdev/vt/cvt.htm

For locomotive technologies:
https://ww2.arb.ca.gov/our-work/programs/reducing-rail-emissions-california/locomotive-emission-verifications-technology

For At Berth Alternative Control Technologies:

https://ww2.arb.ca.gov/berth-regulation-executive-orders

Certification for light-, medium-, and heavy-duty vehicles and off-road engines and equipment is conducted in the New Vehicle/Engine Branch of the Emissions Certification and Compliance Division. Evaporative component certification is conducted by the Quality Management Branch of the Monitoring and Laboratory Division and the In-Use Programs Branch of the Emissions Certification and Compliance Division. Aftermarket Parts and Alternative Control certification and approval work is conducted in the Aftermarket Parts Certification and Audit Branch of the Emissions Certification and Compliance Division and the Freight Activity Branch of the Transportation and Toxics Division.

On-Board Diagnostics (OBD)

On-Board Diagnostics (OBD) systems are computer-based self-diagnostic systems mainly comprised of software designed into a vehicle's on-board computer that monitor virtually every component in a vehicle that can cause increases in emissions. The primary functions of the OBD system are threefold: 1) detect emission-related malfunctions; 2) alert the vehicle owner that there is a faulty component or system by illuminating a malfunction indicator light (MIL or "check engine light") on the instrument panel; and 3) store information on the identified malfunction, which enables technicians to quickly and properly repair such faults. OBD systems are therefore an immense benefit to vehicle owners because they better ensure that any detected malfunctions can be promptly and correctly repaired.

Additionally, CARB's OBD program is currently used by more than 30 states for their light duty vehicle inspection and maintenance programs (I/M) and U.S. EPA certifications of OBD systems are largely based on CARB's OBD program. OBD will also be the underlying tool for the up-and-coming heavy-duty vehicle I/M program, starting in 2023. Besides OBD being used to identify emission-related malfunctions, OBD is used to track NO_x, CO_2, and greenhouse gas (GHG) emissions in the real world (Real Emissions Assessment Logging-REAL) for vehicle compliance screening, inventory development, and emission component durability demonstrations.

The current "OBD II" monitoring systems were initially implemented in 1994 model year for light and medium on-road cars and trucks, and mandatory for all 1996 model year and newer vehicles. At that time, OBD review and approvals were simpler due to fewer required OBD monitors, fewer and less complex emission control components, and minimal OBD data submission requirements. Over time, OBD systems have grown in complexity to keep pace with the emission control systems that have become more sophisticated. Today, OBD applications are typically 200 to 1,500 pages and can contain between 300 to 1,500 individual monitors or diagnostic trouble codes. Due to the substantial amount of details provided and complexity of the information, the process is streamlined where possible. However, as a result of some manufacturers recently circumventing the diagnostic system with defeat devices, more pre- and post-sale testing is required to deter and detect potential cheating. Unique among CARB requirements, vehicle OBD systems are required to remain functional for the actual life of the vehicle or engine to ensure emission controls are

adequately maintained as long as the vehicle is operated. Malfunctions detected by the OBD system are also subject to emission warranty coverage and reporting during the applicable warranty period.

Light-, medium-, and heavy-duty on-road vehicle and engine manufacturers are required to obtain CARB approval of their OBD systems in order to obtain an Executive Order to sell or operate their on-road engine or vehicles in California. OBD approval involves the manufacturer submitting an application that includes a detailed explanation of how each OBD monitor works and data supporting monitor design and performance. CARB staff reviews the application to determine if the OBD system meets the requirements of the OBD regulations.

After the OBD application has been reviewed and the OBD system is approved, the manufacturer is also responsible for demonstrating that their OBD system has indeed been designed and built as described on production vehicles and engines. Manufacturers perform several post-certification tests to ensure their production vehicles and engines comply with the OBD regulations which are reviewed by staff. The post-production testing and review process entails the collection of four different types of testing and reporting requirements conducted by the manufacturer. Light-, medium-, and heavy-duty on-road vehicle and engine manufacturers are required to conduct and submit three different types of production vehicle/engine evaluation (PVE) testing reports verifying the vehicles/engines: meet communication standardization requirements; properly store and report fault codes for each and every diagnostic; and are working in-use such that diagnostics are running with sufficient frequency in normal customer usage. Heavy-duty engines are subject to an additional type of testing whereby the manufacturer must procure in-use vehicles and conduct emission tests in the laboratory to confirm proper fault detection of key emission controls. Each of these tests is described in further detail below

Standardized verification testing

A critical development and evolution from OBD I to OBD II, and eventually the implementation of HD OBD for heavy-duty on-road engines, is the requirement for standardization. The OBD II and HD OBD regulations are comprised of numerous standardized requirements that manufacturers must adhere to. These requirements include basic items such as reporting data from the on-board sensors (e.g., vehicle speed, engine coolant temperature), status of several major monitors and whether the monitors have made a decision and are "completed," to more complex subjects pertaining to a malfunctioning component or system information accessed by technicians via a "generic" scan tool when diagnosing and repairing detected faults. It is important that manufacturers meet these standardization requirements not only for the continued success of the OBD program, but to also guarantee that technicians are able to access the stored information in the on-board computer in a consistent manner. The need for consistency is even more paramount as multiple states across the nation, including California, have implemented OBD into their inspection and maintenance programs (which rely on access to the information via a "generic" scan tool). As such, the purpose of standardized verification testing is to ensure

that a generic scan tool can connect and properly communicate with the vehicle's OBD system, the OBD system supports the regulatory parameters, and any issues with communication are identified early and addressed. This testing helps identify both major and minor issues with regard to the implementation of the standardized requirements. A minor issue being as simple as oversight or misinterpretation in the implementation of a diagnostic-related parameter. A major issue being an inspection and maintenance program cannot successfully pass a healthy vehicle or engine (e.g., software bug preventing a major monitor's status to update to "complete" and indicate the vehicle is ready for inspection) or properly fail a vehicle in need of repair. The OBD II regulation requires manufacturers to test one production vehicle from the assembly line for every unique software calibration. For HD OBD, manufacturers are required to test ten unique production vehicles (i.e., engine rating and chassis application combination) per engine family.

Monitoring Requirement Verification Testing

Typical OBD systems contain between 300 to 1,500 individual OBD monitors. Manufacturers are required to individually implant or simulate malfunctions on production vehicles (i.e., vehicles taken directly off the assembly line) to verify each and every monitor functions as intended. This process requires a large effort from the manufacturer and can take up to six months per system to test every OBD monitor. The manufacturer is required to test between one and six production vehicles per year, depending on the number of test groups or engine families certified for that model year. Manufacturers are expected to complete the monitoring requirement verification testing and submit the results of that evaluation to CARB no later than six months after start of production.

In-Use Monitoring Verification Testing

This testing primarily involves manufacturers demonstrating that their OBD monitors operate frequently enough during regular driving conditions. OBD monitors are designed to determine if emission-related components or systems are healthy or failing. Manufacturers must also engineer their OBD monitors to run reliably during normal driving conditions in which the OBD system can accurately determine if the emission-related component or system is healthy or failing. The set of conditions in which an OBD monitor runs are known as enable conditions and these enable conditions must be well optimized by the manufacturer. If the enable conditions are too broad, the OBD monitor may yield inaccurate decisions (e.g., falsely indicating that a healthy system is failing). If the enable conditions are overly restrictive (e.g., very narrow vehicle speed and engine speed conditions), then the monitor may not run frequently during real-world driving conditions and the OBD system may not detect a failed emission-related component or system and alert the vehicle owner via a MIL to service the vehicle in a timely manner. Thus, the in-use monitoring verification testing is critical to ensure that manufacturers do not overly restrict their monitors and properly demonstrate that the OBD monitors run frequently during typical driving conditions.

Manufacturers' OBD systems keep track of how many times each of the OBD monitors have completed as well as how often the vehicle has been driven under certain reference

conditions. By measuring both these values, the ratio of the monitor operation relative to the amount of vehicle operation can be calculated in a standardized manner to determine the monitoring frequency. To complete the testing requirement, manufacturers are required to access customer-owned vehicles, download the in-use monitoring frequency data, and submit the data to CARB to verify that the OBD monitors are running often enough compared to the required minimum frequency in the regulation. This data is primarily intended to determine whether the designed enable conditions prevent the monitor from executing frequently enough during real world operation. Failure to meet the minimum acceptable monitoring performance ratios may result in CARB issuing deficiencies or, if severe enough, requiring a recall of all affected vehicles. Manufacturers are required to collect and report in-use monitoring performance data representative of every test group to CARB no later than twelve months after the start of production.

OBD Manufacturer Self-Testing

Manufacturer Self-Testing (MST) pertains only to heavy-duty engines (i.e., engines for use in vehicles greater than 14,000 lbs GVWR) and is conducted to ensure that the OBD systems on in-use aged engines certified on an engine dynamometer are able to detect a fault before emissions exceed the malfunction criteria. Prior to a manufacturer receiving certification for an engine family for a given model year, manufacturers must conduct durability demonstration engine (DDE) testing on at least one engine family as specified by CARB staff using a pre-production engine combined with artificially aged emission control components. For MST, manufacturers then conduct the same tests three years later, but on a procured real-world aged engine and aftertreatment system.

Prior to conducting MST, the manufacturer notifies CARB of the sales volume and the applicable running changes and field fixes for each engine family. Upon CARB's selection of the engine family and rating, the manufacturer will procure engines meeting the following criteria, among others, that:

1) Have mileage that is between 70 to 100 percent of the certified full useful life mileage,
2) Have not been tampered with or equipped with add-on or modified parts that would cause the OBD system not to comply with the OBD requirements,
3) Have not been subjected to abuse (e.g., overloading, misfueling) neglect, improper maintenance, or other factors that would cause the OBD system not to comply with the OBD regulations,
4) Have no detected or known malfunction(s) unrelated to the monitor or system being evaluated that would affect the performance of the OBD system.

A critical aspect of MST is for the manufacturer to confirm through testing on a real-world aged engine that monitors identified as compliant during certification, maintain compliance on a real-world engine.

OBD Confirmatory and Enforcement Testing

CARB periodically evaluates manufacturers' OBD systems for compliance with the OBD regulations by conducting confirmatory and enforcement testing. Confirmatory testing requires the manufacturer to make available a representative vehicle or engine that was used to obtain OBD certification, whereas enforcement testing evaluates the OBD system on in-use procured vehicles or engines from rental agencies, private owners, or fleet owners. Such testing includes both on-road evaluation testing and in-laboratory testing with malfunctioning or deteriorated components provided by the manufacturer. Since OBD testing consists of installing upwards of thirty different faulty or deteriorated components on a test vehicle or engine and then confirming OBD compliance for each failed part, it can take several months to complete the testing program.

The majority of the OBD approval and testing is conducted in the On-Board Diagnostics Branch of the Emissions Certification and Compliance Division, with support of the Mobile Source Laboratory Division testing team.

Presale Confirmation, Assembly Line Testing, and Manufacturer Facilities

At its discretion, CARB conducts confirmation testing on representative engines or vehicles to ensure the emissions match the data reported by the manufacturer at the time of certification. As necessitated by the discovery of defeat devices in late 2015, CARB staff also began conducting AECD screening tests to verify if the disclosed AECDs function as described in the application and to investigate possible undisclosed AECDs or defeat devices. The screening tests include laboratory tests on a chassis dynamometer using non-traditional testing cycles designed by CARB staff, and road tests on routes designed to explore unexpected behavior of the emission control systems for discussion and resolution with the manufacturer. For confirmation testing, CARB can also retest the same product used by the manufacturer for developing submitted test data, using the same procedures, but may use its own or a separate testing facility. Assembly line emission testing confirms the product coming off the assembly line is the same as was described in the manufacturer's application and meets emission requirements before they are sold to consumers. These activities are specified by Title 13, California Code of Regulations, as to the number of products and type of tests performed. Also, CARB audits manufacturing testing facilities to ensure laboratory quality control and assurance protocols are followed, and to review testing results. Regulations for aftermarket parts include provisions to conduct confirmatory testing to verify the emission performance or OBD compatibility data submitted by the manufacturer.

Confirmation testing is directed by New Vehicle/Engine Branch in Emissions Certification and Compliance Division (ECCD), with support of the Mobile Source Laboratory Division testing team. Manufacturer facility audits are conducted by the In-Use Vehicles Program Branch in ECCD.

Post-sale Compliance and Audit Testing

The oversight of engines and vehicles continues after the sale of the product. Testing is done on on-road vehicles that are owned and operated by the public to reflect how normal wear and tear affects the emission control systems. The main goal is to enforce durable and reliable emission control designs, and to catch and fix problems early in the life of a vehicle. For the on-road program, the in-use testing requirements include manufacturer activities and CARB testing activities within the useful life of the vehicle. For smaller off-road and evaporative products, testing is conducted by CARB on newly purchased products.

Manufacturer In-Use Testing and Oversight

On-Road Program

For the light-duty program, manufacturers conduct in-use testing CARB has adopted from US EPA's In-Use (emissions) Verification (testing) Program (IUVP). This program directs manufacturers to perform tests on randomly selected vehicles procured from the public up to five years after production. The number of vehicles selected is based on test group production/sale volumes and are stratified by mileage. Vehicles must be selected from low and high mileage vehicles, ranging from 10,000 to 50,000 miles (or up to 75% of the useful life mileage) and from 1 to 4 years of service, respectively. Each test group has a specific number of vehicles to be tested at different mileages, but also are required to be from different geographic locations including from high altitude and a limited quota from California, when applicable. The tests conducted include a mix of urban, highway and aggressive driving, and evaporative emissions at rest and during fueling. The testing information is reported to US EPA and CARB. CARB actively monitors and uses this data to ensure that manufacturers are complying with California emission standards and that the number of vehicles required by the program based on production numbers and mileage are met. If the majority of the vehicles in a test group have high emissions and/or the average emissions of the test group exceed the threshold based on the corresponding standard established in the regulations, an In-Use Confirmatory (testing) Program (IUCP) is triggered. Ten vehicles from each failing test group must be procured and tested. Testing can cease if the first five show a mean emission level of 75% or less of the applicable standard of a single pollutant which the test group failed previously with no vehicles exceeding the any pollutant standard. The IUVP and IUCP data permits the manufacturers, US EPA, and CARB to identify potential issues of concerns. For test groups with identified issues, the manufacturers work with EPA and CARB to determine appropriate follow-up actions up to and including recall.

For heavy-duty diesel engines (HDDE), the manufacturer-run Heavy-Duty In-Use Testing (HDIUT) was established as a settlement between US EPA, CARB, and the engine manufacturers as a part of the 2004 program changes, adopted by CARB in 2006. CARB, along with EPA and the manufacturers, developed a testing methodology to evaluate "Not-To-Exceed"(NTE) requirements, emission standards, test procedures, and guidance documents for test vehicle selection and screening, testing, reporting, and compliance determination. The goal of the HDIUT program is to generate data on in-use emissions of

heavy-duty on-highway diesel engines that can be used by EPA, CARB, and manufacturers to ensure that emission standards are met throughout the useful life of 2007 and later model year HDDEs under conditions normally experienced in-use.

For the HDIUT program, EPA and CARB jointly issue test orders to HDDE manufacturers specifying engine families to be tested. In general, about 25% of the engine families that HDDE manufacturers produce and sell are selected annually for testing and data submittal.

Upon receiving the data from HDDE manufacturers, staff review the submitted data along with asking the HDDE manufacturers questions about the submitted data to ensure that they comply with the NTE standards and followed the test procedures and guidance documents. Based on the results of the data examination and reviews, HDDE manufacturers may be required to initiate recalls or other in-use actions to correct identified defects in the aftertreatment systems and/or emission control devices.

Off-Road Program

For the small off-road engine (SORE), large spark-ignited (LSI) engine, and spark-ignited marine engine (SIME) programs, staff evaluates manufacturer's quarterly audit reports, reviews and approves functional and alternate test procedures, and oversees compliance testing performed at manufacturer's test facilities to ensure standards are met and regulatory requirements are being followed. Quarterly staff reports are prepared for each regulated sector summarizing production totals for each engine family and the emission performance, if audit testing is required. For exhaust certification, exhaust production line testing (PLT) reports are reviewed each quarter. For SORE, LSI, and SIMW evaporative certification, the required Production Volume Report (PVR) is verified to ensure production quantities for each evaporative family are accurate. At the end of the model year, compliance with fleet average standards, phase-in requirements, and Averaging, Banking, and Trading (ABT) provisions (if applicable) is determined.

Aftermarket Program

Regulations are in place to evaluate aftermarket modifications to certified vehicles or engines, such as changing the fuel system from a conventional gasoline or diesel to alternative fuels like natural gas and ethanol. The related verification program for diesel emission control systems also has post-sales testing (field and emissions) in two stages based on sales triggers and age of systems relative to warranty periods.

Diesel Emission Control Strategies (DECS) Program

The in-use compliance requirements apply to all DECS for on-road, off-road, stationary, marine, rubber-tired gantry (RTG) crane, auxiliary power unit (APU), and transport refrigeration unit (TRU) applications. Field testing is required when 100 units within a given DECS family have been sold or leased in the California market and emission testing is required when 300 units have been sold or leased in the California market. For field testing, applicants must identify and test DECS once they have been operated for at least 25% of their minimum warranty period or for one year, whichever comes first. For emission testing,

applicants must obtain and test DECS once they have been operated for at least 60% of their minimum warranty period or for three years, whichever comes first. For both field and emission testing, applicants must submit a testing proposal to the Executive Officer for review which includes elements such as DECS family name, a representative list of candidate test units, vehicle/equipment location of operation, and a description of test equipment, test personnel, and test methodologies. Within 45 days of receipt of any completed testing proposal, the Executive Officer shall determine whether the applicant has an appropriate testing proposal to support in-use compliance testing and issue an in-use compliance test plan approval letter.

For in-use compliance field testing, applicants must test a minimum of eight units per DECS family. Each tested unit passes in-use compliance field testing if the strategy meets the average opacity level and meets additional functional and visual test requirements defined in the applicant's in-use compliance test plan approval letter issued by the Executive Officer. If the first eight units tested within a DECS family meet these standards, the DECS family passes in-use compliance field testing. If any of the first eight units tested fail to meet these standards, additional units must be procured and tested.

For in-use compliance emission testing, applicants must test a minimum of four units per DECS family. Each unit passes in-use if emission test results indicate that the strategy reduced emissions by at least 90% of the lower bound of the emission reduction level the Executive Officer originally verified it to. For example, if the DECS was originally verified to "At least 85% of PM reduction", each unit passes if the strategy has reduced PM emissions by at least 76.5% (i.e., 90% of 85%). Moreover, if required in the applicant's in-use compliance test plan approval letter, the strategy must meet additional test requirements (e.g., comply with certain NO_2 emissions requirements) to pass the in-use compliance emission testing. If the first four units tested within a DECS family meet these standards, the DECS family passes. If any of the first four units fail to meet these standards, and more than four units are tested, at least 70% of all units tested must meet these standards for the DECS to pass.

At-Berth Program

The in-use compliance requirements of the At Berth regulation apply to all CARB-Approved Emission Control Strategies (CAECS) except for shore power. In order for an emission control strategy to be considered a CAECS, an applicant must receive approval by CARB though an Executive Order. The Executive Order provides compliance instructions for each emission control strategy and includes in-use compliance requirements that each responsible party must follow in order to use that strategy.

For in-use compliance emission testing, at a minimum, CAECS are tested annually to demonstrate that the expected percentage of emission reductions are being achieved. The applicant is required to submit the results of such testing to the Executive Officer by December 31, annually.

CAECS that utilize selective catalytic reduction (SCR), are required to continuously test for ammonia slip and NOx emissions with a continuous emission monitoring system (CEMS). CEMS data must be collected every time the strategy is used for compliance and the data is then submitted to the Executive Officer.

The Executive Officer may modify the testing frequency and may request that the owner or operator of a unit with a CAECS to conduct periodic emission source testing or other types of monitoring to verify the proper operation of a CAECS.

Manufacturer/Independent Laboratory Audits and Test Observations

CARB regularly audits laboratories where the manufacturers' in-use testing is performed at both manufacturer-operated or contracted facilities. These audits ensure the vehicles are tested in agreement with current regulations and are comparable to other laboratories performing similar tests. During a typical laboratory audit, CARB inspects and verifies laboratory equipment using CARB-owned tools and gases, observes engine dynamometer testing, and reviews calibration records and maintenance. Such audits include verifying the calibration of the equipment and instruments and that the procedures implemented at the site conform to the current regulations. Other aspects of the audits include the review of record keeping and retention. For example, the procurement records for the program and the instrument calibration reports are required to be retained for eight years. These audits also help the manufacturers refine their procedures to ensure they will be generating acceptable data for certification and in-use testing. In addition to the audits, CARB performs test observations at the manufacturers' or contractors' facilities. In general, these observations are performed when there is a manufacturer's confirmatory test, or as the result of required special or additional testing. CARB observers verify preconditioning of the vehicles, test arrangements, fan ventilation, environmental conditions, and speed traces and testing inputs to the analyzers and sampling system. When a laboratory is found to be noncompliant, CARB may no longer accept data from the lab until the non-compliances are addressed.

CARB's In-Use Compliance Testing Program

Light-Duty On-Road Cars and Trucks

CARB has been conducting the In-Use Compliance Testing Program on light-duty vehicles since 1983, to help California meet ambient air quality standards by ensuring that vehicles do not exceed their emissions standard over time, or their useful life period. A limited number of privately-owned vehicles of a given test group are procured, inspected, and if needed, subjected to minor adjustments to restore the engine to the manufacturer's specifications. These vehicles then undergo emission testing identical to the testing done by the manufacturer during the certification process. The main difference with the manufacturer-conducted IUVP testing and this program is that this program requires procuring and testing a minimum of 10 properly maintained vehicles per test group that have up to 75% of their useful life mileage. The test groups and engine families targeted for testing under these programs are selected considering a number of factors such as: certification data, past

emission performance, vehicle production volume, smog check data, warranty history, public complaints and inquiries, and by monitoring the data submitted from IUVP. Other criteria that may be considered include vehicles from a new manufacturer and/or a new technology. Representatives from the vehicle manufacturer are invited to observe this testing accompanied by CARB's project and/or test engineer.

In 2015, an additional In-Use Screening Testing strategy was initiated focusing on diesel light- and medium-duty vehicles as the result of the investigation of the VW defeat devices. In the traditional in-use compliance test, each vehicle was tested on up to three prescribed laboratory test cycles (FTP, HFE, and SFTP). Now, special test cycles are often included to detect non-disclosed AECDs or defeat devices. Test methods include the use of OBD data and Portable Emission Measurement Systems (PEMS).

Heavy-Duty On-Road Trucks and Engines

CARB's heavy-duty in-use compliance (HDIUC) program was initiated in 2016. HDIUC is one of CARB's primary programs for assessing whether manufacturers meet the on-road standards. Staff runs emission testing using PEMS connected to the truck's engine exhaust to determine whether an engine family complies with the Not-to-Exceed (NTE) standards and analyzes test data to identify any systematic failures or defeat devices. In some cases, the PEMS testing is supplemented with engine and chassis dynamometer testing. The heavy-duty in-use compliance program ensures that heavy-duty engines meet the required emission standards in both the lab and in operation on the road and provides a level playing field between all manufacturers.

Staff tests a minimum of ten vehicles for in-use compliance testing of an engine family. Trucks are accepted for testing if they are within their useful life (435,000 miles or less for heavy heavy-duty engines), are properly maintained, and representative of an engine family. Using the NTE protocol and PEMS equipment, staff tests engines under conditions that are reasonably expected to be encountered during normal vehicle operation. Trucks are driven on common freight routes and with loads under normal ambient conditions and tested for at least three hours of non-idle time. When heavy-duty engines are initially certified, the required engine tests are performed without a complete vehicle. Heavy-duty in-use testing, on the other hand, involves alternative procedures to provide data demonstrating how engines perform once installed in a chassis as part of a complete vehicle. These tests require fuel testing, opacity testing, PM filter testing, data logging, PEMS installation, and data analysis.

Small Off-Road Engines (SORE)

CARB conducts evaporative emission compliance testing of new small off-road engine evaporative components (fuel tanks, fuel lines, and carbon canisters) to ensure they meet the applicable standards. The Executive Officer either orders a manufacturer to provide samples of a component to CARB staff for compliance testing or purchases components for testing. Units are acquired from retail establishments in California or are purchased online and provided to CARB for testing.

Portable Fuel Containers (PFC) and Portable Outboard Marine Tanks and Components (OMT)

CARB conducts evaporative emission compliance testing of new PFCs and OMTs to ensure they meet the applicable emission standards. CARB staff purchase units for testing. Units are acquired from retail establishments in California or are purchased online for testing.

Aftermarket Parts

CARB can monitor the performance of aftermarket parts after they enter commerce through in-use compliance testing. Regulations for add-on and modified parts, alternative fuel retrofit systems, motorcycle critical emission control parts, catalytic converters, diesel particulate filers, and diesel emission control systems include in-use testing provisions. The testing is intended to ensure manufacturers produce parts that meet the specifications disclosed in their exemption applications and that in-use emissions remain at levels specified during the exemption/verification application process.

Warranty Reporting

The Emission Warranty Information and Reporting (EWIR) and Recall program, adopted in 1988, is a critical tool that allows CARB to gain insight and knowledge about how durable emission-related components are and if they are performing as intended by maintaining emission levels below the applicable standard throughout the useful life period. The EWIR program has shown to be effective as it allows for early detection of failures occurring in the field and continuous tracking of warranty claim and failure rates throughout the warranty period. This provides CARB with critical information to determine when corrective action should be taken by a manufacturer. If it is found that there are in-use issues, CARB can require manufacturers to remedy them through corrective action. The program applies to on-road light-duty, medium-duty, heavy-duty, and motorcycle classifications.

Manufacturers are required to provide repair and replacement of defective emission-related parts free of charge to consumers during the warranty period. Manufacturers are required to report the number of parts replaced under warranty and identified as defective. If the failure rate of a warranted component exceeds regulatory limits, the manufacturer may be required to implement corrective action in the form of a recall or extended warranty. There are three progressive levels of warranty reporting requirements for on-road vehicles: emission warranty information report (EWIR), field information report (FIR), and the emission information report (EIR),

The first level of reporting is the EWIR. This report requires manufacturers to report the number of unscreened warranty claims that occurred in the field. An unscreened warranty claim is a claim reported to the manufacturer regarding an emission-related part but has not been verified by the manufacturer as a valid failure nor investigated to determine the root cause of the failure. The report is due once the number of unscreened warranty claims for an emission-related component in an engine family or test group exceeds 1% or 25 claims, whichever is greater. Manufacturers submit this data to CARB on a quarterly basis in

electronic format throughout the reporting period which typically coincides with the warranty period.

The second level of reporting is the FIR. The FIR is due once the unscreened warranty claim rate for an emission-related component in an engine family or test group exceeds 4% or 50 claims, whichever is greater. This report requires manufacturers to investigate the issue further to determine the failure modes and root causes, an adjusted valid failure rate, and to provide projections for the failure rate through the end of the useful life period. Manufacturers are given the opportunity to screen warranty claims and determine what percentage of unscreened claims were valid failures. Example of warranty claims that may be screened out and not counted as valid failures include components that were later analyzed by the manufacturer and found to be operating within specifications, components mistakenly replaced due to a misdiagnosis by the service technician, etc. Manufacturers gather this information by analyzing returned components.

The third level of reporting is the EIR. The EIR is due once the valid failure rate for an emission-related component in an engine family or test group exceeds 4% or 50 valid failures, whichever is greater. The report requires manufacturers to assess how the failure of the component will affect emissions over the useful life of the vehicle and provide information on how other factors such as drivability and fuel economy will be affected by the failure.

Manufacturers are subject to corrective action once the valid failure rate for an emission-related component in an engine family or test group exceeds 4% or 50 valid failures. Corrective action can be voluntary from manufacturers or CARB can order manufacturers to perform corrective action based on evidence of a noncompliance. High warranty rates for defective emission-related components from previous model years are also reported to the certification branch for consideration, as applicable, during the certification process for future model year vehicles.

Manufacturers of off-road engines, such as lawnmowers, weed trimmers, forklifts, all terrain equipment, recreational boats, and large construction and farm equipment, are required to provide repair and replacement of defective emission-related parts free of charge to consumers during the warranty period. The manufacturers are required to report the number of parts identified as defective and replaced under warranty under various regulations by submitting reports following procedures as specified in regulation. If failure rates exceed regulatory limits, the manufacturer may be required to implement corrective action in the form of a recall or extended warranty.

The investigation and reporting procedure requires manufacturers to report to CARB the number of warranty claims that occur in the field. The report is due once the number of warranty claims for an emission-related component in an engine family or test group is exceeded. Manufacturers submit this data to CARB on a regular basis in electronic format throughout the reporting period which typically coincides with the warranty period. The defect rates are evaluated to see if they exceed the threshold for triggering a recall or

extended warranty. Most of the off-road categories have a minimum warranty period of two years or 1,500 hours.

These reporting procedures require manufacturers to investigate the issues with emission-related components further to determine why components are failing in the field, the impact that the failures will have on emissions, and if the failures will cause any operational problems. The defect reports must also explain the actions that the manufacturer will take to resolve the issues.

Manufacturers are subject to corrective action once the valid failure rate for an emission-related component in an engine family or test group reaches a substantial amount. Corrective action can be voluntary from manufacturers or CARB can order manufacturers to perform corrective action based on evidence of a noncompliance.

Corrective Actions

If tested vehicles exceed their specified emissions standard for their engine family or test group, the vehicle manufacturer is required to investigate the cause and begin corrective action to correct the issue and ensure that all affected vehicles or products are compliant.

Additionally, manufacturers are subject to corrective action once the valid failure rate for an emission-related component in an engine family or test group exceeds 4% or 50 valid failures, whichever is greater. CARB uses the information provided in warranty reports to help determine the appropriate level and type of corrective action that manufacturers must take when conducting corrective action.

Corrective action can be voluntary from manufacturers or CARB can order manufacturers to perform corrective action based on evidence of a noncompliance. Once it has been determined that an engine family or test group is not meeting its specified emission standard or is equipped with an emission-related component that has exceeded the corrective action threshold, CARB works with the manufacturer to determine how to remedy the in-use issue.

The types of corrections that manufacturers may be required to take can include providing an extended warranty, performing targeted service campaigns, or recalling products. Occasionally, manufacturers may come up with an appropriate solution to effectively resolve the in-use issue without needing to perform a recall, such as a targeted service campaign that will inspect and repair all affected vehicles that enter a service center without needing to mail out customer notification letters. More typically, however, recalls are conducted or extended warranties are issued.

An in-use issue affecting a test group or engine family may have an impact on several carry-over and carry-across test groups or families from previous or subsequent model years as they may have the same issue. Corrective action may consist of only a software solution or be more extensive and include changes, replacements, or addition of components to remedy the in-use issue. Staff works with the manufacturer to ensure that replacement components are available and not subject to the same issue that the defective components were found to

have. It is extremely important to have assurance that the recall fix works; otherwise, there is a risk of a second recall.

Once the appropriate corrective action has been determined, manufacturers must follow CARB's corrective action requirements. This ensures that the corrective action program will be successful and effective. CARB reviews all customer notification letters and dealer bulletins to ensure that they are satisfactory and will adequately inform customers and dealers on how to proceed. Close coordination occurs with in-use testing, warranty, certification, and OBD staff to ensure that manufacturers' fixes adequately address the in-use issues and that all required documentation, such as field fixes and running changes, have been submitted to and approved by CARB.

Corrective action is usually in the form of a statewide recall in which the manufacturer notifies all affected vehicle owners about the issue. The communication includes instructions for vehicle owners to follow to have the issue remedied, where they can have the recall repair work performed, and informs vehicle owners that the manufacturer will provide the repair at no cost to the vehicle owner.

Manufacturers must also submit six quarterly progress reports indicating the number vehicles subject to the corrective action and the capture rate of the program. This allows for CARB to make sure that vehicles are being repaired in the field and recall campaigns are being carried out satisfactorily.

The DMV tie-in program is a powerful tool that CARB requires manufacturers to use when conducting California on-road recalls. Vehicle owners are unable to renew their vehicle registration until they have the recall repair work performed on their vehicles. This is accomplished by manufacturers submitting a list of vehicle identification numbers (VINs) that still need to have the recall repair work performed to CARB on a monthly basis. Vehicle categories affected by the DMV tie-in are passenger cars, light-duty trucks, medium-duty vehicles, heavy-duty vehicles, and motorcycles. CARB then provides this information to the DMV and it places registration holds on VINs still needing the repair work to be performed. This ensures that recalls achieve high capture rates; typically, over 90%.

If emission testing indicates that off-road engines are not meeting emission standards or failures of emission control components are reaching a substantial number, the manufacturer is required to investigate the root cause and begin action to correct the issue and ensure that all affected equipment or products are compliant. Much like on-road, the types of corrections include extended warranty, targeted service campaigns, or recall of the product. However, the DMV tie-in with registration hold is not part of the off-road program.

Accordingly, if the capture rate for a recall or other applicable corrective action is insufficient, CARB can require that the manufacturer submit additional quarterly progress reports during the length of the warranty period. The reports will indicate the number of units/equipment subject to corrective action and the capture rate of the program. This allows for CARB to ensure that equipment is being repaired in the field and recall campaigns are carried out satisfactorily.

The majority of the in-use testing and warranty activity is conducted by the In-Use Vehicle Program Branch of the Emissions Certification and Compliance Division with testing support from the Mobile Source Laboratory Division. In-use testing on aftermarket parts is coordinated within the Aftermarket Parts Certification and Audit Branch with testing support from the Mobile Source Laboratory Division.

The MSCCP activities discussed above ensure all types of engines, vehicles, and components used in mobile sources meet all emission requirements both when new and when in use. The following sections will discuss each of the on-road, off-road and aftermarket part engine, vehicle, and component certification and compliance program activities conducted in 2020 and 2021.

On-Road Engine, Vehicle, and Component Certification and Compliance Program

The On-Road Certification and Compliance Program is responsible for the annual certification and post-certification auditing of new light-duty (LD) vehicles rated below 14,001 pounds (lbs) gross vehicle weight (GVWR), such as passenger cars (PC), light-duty trucks (LDT), medium-duty vehicles (MDV), and medium-duty passenger vehicles (MDPV); motorcycles; heavy-duty engines and vehicles (HD) above 14,000 lbs GVWR and greenhouse requirements for heavy-duty vehicles and trailers. Below provides an overview of activities that ensure regulatory compliance for on-road engines, vehicles, and components before and after the sale of the product.

Before the Sale: Certification, Confirmation Testing and Approvals

Figure 2 provides the key elements for on-road engine or vehicle certification for the issuance of an executive order.

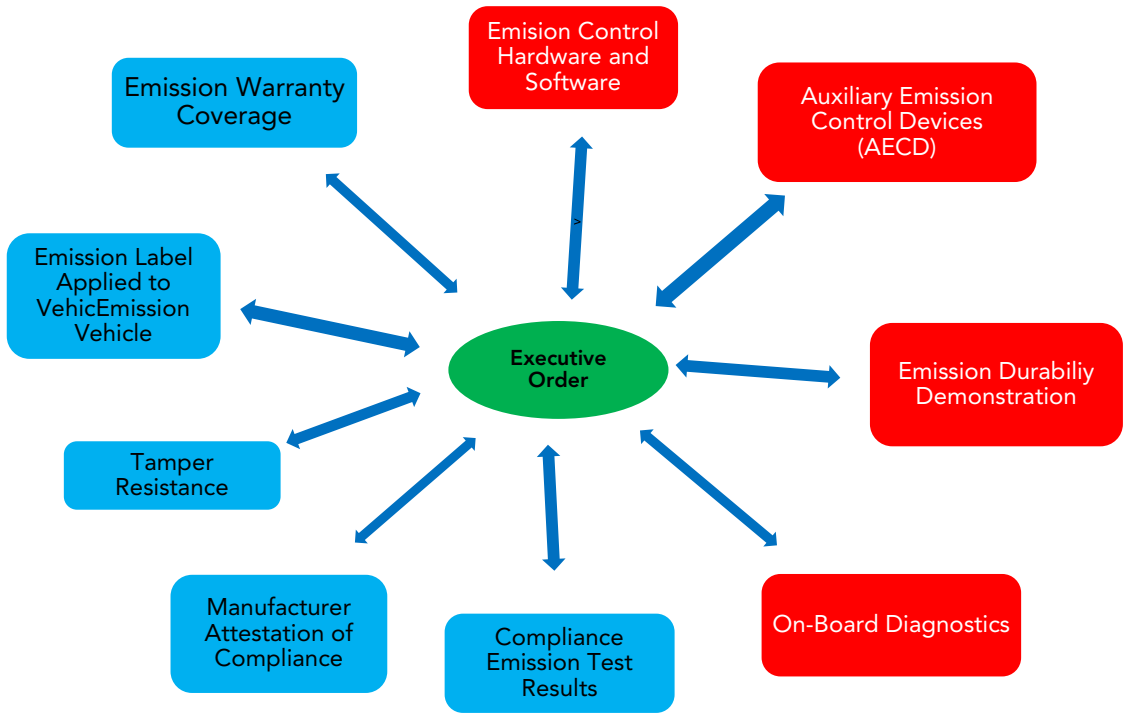


Figure 2: What goes into an On-Road Product Approval

Each product type must meet the adopted standards for its category. The on-road program certifies a wide variety of products. Each product is subject to multiple standards depending on the size and type of product under evaluation (Table 2).

On-Road Product Category	Standards Category
Passenger cars/Light-duty trucks and Medium-duty passenger vehicles	Gross Vehicle Weight Rating (GVWR) <8,500 pounds
Medium-Duty Vehicles	GVWR 8,500 to 10,000 pounds; GVWR 10,000 to 14,000
Highway Motorcycles	Class 1: 50 cc to <170 cc Class 2: 170 cc to <280 cc Class 3: 280 cc and above

Heavy-Duty Engines	MDE: GVWR 8,500 to14,000 pounds LHDD: GVWR 14,000 to 19,500 pounds MHDD: GVWR 19,501 to 33,000 pounds HHDD: GVWR greater than 33,000 pounds HOE: GVWR up to 33,000 pounds HHOE: GVWR greater than 33,000 pounds Urban Bus
Heavy Duty Vehicles	Evaporative Standards and GHG Standards
Trailers	Trailers
Aerodynamic Component	Aerodynamic Components

Table 2: On-Road Product Standards Categories

It is expected that an application submitted by the manufacturer will be entirely complete at the time of initial submission, but there are scenarios when specific items may be submitted once available, e.g. on-board diagnostic (OBD) approvals (See Before the Sale: On-Board Diagnostics). The type of information submitted for review can been seen in Figure 3.

Type of On-Road Manufacturer Information Required Application Submittal		
	Required	**If Applicable**
Manufacturer Registration	EPA Manufacturer Code Letter of Intent Electronic Signatures Letter DMS (Document Management System) Users Worksheet DMS Training	Authorized Consultants Letter
	Required	**If Applicable**
Pre-Application	Certification Preview	Durability Plan DF Carry Across Worksheet AECD Declarations Template Corporate Average Plan

Application	**Required** Cover Letter Statements of Compliance Defeat Device Declaration Waiver Requests Durability Report Emission Label Schematic or Photo Sensor Descriptions Worksheet Emission Test Data Catalysts Description Tamper Resistance Declaration Maintenance Schedule Projected Production	**If Applicable** Application Templates Evaporative/Refueling Application Template GHG Vehicle Application Template Ammonia Slip Values NTE Deficiency Declaration DPF Regeneration Strategy Description SCR Inducement Strategy Description Electric and Off-Cycle Component Description Projected ABT Report OBD Approval Exhaust Application Approval Concurrent Exhaust Application Delegates Assembly Documentation
Post-Application	**Required** Annual Production Report	**If Applicable** Running Changes Field Fixes Annual ABT Report

Figure 3: On-Road Manufacturer Application Information for Submittal

Within 30 days of an application submission, CARB conducts a preliminary review of the documents and notifies the manufacturer that the application has been received and whether the information submitted is sufficient to proceed to a full, detailed review ("Accepted for Filing") or "Not Accepted for Filing." CARB staff and management review the submitted package to check whether the application contains information that demonstrates compliance with all applicable requirements, and if so, an EO will be issued within ninety calendar days from the time that a complete application package was "Accepted for Filing." If the application is for a product that was certified the previous model year and meets specific conditions (Mail-Out # ECARS 2015-7: Streamlined Certification Process for Carryover and Partial Carryover Certification Applications), a manufacturer may request a streamlined or expedited review. The on-road program issued 1,045 and 1,244 EOs during 2020 and 2021, respectively (Table 3).

Product Type	CARB On-Road Program

	Number of Executive Orders Issued per Year	
Year	2020	2021
LD/MD cars and trucks	510	463
HD engine and vehicle-criteria	135	145
On-Road HD vehicle – GHG (Phase 1/Phase 2)	42/83	NA/352
GHG Aerodynamic Components/Trailers	10	14
Motorcycles	252	251
Other (Exempt HD Vehicles, ZEP, Fuel-Fired Heaters)	13	19
Total	1,045	1,244

Table 3: Total Number of On-road EOs Issued from 2020 and 2021

CARB strives to provide the most efficient processing time from application to issuance of the EO. CARB continues to review and evaluate its approval process. Individual review times can vary significantly within and across sectors based on the complexity of the emission controls utilized, the types of applicable emission standards, and even the previous experience of the manufacturer in adequately documenting the required information in a clear and concise format and responding to staff questions in a timely manner. Figure 4 shows the average time from submittal to issuance of an EO in 2020 and 2021 for the on-road programs.

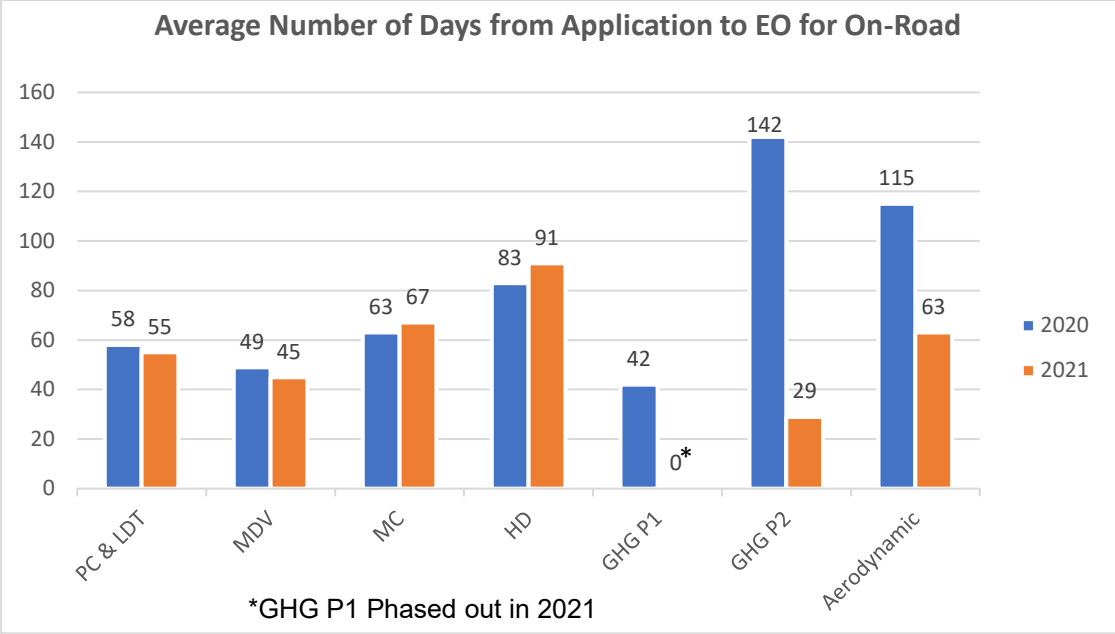


Figure 4: Average Processing Time to Receive EO

GHG trailer requirements are new and currently voluntary. Six EO's were issued for GHG trailers in 2020 but none were issued in 2021. It is worth noting that there is some interest shown from industry for this program but, due to the newness of the program and voluntary nature, the processing time was not included in Figure 4.

Light-duty and Medium-duty Car and Truck Certification Activities

During 2020, 824 applications were received from 38 LD manufacturers for 401 applications for new EOs for light- and medium-duty test groups (359 PC/LDT and 42 MDV TGs) and 423 applications for running changes or field fixes (343 PC/LDT and 80 MDV TGs). During 2021, 774 applications were received from 38 LD manufacturers for 382 applications for new EOs for light- and medium-duty test groups (343 PC/LDT and 39 MDV TGs) and 392 applications for running changes or field fixes (342 PC/LDT and 50 MDV TGs). All light- and medium-duty manufacturers certified to LEV III, except for some small volume manufacturers that were still allowed by regulation to certify to LEV II through model year 2021. The breakdown type of applications received is shown in Figure 5.

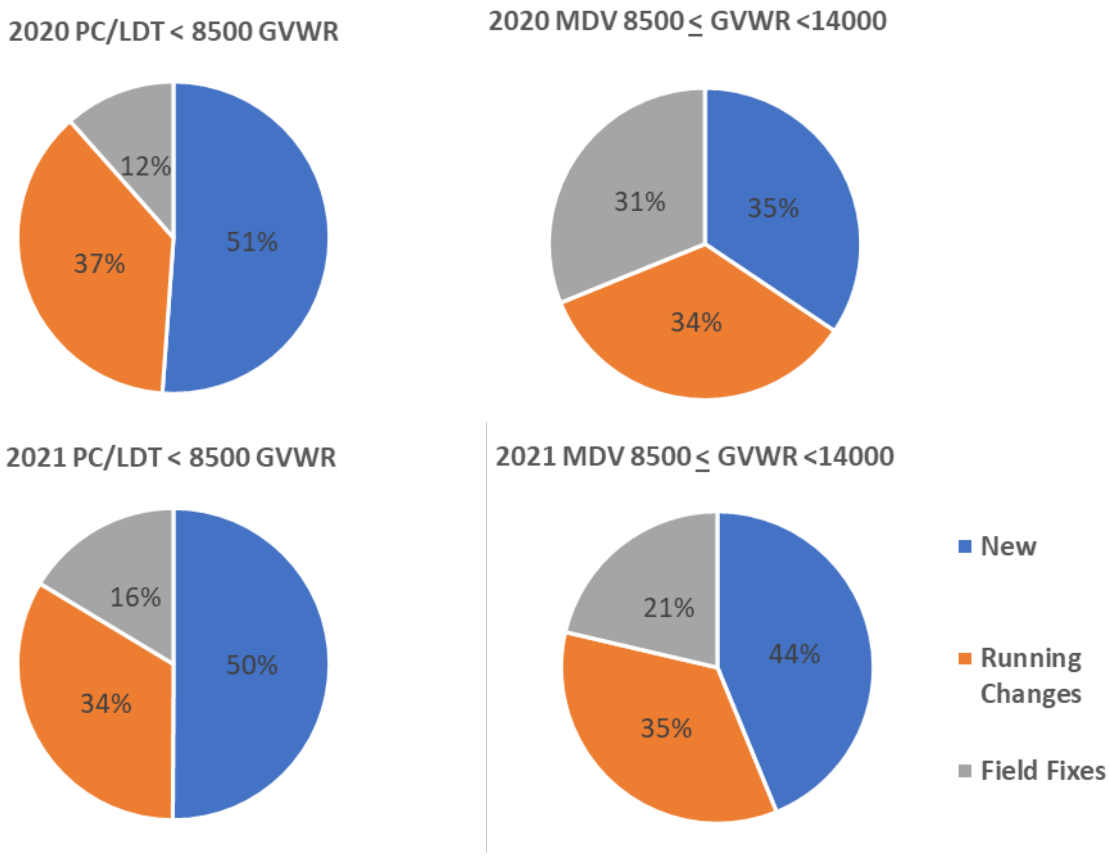


Figure 5: Light-Duty and Medium-Duty Applications

CARB usually conducts between 2 and 6 confirmatory/screening tests per year for light-duty cars. Confirmatory testing is used to verify manufacturers' emission results submitted at the time of certification. Auxiliary Emission Control Device (AECD) screenings are used to verify that the product contains no defeat devices like those used by Volkswagen to falsify emission test data in 2015. But in 2020 and 2021, due to lab closures as the result of the stay-at-home pandemic shutdown and laboratory staff's involvement with the acceptance of the new CARB test lab in Riverside, California, testing was more limited than typical. To illustrate the normal workload, Table 4 below provides a summary of CARB confirmatory tests during 2018 and 2019.

CONFIRMATORY TESTING RESULTS					
CY	Arrived at Lab	Passed	Failed	Not Testable (repeated breakdowns of test vehicles)	% Passing
2018	3	2	1	0	66%
2019	3	3	0	0	100%

Table 4: Light- and Medium-Duty Vehicle Confirmatory Testing, Model Years 2018 and 2019

Motorcycle Certification Activities

During 2020, a total of 362 applications were received from 55 different motorcycle manufacturers, of which 227 were new EO applications and 135 were for running changes, field fixes, or "corporate average plan" where manufacturers select certain EF to meet a "designated HC+NOx standard." During 2021, a total of 364 applications were received from 55 different motorcycle manufacturers, of which 229 were new EO applications and 135 were for running changes, field fixes, or corporate average plan (Figure 6).

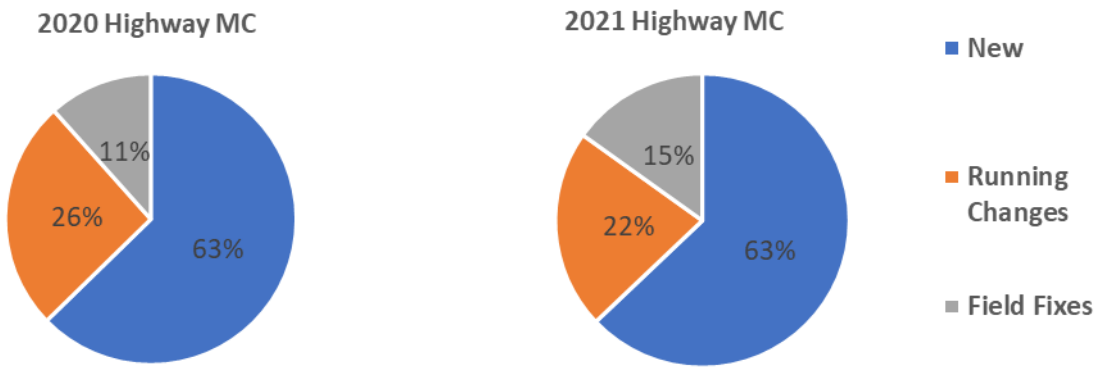


Figure 6: Total Number and Type of Motorcycle Applications

CARB usually conducts about 5 to 10 confirmatory/screening tests per year for on-road motorcycles. But in 2020 and 2021, due to lab closures as noted above, testing was not conducted. To illustrate the normal workload, Table 5 below provides a summary of CARB confirmatory tests during 2015 to 2019.

CONFIRMATORY TESTING RESULTS					
CY	Arrived at Lab	Passed	Failed	Not Testable (repeated breakdowns of test vehicles)	% Passing
2015	12	9	2	1	75%
2016	10	9	0	1	90%
2017	3	3	0	0	100%
2018	7	7	0	0	100%
2019	6	6	0	0	100%
Total	57	50	4	3	89%

Table 5: Highway Motorcycle Vehicle Testing, Model Years 2015 to 2019

Since 2015, manufacturers have improved the robustness of their emission control systems going from a 75% passing rate to a passing rate of 100%. This is similar to trends observed in the mid-1980's when in-use compliance testing was first begun for light-duty vehicles. It should also be noted that a few on-road motorcycle manufacturers withdrew their applications for certification when a confirmatory test vehicle was requested by CARB to verify the submitted emission test results.

Figure 7 shows the tamper resistance tests performed for on-road motorcycles with carbureted engines during the 2018 through 2021.

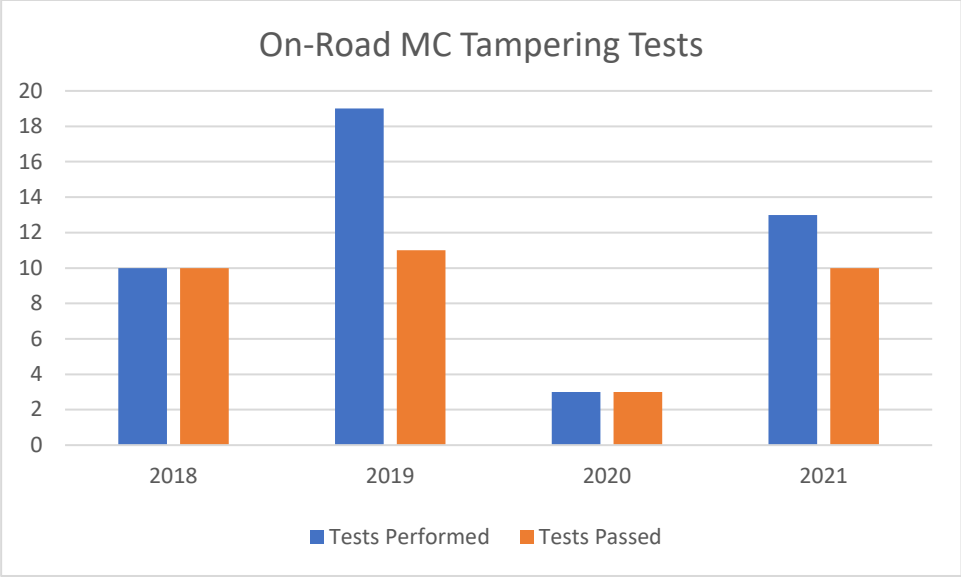


Figure 7: Tamper Resistance Tests, Model Years 2018 through 2021

Heavy-Duty Engine, Vehicles and Component Certification Activities

CARB received 709 applications during 2020: 89 for new engine certifications, 63 for new vehicle certifications, 246 for running changes, and 311 for field fixes for heavy-duty engines and vehicles. CARB received 866 applications during 2021: 96 for new engine certifications, 20 for new vehicle certifications, 262 for running changes, and 488 for field fixes for heavy-duty engines and vehicles. The breakdown of the applications can be seen in chart in Figure 8.

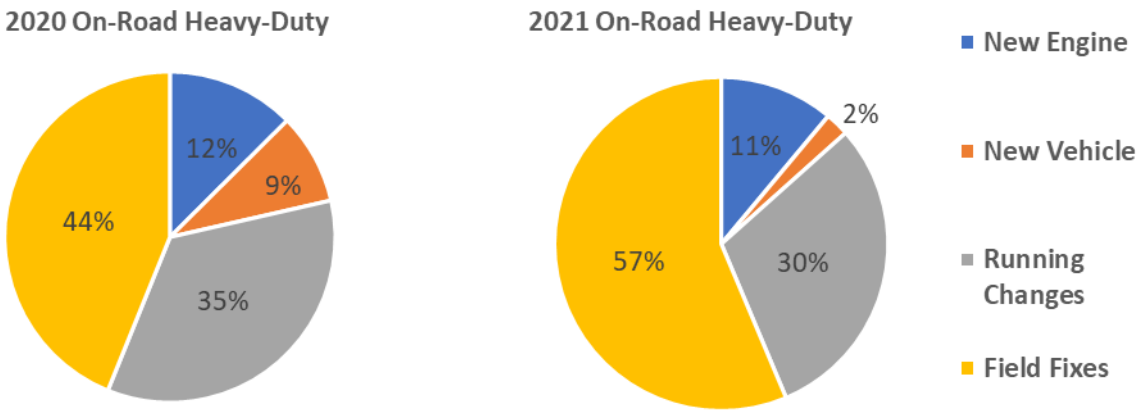


Figure 8: Application received for On-Road Heavy-Duty Certification

In addition to the above applications, CARB also reviewed 5 applications for fuel-fired heaters and issued 2 close-out letters for applications that the manufacturer failed to submit required information when requested to do so. As of 2021, CARB had no capability to

conduct confirmatory and before sale AECD screening testing for on-road heavy-duty products but as the new Riverside facility becomes operational, CARB will begin testing on these products before certification. There were two tampering tests performed in 2020 and 2021, both passing. This number of tampering resistant tests was abnormally low due to laboratory closures noted above. Also in 2020, CARB initiated the deterioration factor (DF) validation program which requires manufacturers to validate the DFs developed for programs utilizing Selective Catalyst Reduction (SCR). The DF is used to predict the amount of deterioration in emission control (i.e., increase in emissions) by the component over its useful life. Initial results found that in-use emission deterioration was far greater than that projected in the manufacturer-run durability programs. As a result, CARB staff developed a program to be run by manufacturers to validate the as certified DFs with testing of engines/vehicles in the field. To conduct this testing, the manufacturer must first submit a plan for CARB review and approval. Those reviews began in 2020 and the process is proving to be a lengthy one with some reviews taking weeks to complete while other have taken several months based on the complexity of the technology being evaluated, the level of detail in the manufacturer's original submittal, and the number of follow-up questions from staff and timely responses by manufacturers. CARB staff have reviewed 12 DF validations for the on-road heavy-duty categories and expect to review more as the DF validation program is ongoing and will be in place for the next several model years.

Greenhouse Gas (GHG) Program Certification Activities

In 2008, CARB adopted the Tractor-Trailer GHG (TTGHG) regulation that requires tractor-trailers to use tires and aerodynamic equipment to improve fuel efficiency beginning in 2010. In 2013, CARB adopted a series of new regulations for GHG emissions for heavy-duty trucks and engines sold in California and harmonized with the adopted U.S. Environmental Protection Agency (EPA) rule for new trucks and engines nationally. These new regulations are known as the GHG Phase 1 standards for heavy-duty trucks and engines and applied to 2014 Model Year (MY) and later heavy-duty vehicles.

Although the GHG Phase 1 standards reduced emission inventories in California, the annual growth of the heavy-duty vehicle industry and vehicle miles traveled would soon surpass all initial emission reduction benefits. In 2016, U.S. EPA and the National Highway Traffic Safety Administration jointly adopted the federal Phase 2 standards that built on the Phase 1 standards in order to achieve additional GHG reductions. California then aligned with these federal Phase 2 standards in 2018. In December 2019, the California Air Resources Board adopted more stringent requirements (California GHG Phase 2) to reduce CO_2 and other GHG emissions from HD trucks and trailers and certify aerodynamic components. In order to allow trailer fleet owners to comply with the TTGHG trailer requirements by using Phase 2 GHG trailer certification technology for 2020 through 2022 MY, CARB also created the Tractor-Trailer Greenhouse Gas Aero Device Approval Program. For aerodynamic devices certified in 2020, manufacturers are required to recertify them in 2021, and then again in 2024, with these respective years correlating to the increasing stringency of trailer GHG standards.

Notably, 2020 marked a monumental transition of a variety of GHG programs and regulations, most importantly from GHG Phase 1 to GHG Phase 2. In Phase 2, a manufacturer's application must go through independent CARB review and approval. The new regulations no longer allow manufacturers to use a deemed-to-comply provision to demonstrate compliance with EPA requirements in lieu of CARB requirements and instead must get separate CARB approval. In addition, the second critical change that is unique to CARB GHG Phase 2 compared to federal requirements is the required compliance to air conditioning (A/C) leakage standards that ensures the A/C systems are designed and assembled such that any refrigerant leakage is below the allowable limits.

Table 6 provides a side-by-side comparison of the main differences between Phase 1 and Phase 2.

GHG PHASE I (MY 2014-2020)	GHG PHASE 2 (MY 2021+)
Manufacturers certified with EPA may use the deemed-to-comply provision for California	CARB does an independent review prior to Executive Order (EO) issuance
Trailers not included	Trailers included
Small business manufacturers are exempt	Regulations apply to small business manufacturers starting in 2022 MY
AC leakage standards apply to tractors	AC leakage standards apply to tractors and vocational vehicles with additional AC leakage requirements for CARB certification
Subcategories based on combustion cycle and GVWR	Subcategories based on combustion cycle, GVWR, and duty cycle

Table 6: Changes in requirements between Phase I and Phase II GHG

In 2020, not only did engine/truck manufacturers began submitting more substantial information for 2021 MY applications under the new California GHG Phase 2 regulations, but also the new California GHG Phase 2 trailer standards took effect and required trailer manufacturers to incorporate existing and new emission technologies specific to trailers. Under these standards, trailer manufacturers designed their trailers to be more efficient to decrease the power required by the HD engine/truck carrying the payload thereby lowering the associated GHG emissions. Affected trailer types include box-type trailers of the dry and refrigerated variety, flat bed trailers, tank trailers, and container chassis. The trailer standards can be met through aerodynamic improvements, low rolling resistance tires, tire pressure systems (Tire Pressure Monitoring System/Automatic Tire Inflation System), and/or weight reduction. Trailer manufacturers must certify to California standards (originally starting January 1, 2020, however delayed until January 1, 2022) to receive an EO from CARB to legally sell trailers in California. In 2020 and 2021, CARB administered the California GHG trailer regulation on a voluntary basis.

CARB received 113 applications in 2020 with 89 applications for new vehicle EOs, six trailer, four aerodynamic devices, and 14 applications for running changes. CARB received 552 applications in 2021 with 366 applications for new vehicle EOs, 14 aerodynamic devices, and

172 applications for running changes. The breakdown of the applications can be seen in Figure 9.

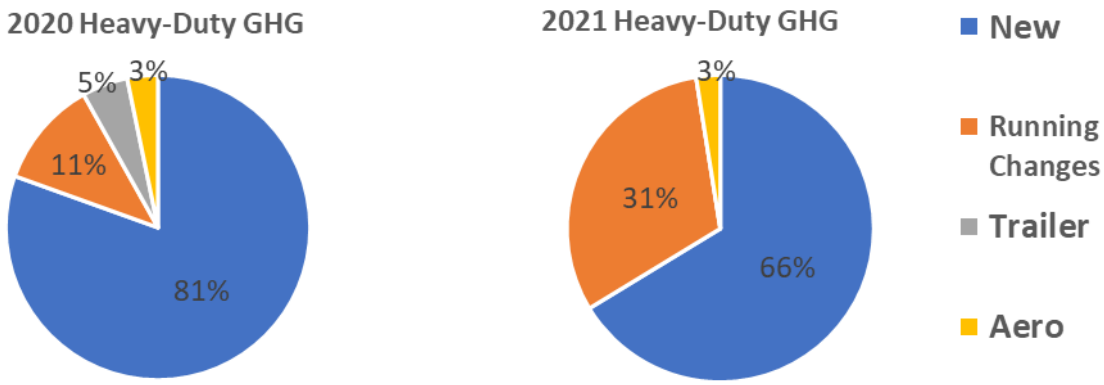


Figure 9: Applications for Tractor, Trailer, and Aerodynamic Devices for 2020 and 2021

Since this program is new to CARB and industry, reviews typically required more time (Figure 4) with both staff and industry getting up to speed on relevant regulations and applicable technical knowledge. Compared to Phase 1 tractor/vocational applications, Phase 2 applications took three times as long to process due to additional certification and document review requirements. Staff spent a significant portion of 2020 updating manufacturers on the new CARB Phase 2 requirements and drafting and releasing documents such as Manufacturer Advisory Correspondences (MAC) and Guidance mail outs to inform manufacturers of these upcoming changes. The MACs provided guidance on general Phase 2 GHG applications, and provided direction on specific items, such as the updated powertrain family naming convention for Zero-emission powertrain (ZEP) certification.

Before the Sale: On-Board Diagnostics

OBD approvals are the critical first step for manufacturers to obtain an Executive Order to sell their vehicle or engine in California. Manufacturers' OBD systems are reviewed for compliance with the OBD regulation requirements and subsequently approved. There are many pre- and post- certification activities that are considered for an OBD approval (Figure 10):

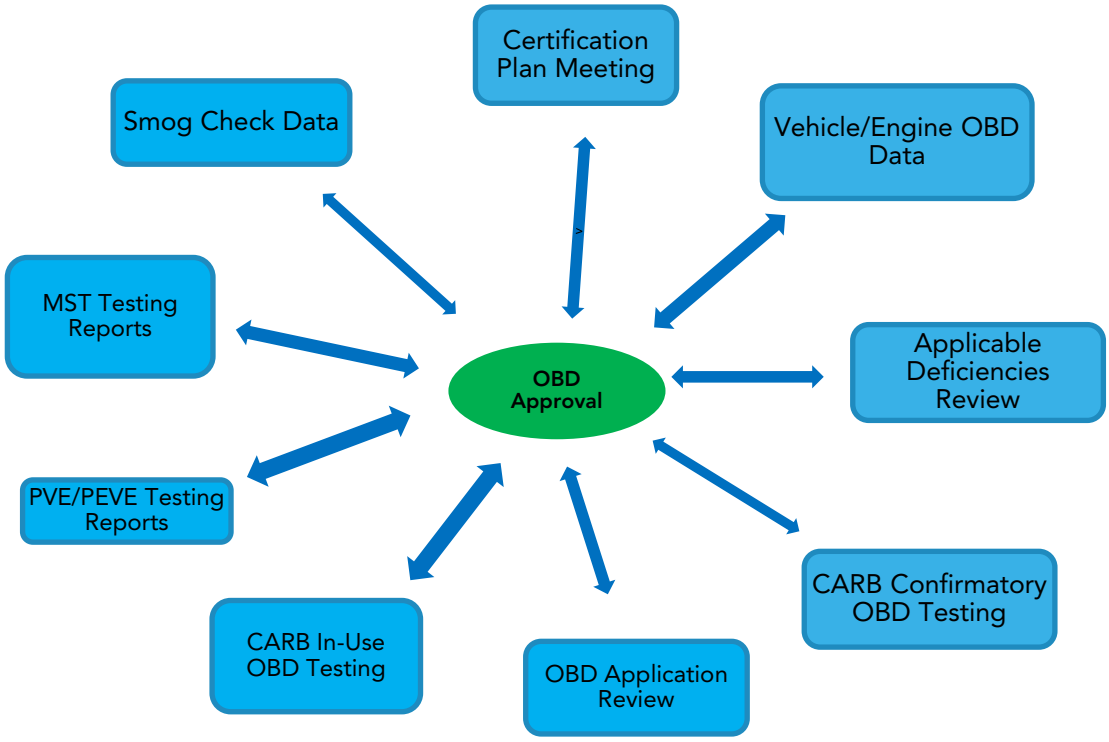


Figure 10: What goes into an On-Board Diagnostic (OBD) Approval

To receive an OBD approval letter, manufacturers submit an OBD application that includes detailed explanations of how each individual diagnostic in the system works with supporting data. For each submission, OBD staff review the application and typically have at least one round (often more) of questions and answers with the manufacturer for clarification before issuing an approval letter. CARB targets 90 days from initial submission of a completed OBD application to finish its review and issuance of an OBD approval letter. Review consists of using engineering analysis to judge whether the monitors, individually and collectively, meet requirements set forth in the regulation. The OBD application consists of the information shown below in Table 7.

Type of OBD Information Required Application Submittal
Cover Letter
Check List
Summary Tables
Durability Demonstration Vehicle (LD) Data/ Durability Demonstration Engine (HD) Data
Misfire Catalyst Damage, Disablement Detection Charts, Probability of Detection (POD) Charts
Applicable Test Cycle and Adjustment Factor for each Monitor ((Light/Medium duty vehicles)/ Applicable Test Cycle, Emission Threshold Monitor Data and Adjustment Factors (Heavy Duty Engines)
Input and Output Signal List
Closed Loop Description (LD and HD)/ Feedback Descriptions (HD)
Diagnostic Link Connector (DLC) Location Connector Picture
Positive Crankcase Ventilation (LD)/Crankcase Ventilation System (LD,HD) Description
Auxiliary Emission Control Device (AECD) and Emission Increasing AECD (EI-AECD) Descriptions
MIL Location and Image (LD only)
NOx and PM Not-To-Exceed (NTE) Carve-Out (HD only)
Standardization Data
Non-MIL (LD Only)/ Non-OBD Components (LD and HD)

Inducement Strategies Description
Certification Documentation Remainder (LD only)
Engine Purchaser/Chassis Manufacturer Build Specifications and Agreements (HD only)
Cold Start Emission Reduction Strategy (HD Only)
NOx Sensor Information (HD Only)
Other Certification Documentation Information (HD Only)

Table 7: OBD application information required at time of submittal

Staff review the pertinent information for each monitored component or system that is part of the emission control system to determine whether all emission-related malfunctions will be detected and illuminate the MIL. When evaluating a particular component/system's monitor, CARB staff ensures, among other things, that the monitor will reliably make robust decisions if the component/system is healthy or malfunctioning, will catch all reasonably expected types of failure modes, will run frequently during most typical in-use modes of operation, and will store the appropriate fault code in the required timeframe.

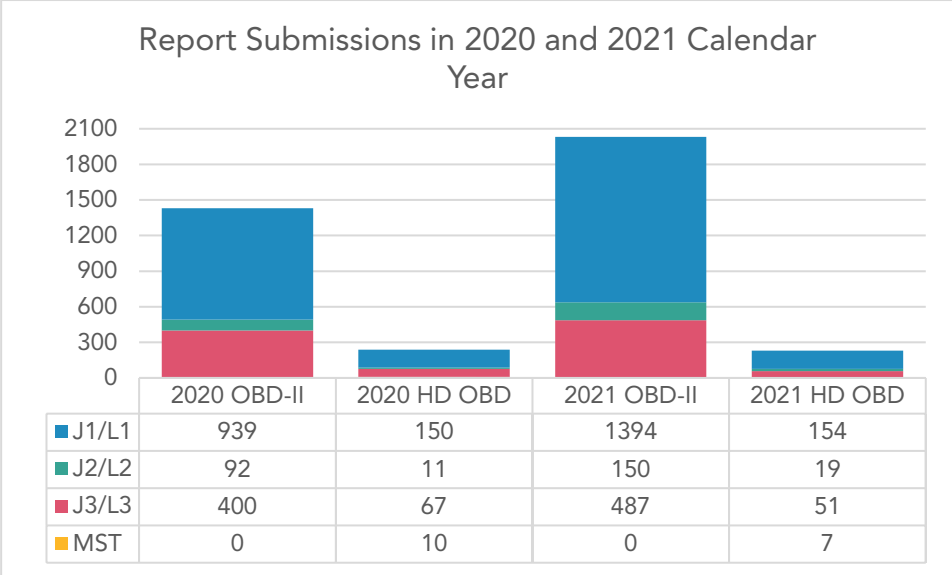
Another important section of the OBD application is the Durability Demonstration Vehicle/Engine Data. This subsection of the pre-certification documentation is a crucial element in verifying that the major OBD monitors are indeed calibrated correctly and are able to detect malfunctions before the applicable emission thresholds are exceeded. This spot-check testing of major OBD monitors is required to be conducted by the manufacturer on one to three vehicles/engines per year.

CARB staff approved 195 and 211 new vehicle/engine OBD systems in the 2020 calendar year and 2021 calendar year, respectively. Following approval of a manufacturer's OBD system, staff is also responsible for reviewing manufacturers' post-certification testing data to ensure the OBD systems on production vehicles and engines have indeed been designed and built as described in their OBD application and complies with essential parts of the OBD regulation.

Production Engine/Vehicle Evaluation (PVE/PEVE) Testing Manufacturer Reports

In the 2020 and 2021 calendar years, staff received 1,669 and 2,262 post-production reports, respectively. Figure 11 summarizes all the OBD II PVE and HD OBD PEVE reports submitted in 2020 and 2021. Over the two calendar years, there were 7 times more OBD II PVE reports

received than HD OBD PEVE reports. This corresponds to the greater number of manufacturers and a larger variety of on-road light- and medium-duty vehicles subject to the OBD II requirements compared to on-road heavy-duty engines subject to HD OBD. Analysis submitted in these reports is representative of the 39 original equipment manufacturers (OEM), with some manufacturers certifying products for both OBD II and HD OBD, spanning several hundred test groups and engine families. Figure 12 summarizes the number of manufacturers that submitted PVE/PEVE reports during the 2020 and 2021 calendar year. Light-, medium-, and heavy-duty on-road vehicles and engines are required to conduct and submit three different types of production engine/vehicle evaluation testing reports, denoted as PVE J1-J3 for light/medium duty and PEVE L1-L3 for heavy duty. Heavy Duty vehicles must test and submit an additional report, manufacturer self-testing data (MST), which is denoted as PEVE L4.



	2020 OBD-II	2020 HD OBD	2021 OBD-II	2021 HD OBD
J1/L1	939	150	1394	154
J2/L2	92	11	150	19
J3/L3	400	67	487	51
MST	0	10	0	7

Figure 11: Total Submissions in the 2020 and 2021 Calendar Year

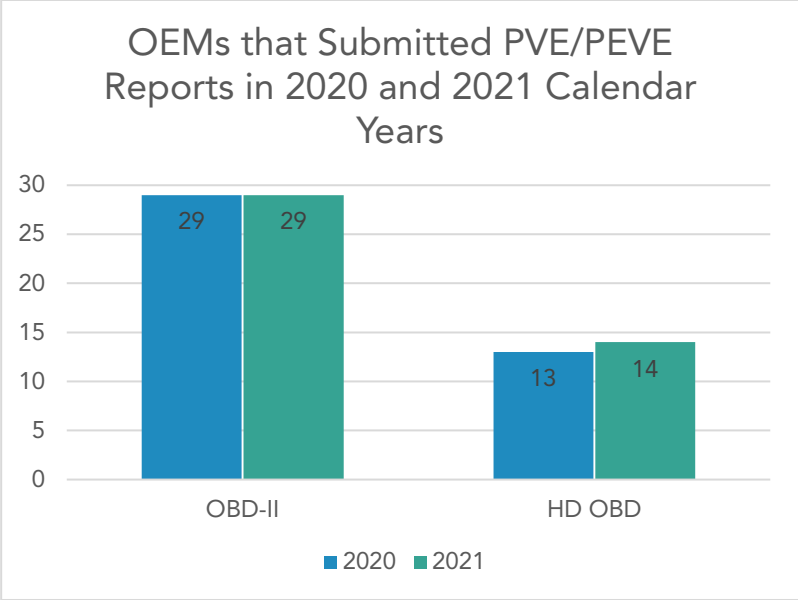


Figure 102: PVE/PEVE Reports for OBD II and HD OBD Programs

PVE J1 and PEVE L1: Standardization Verification

CARB received 1,089 reports in 2020 and 1,548 reports in 2021, 88% for OBD II and 12% for HD OBD. For the 2020 and 2021 calendar years, nearly three-quarters and two-thirds of all OBD communication verification[3] tests conducted for OBD II and HD OBD successfully passed and did not identify any failures, respectively. Figure 13 combines all light-, medium-, and heavy-duty OBD communication verification tests, and shows the percent of tests in which no failures were identified and percent of tests in which at least one failure was identified. The data from Figure 13 represents a total of 750 light- and medium-duty test groups (with 2,333 OBD II communication verification log reports submitted) and 22 heavy-duty engine families (with 99 HD OBD communication verification log reports submitted).

[3] Analysis and results only include data from SAE J1699 log reports. Results from SAE J1939-84 tests were not ready in time for this report due to the complexity of determining which failures were the result of an SAE J1939-84 software issue falsely flagging a failure versus the manufacturer's failure to correctly implement the standardization requirements found in the OBD regulations.

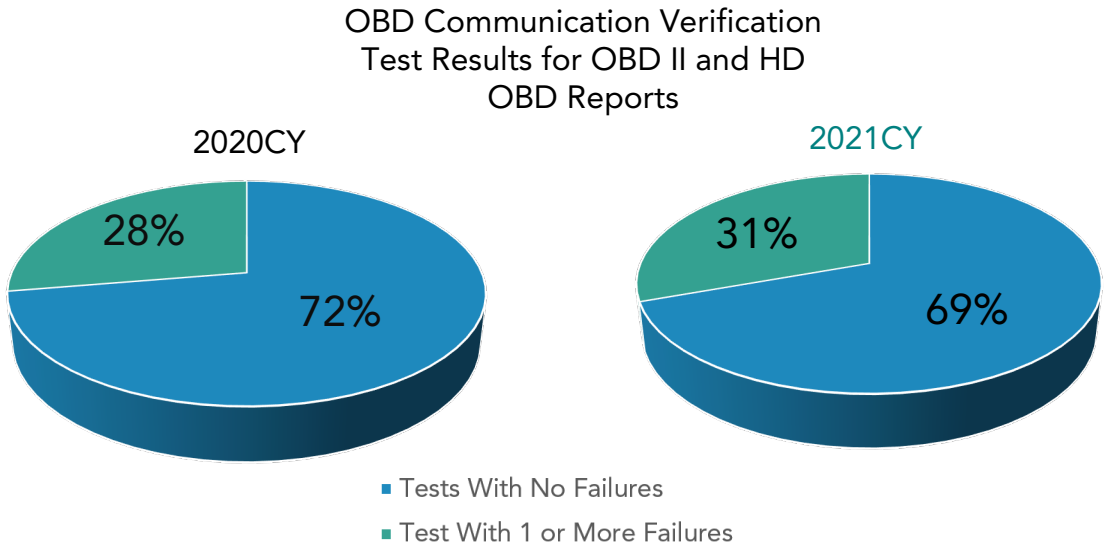


Figure 113: OBD II and HD OBD communication verification[4] Test Results

For vehicles and engines that observed any failures during the standardization verification testing, manufacturer would submit a written report of the issue(s) identified and propose corrective actions (if any) to remedy the problem(s) to CARB for approval. The corrective action can vary depending on the severity of the issue, but in most cases will either result in the development of a software fix via a running change, a complete recall of all affected vehicles, or in some cases, manufacturers may request a retroactive deficiency that could result in fines for each vehicle/engine sold.

PVE J2 and PEVE L2: Monitoring Requirement Verification Testing

CARB received a total of 103 monitoring requirement verification testing reports in 2020 and 169 monitoring requirement verification testing reports in 2021, 89% for OBD II and 11% for HD OBD. The average passing rate of all OBD monitors within a production-ready OBD system is near 100 percent. Figure 14 summarizes the average OBD monitors tested per test group or engine family, and the average passing rate within those groups or families. The significantly high average passing rate indicates that among all the test groups and engine families tested in 2020 and 2021, almost all the monitors within those OBD systems were functioning as expected (e.g., detecting, recording, and notifying users of malfunctions correctly).

[4] Pie charts only include data from SAE J1699 tests and not SAE J1939-84 tests.

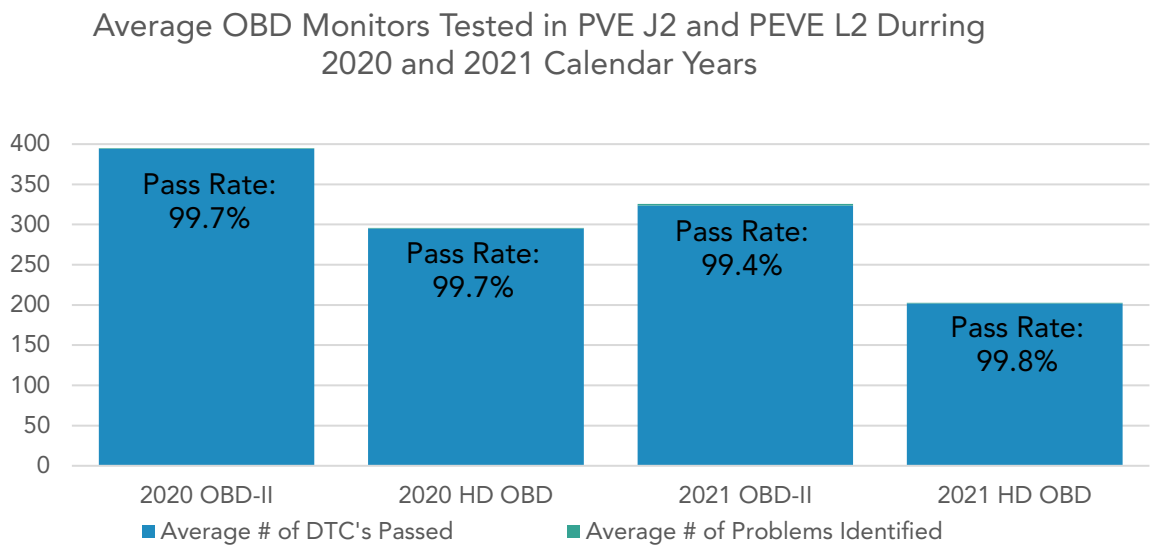


Figure 14: Average pass rate for PVE J2 and PEVE L2 reports during the 2020 and 2021 calendar years

When issues are identified, manufacturers may request a retroactive deficiency which could result in fines per vehicle/engine sold. Typically, after identifying the issues, manufacturers will meet with CARB to explain the root cause of the problem and propose how the issue will be addressed. Depending on the severity of the issue, manufacturers may address the issue by developing a software fix via a running change submission and/or may need to develop a field fix change and recall the vehicles in the field that are affected.

PVE J3 and PEVE L3: In-Use Monitoring Verification Testing

CARB received a total of 467 in-use monitoring verification testing report submissions in 2020 and 538 in-use monitoring verification testing report submissions in 2021, 88% for OBD II and 12% for HD OBD. The results of those submissions are shown in Figure 15. Approximately 81% of reports in 2020 and 88% of reports in 2021demonstrate that the given test group was able to achieve the minimum monitoring frequency for all the required monitors, 18 of the reports in 2020 and 11% of the reports in 2021 had instances of being non-compliant with the minimum monitoring frequency, and for both years, about 1% reached the threshold warranting a mandatory recall.

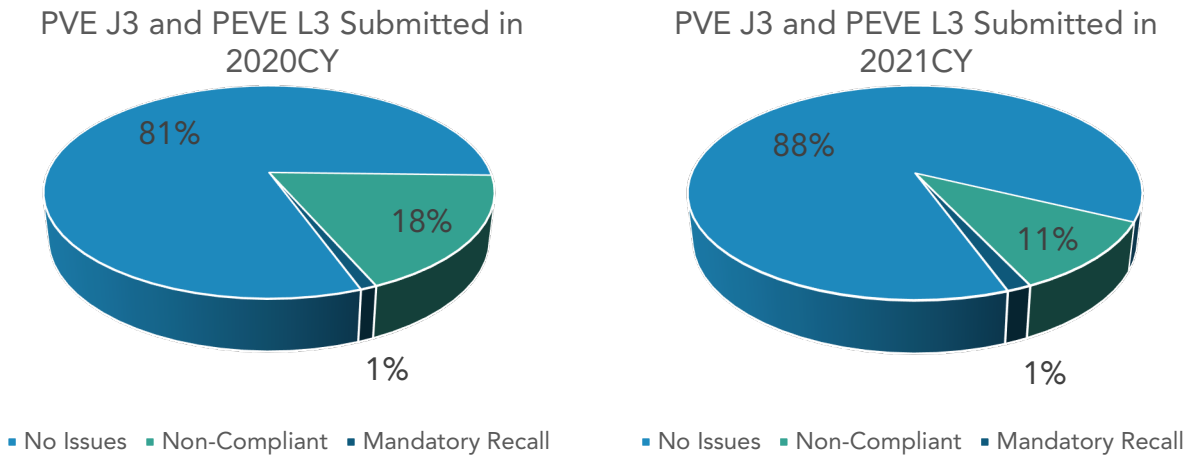


Figure 15: PVE J3 and PEVE L3 Report Compliance for the 2020 and 2021 Calendar Years

PEVE L4: OBD Manufacturer Self-Testing

Manufacturer Self-Testing (MST) pertains only to heavy-duty engines and is conducted to ensure that the OBD systems on in-use aged engines originally certified on an engine dynamometer are able to detect a fault before emissions exceed the malfunction criteria. Shown in Figure 16 below, 41% of all 2020 and 2021 MST reports contained at least one failure, with some reports indicating as high as five OBD monitors unable to detect at the same emission levels as originally certified. For such cases, the HD OBD enforcement regulation stipulates the emission levels that necessitate a recall and requires the manufacturer to submit a plan to correct the nonconformance issue(s). In most cases, such recalls require a significant effort and cooperation from the manufacturer to ensure a fix is developed as expediently as possible and is compliant with the regulations.

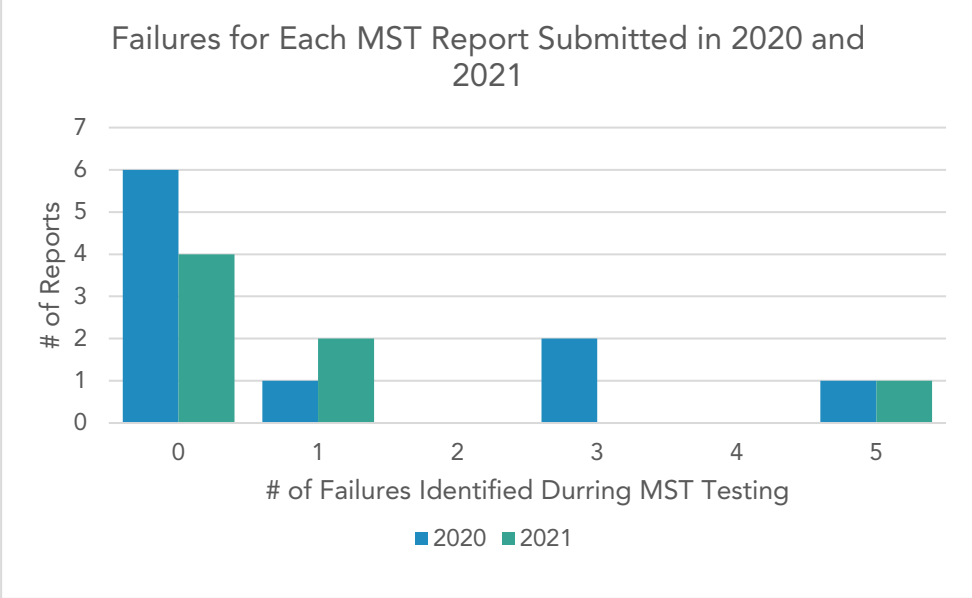


Figure 16: Number of Failures for each MST Report in the 2020 and 2021 Calendar Years.

What happens after the sale: In-Use Testing and Warranty

Light-duty and Medium-duty In-use Testing and Audits

OBD Confirmatory and Enforcement Testing

It can take several months to conduct an OBD audit on one vehicle or engine in order to verify that the OBD system will detect a malfunction of each major monitor and illuminate the MIL below the emission levels as required in the OBD regulations. As shown in the chart below (Figure 17), CARB performs OBD testing on 3 vehicles per year on average. However, what is not represented in the chart below is the additional support provided by OBD audit staff to other programs such as the evaluation of AECDs and potential defeat devices on in-use and future vehicle and engine emission control systems. As a result of CARB and EPA discovering several manufacturers circumventing the emission standards by using defeat devices in 2015, OBD staff were reassigned to heavily focus in the following years on developing screening tests to identify unapproved AECDs and defeat devices. No OBD confirmatory or OBD enforcement testing was conducted during calendar years 2020 and 2021 due to the impacts of the pandemic and relocation of CARB's Southern California facility from El Monte, CA to Riverside, CA.

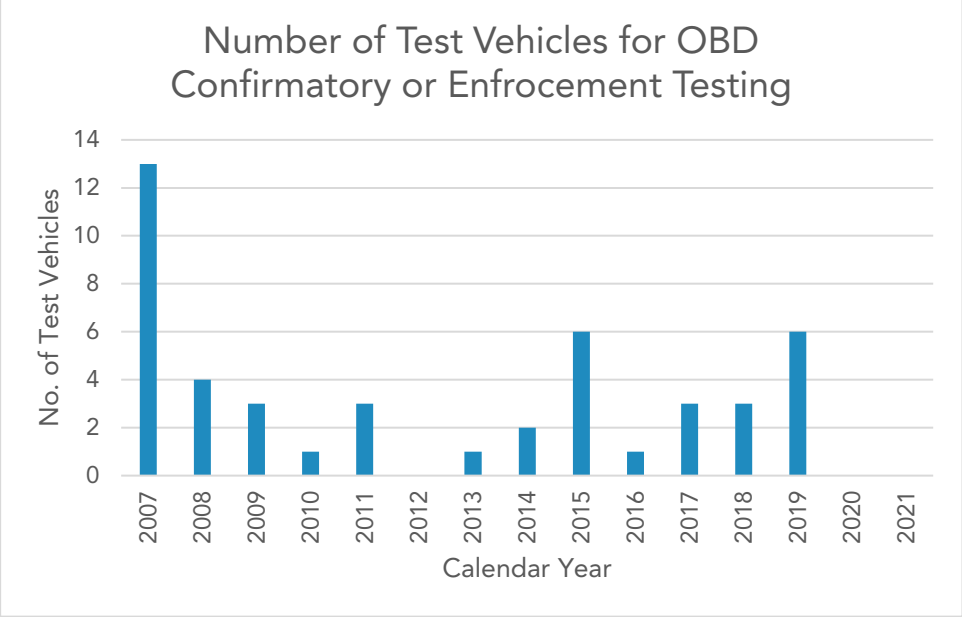


Figure 17: Number of Confirmatory and Enforcement OBD Tests from 2007- 2021

Manufacturers In-Use Verification Program (IUVP)

In 2019, 871 light-duty test groups and 2,136 vehicles were tested under the IUVP, while in 2020, 565 test groups and 1,056 vehicles were tested. The decrease was largely due to the pandemic and by 2021, the number of test groups tested had increased back to 843 with the number of vehicles tested at 1,744. In 2019, 13% of the vehicles presented failures of the emission standards and 14% during 2020 and 2021. Four test groups triggered the follow-up testing of the IUCP in 2019, three during 2020, and four in 2021. The unprecedented circumstance of the pandemic in 2020 led to a significant number of testing waiver requests from the manufacturers that CARB granted. IUVP testing focused on maintaining a useful IUVP while providing reasonable and opportune relief to the manufacturers. In the case of these waivers, CARB reviewed the performance of the specific test group in the current program and in past model years for similar powertrain/vehicle variants to determine if the test group was likely complying with the emission standards. Of the 215 test groups that had testing waivers in 2020, only 4 were unrelated to the pandemic. In 2021, 17 waivers were granted and only 4 were unrelated to the pandemic. Most of these requests were granted in coordination with the US EPA (Figure 18).

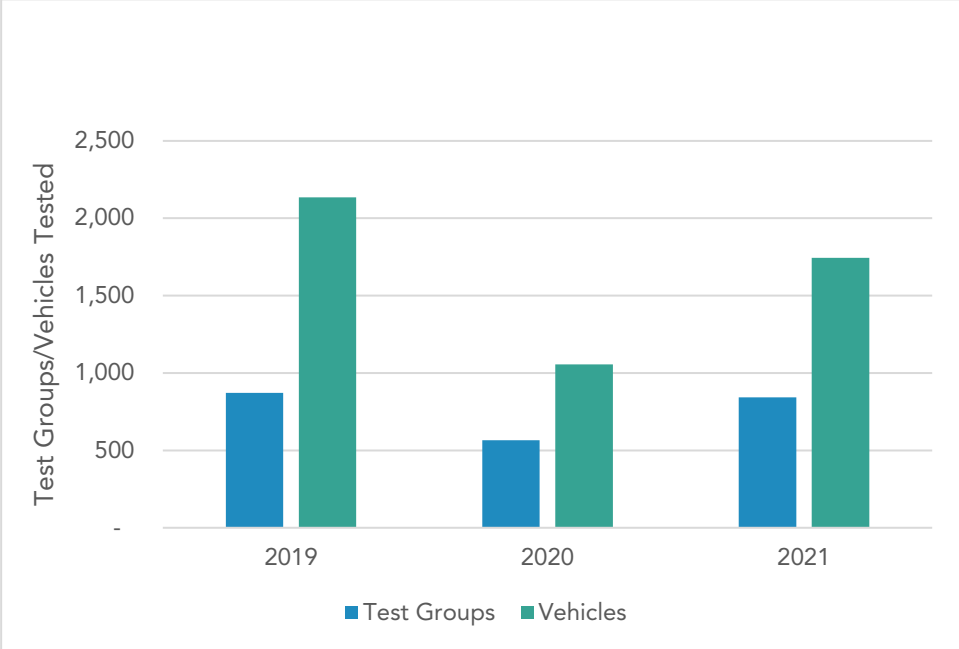


Figure 18: Manufacturers LD In-Use Verification Program

Manufacturer/Independent Laboratory Audits and Test Observations

During the pandemic, virtual test observations have been implemented. Staff dedicated 50 days to test observations during 2019, 51 in 2020, and 36 in 2021. Of those, 14 in 2020 and 21 in 2021 were virtual. Of all these observations, 59% were associated with consent decrees or settlements.

CARB's In-Use Compliance Testing Program and In-Use Screening Testing

During 2015 to 2018, 38% of the testing capacity of CARB's vehicle emission laboratory was used in the VW investigation and the screening of other light-duty diesel vehicles. This was the first time PEMS equipment was used to support light-duty in-use compliance, a tool that today is essential for the program to identify anomalies, defeat devices, and un-approved AECD. Using this equipment, testing a few vehicles has led to the recall and repair of a number of "carry over" certification vehicles of previous model years. For the 2015 through 2018 timeframe, about 44% of the test groups recalled were due to the enhanced screening techniques. In 2019, 24 vehicles were tested with 188 tests; in 2020, 11 vehicles were tested with 125 tests; and in 2021, 7 vehicles were tested with 121 tests. Also in 2019, 74 PEMS test were performed, 28 during 2020, and 70 in 2021. The main reason for the decrease in testing in 2020 was the pandemic, which complicated recruitment of vehicles and diminished the laboratory output, and the preparations for the move to the new facility in Riverside. During 2015, the combined new approach led to the recall of 82,000 vehicles in California and 567,000 vehicles in the US from VW, and about 11 million vehicles were affected worldwide. In 2019, Fiat Chrysler Automobiles acknowledged that 14,000 vehicles in California and more than 100,000 vehicles in the US of its diesel models were equipped with software that made them perform differently to pass emission tests in laboratory conditions than how they operated in real-world driving. In 2020, Mercedes-Benz USA reached a settlement over emissions cheating with alleged violations on diesel vehicles that affected 34,000 vehicles in California and 250,000 vehicles in the US (Figure 19).

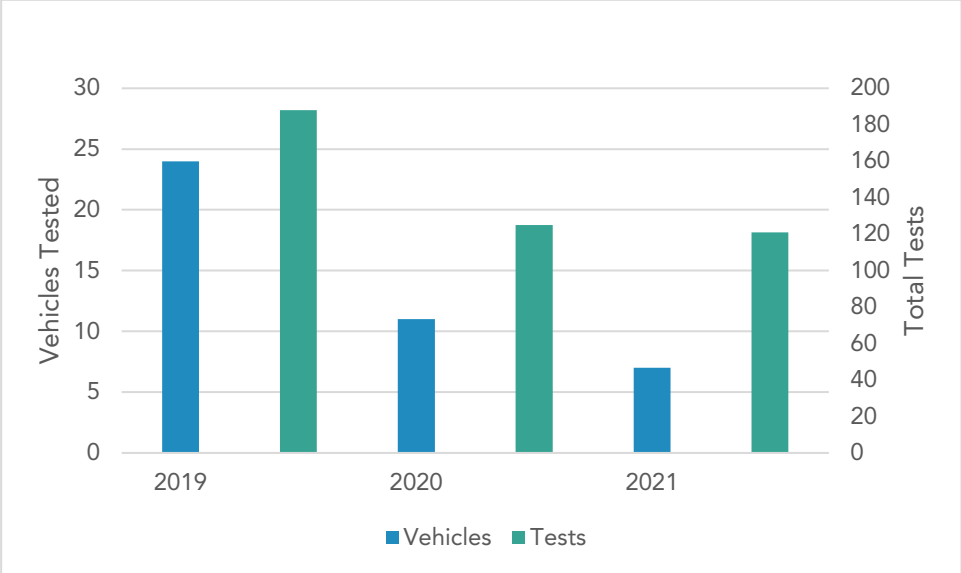


Figure 19: CARB LD In-Use Compliance and Screening Testing

During 2019, 15 test groups were recalled administratively affecting 21,616 vehicles in California and 264,774 in the US. For 2020, 49 test groups were recalled administratively affecting 66,979 vehicles in California and 701,541 in the US. In 2021, 41 test groups were

recalled administratively affecting 80,120 vehicles in California and 520,461 in the US. The groups affected spanned model years 2010 to 2020 (Figures 20 and 21).

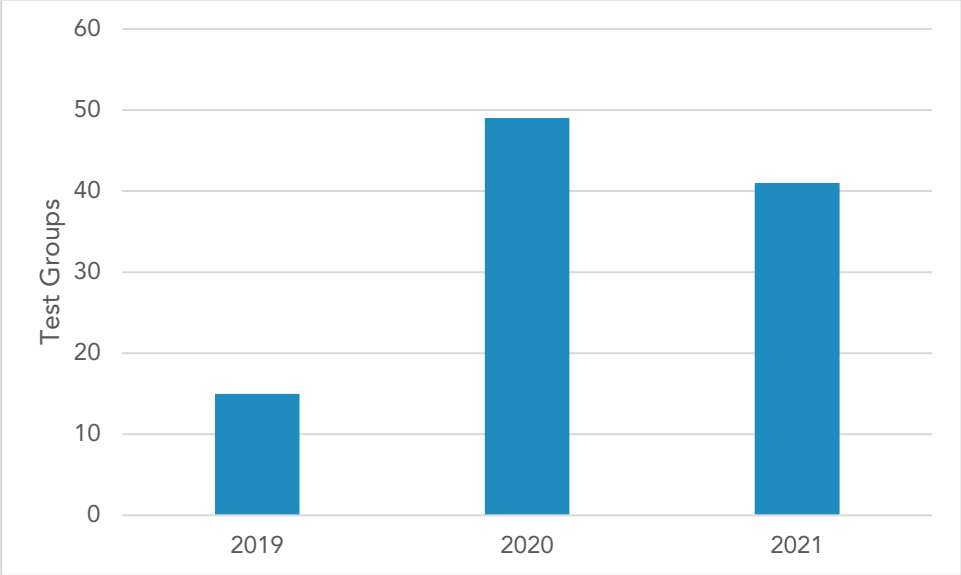


Figure 20: Test Groups Affected due to CARB LD In-Use Compliance Program

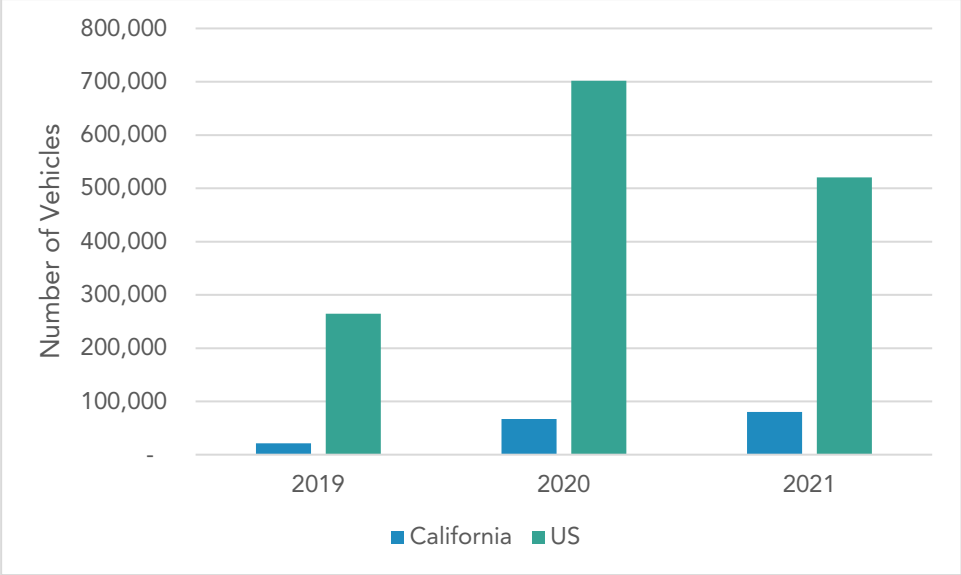


Figure 21: Vehicles Affected in California and Nationwide due to CARB LD In-Use Compliance Program

The Volkswagen Consent Decree has clauses for including In-Use Assurance for the vehicles that were modified for five years after its implementation. A similar clause was incorporated for the FCA and Mercedes-Benz Consent Decrees. These particular manufacturers are

required to notify CARB in advance, when and where their tests are going to be conducted in order to facilitate CARB or US EPA observation of each test. These activities are reported earlier under the test observations. In addition to these observations, the in-use group, in conjunction with the Enforcement Division, reviews the periodic reports generated by these requirements, including their laboratory and PEMS testing results.

The overall tasks of CARB's light-duty and medium-duty in-use compliance activities have changed dramatically in the past six years. The original main tasks included overseeing the correct function of the IUVP in terms of which vehicles required testing, procurement procedures, and proper laboratory operations to ensure accurate results. The additional tasks now performed include screening vehicles for potential defeat devices and unapproved AECDs. Other new assignments include overseeing mandated testing under consent decrees or settlements and the detailed review of the reports generated by such mandates.

Heavy-duty In-use Testing and Audits

In the 1990s, emission violations of state and federal regulations were discovered on the engines of seven of the largest heavy-duty diesel engine (HDDE) manufacturers. In response, CARB adopted not only stricter emission regulations but also a more robust enforcement mechanism. As a means to demonstrate compliance over the useful life of the engines, CARB adopted regulations to codify the oversight of HDDE and ensure they remain compliant.

CARB introduced the regulatory framework in 2004 (implemented in 2005) for the Not-To-Exceed (NTE) requirements. This framework introduced on-board portable emission measurement systems (PEMS) during over-the-road operations. The adoption of this framework paved the way for CARB to begin a heavy-duty in-use compliance (HDIUC) program in 2016.

National oversight of HDDE is critical considering the million trucks that operate on-road in California. Only about one quarter of the vehicles operating in state are registered in California necessitating close collaboration with US EPA for the success of the in-use testing programs. Collaboration is vital at the internal level as well, the Heavy Duty In-Use Compliance group works closely with various internal CARB partners such as staff from OBD, certification, warranty, and PEMS testing. This collaboration is of paramount importance for successful execution of a heavy-duty testing program (Figure 22).

Figure 22: HDIUC collaborators

Manufacturer-Run In-Use Testing Program

Since the program's inception in 2007, CARB, in partnership with the USEPA, has issued test orders for 125 engine families to be tested directly by the engine manufacturers. As of December 2021, 623 individual engines/vehicles have been tested as part of this program. During 2021, CARB received data from 7 engine families which collectively tested 29 individual engines (Figure 23).

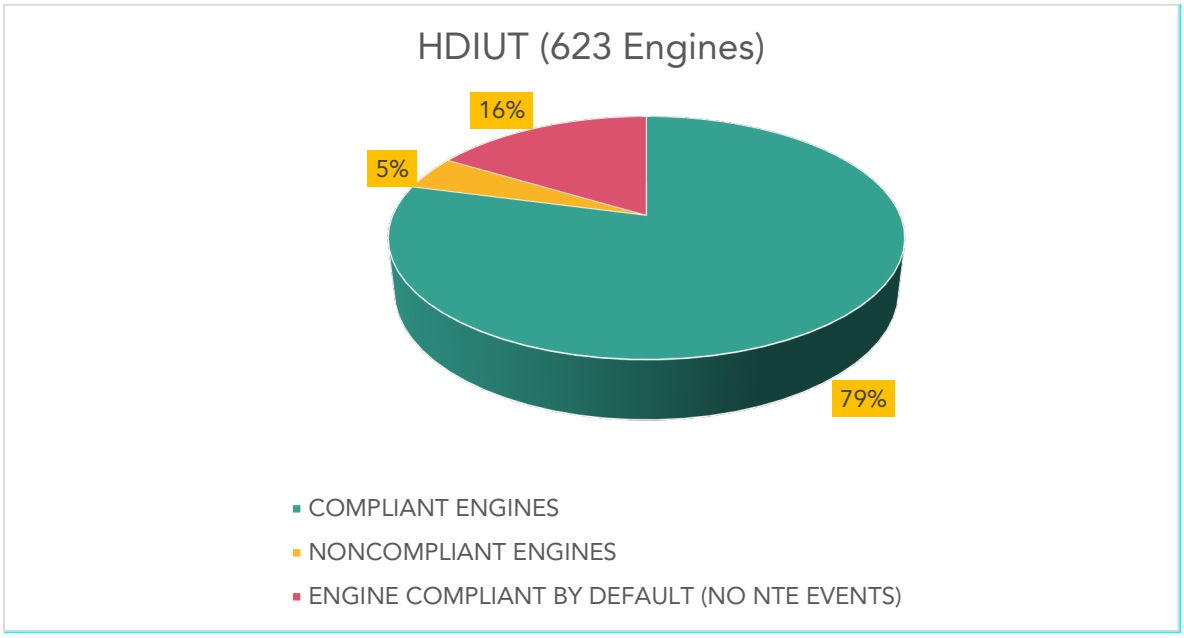


Figure 23: Manufacturer run testing – HDIUT data collected as of March 2022

Manufacturer/Independent Laboratory Audits

HDIUC staff to date has inspected more than 15 HD labs including some visited multiple times. During 2019, we inspected 8 heavy-duty laboratories. During calendar year 2020 and 2021, all laboratory audits were suspended due to pandemic restrictions.

CARB's Heavy-Duty In-Use Compliance Testing Program

Between 2016 and 2021, 69 HDDEs representing 15 engine families were tested by CARB's HDIUC. 55% of those (38 engines) HDDEs were found to be noncompliant and subsequently recalled. Altogether, 98 engine families have been recalled nationwide as a result. The additional families not directly tested were either carryover engine families, shared some emission control strategy, or shared the same after-treatment system as the 13 tested and subsequently recalled engine families (Figure 24).

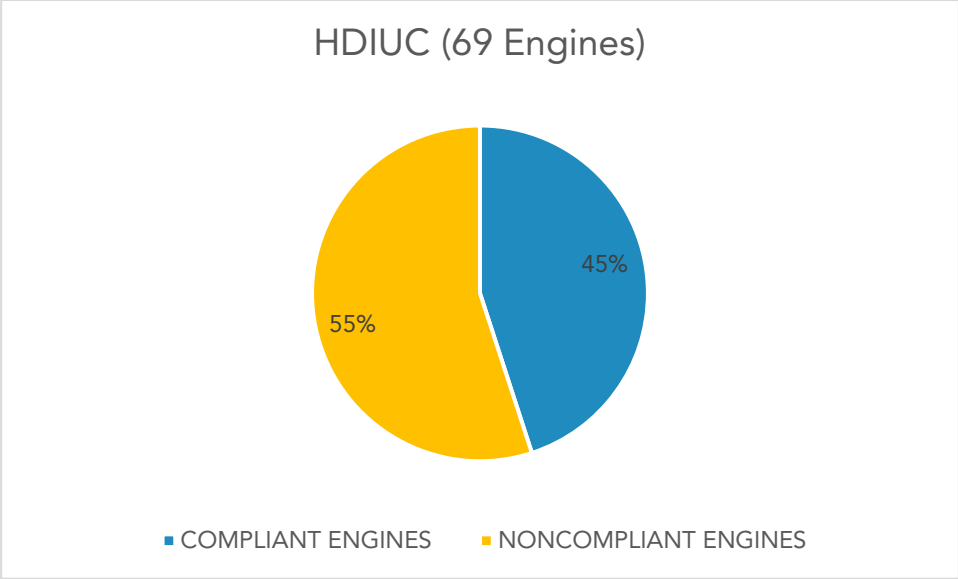


Figure 24: CARB run testing – HDIUC data collected as of March 2022

Since the program's inception, CARB's actions have led to the recall of over 1,000,000 heavy-duty vehicles nationwide (about 82,000 in California). More than 750,000 and 65,000 medium duty vehicles in the US and CA, respectively, were recalled as a result of the HDIUC testing (Table 8).

	EFs Tested	EFs Recalled	Vehicles Recalled US	Vehicles Recalled CA
HDIUC	13	98	1,020,712	82,723

Table 8: California and National Recalls

Testing was reduced due to the pandemic. There was no additional on-road testing that took place during the 2021 calendar year. HDIUC staff continued investigations on previously completed testing that resulted in the recall of 14 engine families (included in table above).

Emission Warranty Reporting and Field Operations

Manufacturer Warranty Reporting

There are three levels of manufacturer reporting requirements: Emission Warranty Information Report (EWIR), field information report (FIR), and the emission information report (EIR). CARB staff evaluated quarterly EWIR reports from each manufacturer. As a result of the quarterly EWIR report requirements, 128 FIR reports and 76 EIR reports were submitted for the 2020 calendar year, and 202 FIR reports and 76 EIR reports were submitted for 2021 calendar year.

Field Inspections

On site dealership inspections are conducted to review and validate compliance with the warranty regulations from manufacturers and their dealerships throughout the State of California. In 2018 and 2019, staff visited two dealerships to audit the dealerships' service repair records for model years 2006 through 2014. During the investigation, the search parameters were expanded to include vehicles meeting the Partial Zero Emission Vehicle (PZEV) certification standard and staff looked for possible violations (customer paying for diagnostics, parts replacement, etc.) of the required PZEV extended emission warranty (Table 9). Staff discovered invoices for vehicles brought into the dealerships for diagnostics/repairs that customers were charged for that should have been covered under the PZEV emissions warranty. In 2020, these activities were put on hold due to the pandemic.

Model Year	# of Customers (Newport Beach)	# of Customers (Ontario)

2006	17	20
2007	24	62
2008	26	22
2009	7	6
2010	1	66
2011	0	45
2012	0	5
2013	0	3
2014	0	3
Total	**75**	**232**

Table 9: Two Dealership Number of Customers Who Paid out of pocket for Warranty Repairs by MY

In August 2019, the field representatives were tasked for the first time to look into service repair records for heavy-duty diesel vehicles. Staff audited the service repair records at two Cummins dealerships for possible violations of the Heavy-Duty Diesel Engine (HDDE) warranty regulations (customer paying for diagnostics, parts replacement, etc.). The audit uncovered 26 irregularities where the customers paid for parts that should have been covered under warranty. However, staff learned that HDDE manufacturers offer custom warranty plans that often are better than the standard warranty in order to incentive fleets to purchase the vehicles in bulk. This a different business model when compared to passenger vehicle customers and therefore requires a different approach for future audits.

In February 2020, staff evaluated a manufacturer's facility for HDDE warranty practices. Unfortunately, this project was put on hold due to the pandemic and will restart once the stay-at-home orders have been lifted.

In 2021, field staff conducted a survey of a variety of different types of locations that may carry DEF (such as truck stops, gas stations, automotive parts retailers, big-box retailers, etc.) to assess the availability of DEF throughout the state. The survey was primarily conducted over the phone. Field staff asked questions regarding whether DEF was available at the location, the price of DEF, how DEF was sold/dispensed (in containers or through a metered

pump), how often the location received shipments of DEF, and if the location ever runs out of stock.

Field staff also worked on a DEF inducement survey in 2021. They surveyed fleets throughout California to obtain a better understanding of fleet owners/operators difficulty with SCR inducement strategies while operating heavy-duty vehicles. The survey was primarily conducted over the phone. The survey questions covered a variety of topics such as the fleet's knowledge of derates (including what inducements are, why they occur, how often they occur, what actions are taken to remedy the issue related to the inducement, and if the operator encounters danger due to derates from inducements).

Consumer Complaints

Staff also works to resolve consumer complaints. If a vehicle owner feels that they have inappropriately been denied warranty coverage by the dealership and manufacturer, they are able to contact CARB for assistance. Many recall complaints are not complex and are instructional in nature, but at times, additional follow-up is required for more complicated issues. Complaints can range from vehicle owners having difficulty renewing their vehicle registration to a wrongful denial of warranty claims. Staff reviews the claim and if it is determined that a repair should have been covered under warranty, staff reaches out to manufacturers to learn why coverage was denied. It has been found that manufacturers or their dealers have occasionally mistakenly denied warranty coverage. In these instances, staff works with manufacturers to ensure that vehicle owners are reimbursed and that manufacturers make improvements to their business practices and processes to ensure that similar mistakes are not made again. Additionally, CARB works with the California Department of Motor Vehicles to aid customers with getting their vehicles registered when there are issues with registration renewals due to recalls. In 2020, staff worked with vehicle owners to address 36 claims for warranty issues and 37 claims for vehicle registration issues. In 2021, staff helped resolve 16 claims for warranty-related issues and 128 claims for vehicle registration issues.

Corrective Actions

In 2020, 43% of vehicles recalled were repaired with hardware modifications and 57% of were repaired with software calibration changes. In 2021, 42% of vehicles recalled were repaired with hardware modifications and 58% were repaired with software calibration changes (Figures 25 and 26).

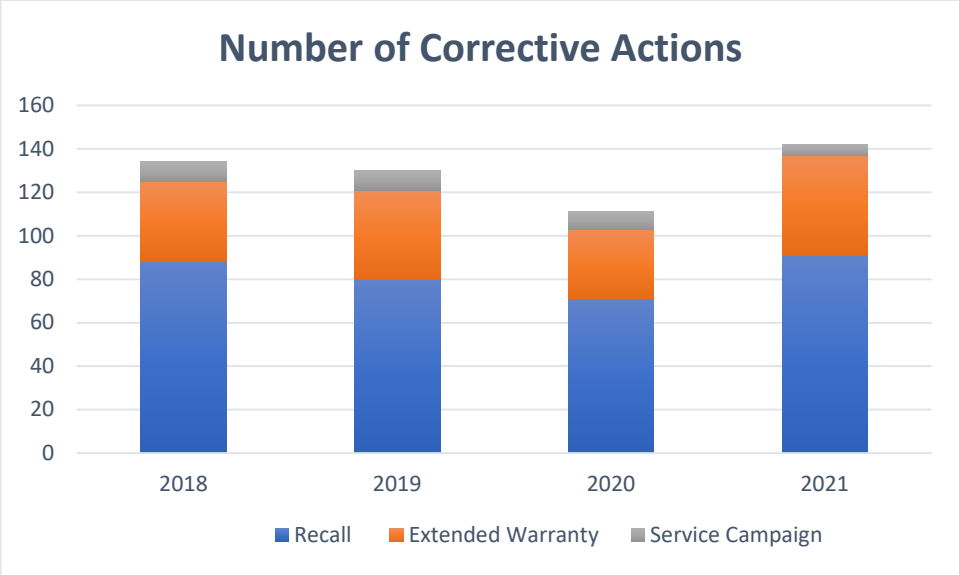


Figure 125: Number of Corrective Actions

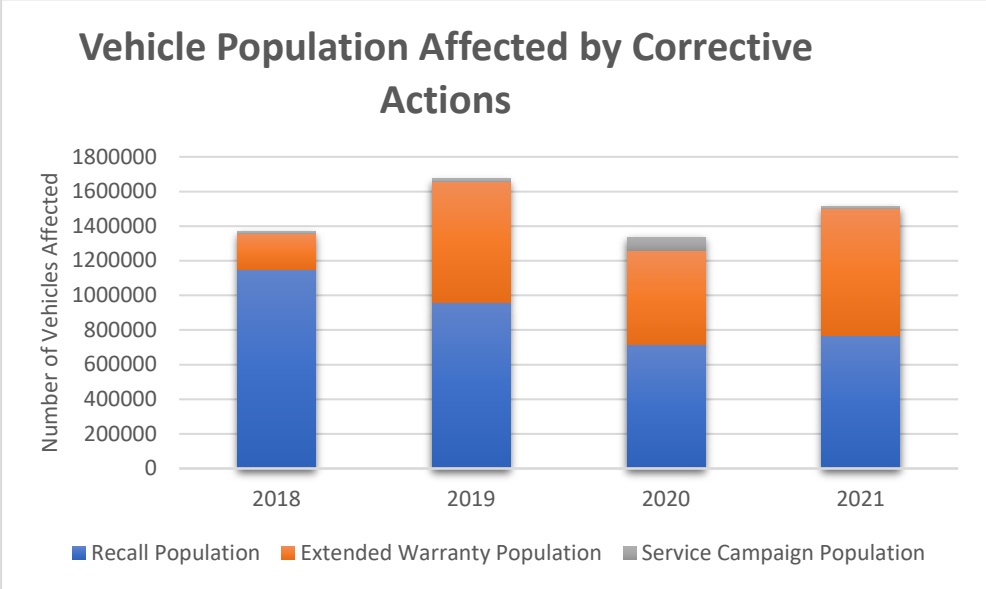


Figure 136. Vehicle Population Affected by Corrective Actions

Program Development and Enforcement Support

As a part of their regular duties at CARB, OBD, certification, and in-use experts are called in on regulation development, implementation of existing or new requirements, and support of enforcement activities. This participation is essential to ensure complete coordination during the regulation development or to develop the needed information to support enforcement activities.

Program Development and Support

Several new regulations were developed during 2020/2021:

On-Board Diagnostics Regulation Update

Since 1989, the certification staff has regularly updated the OBD "technology-forcing" regulations, as shown in the Figure 27 below, and will continue to do so to propose amendments to address manufacturers' concerns, clarify language, keep pace with technology development, and strengthen monitoring requirements.

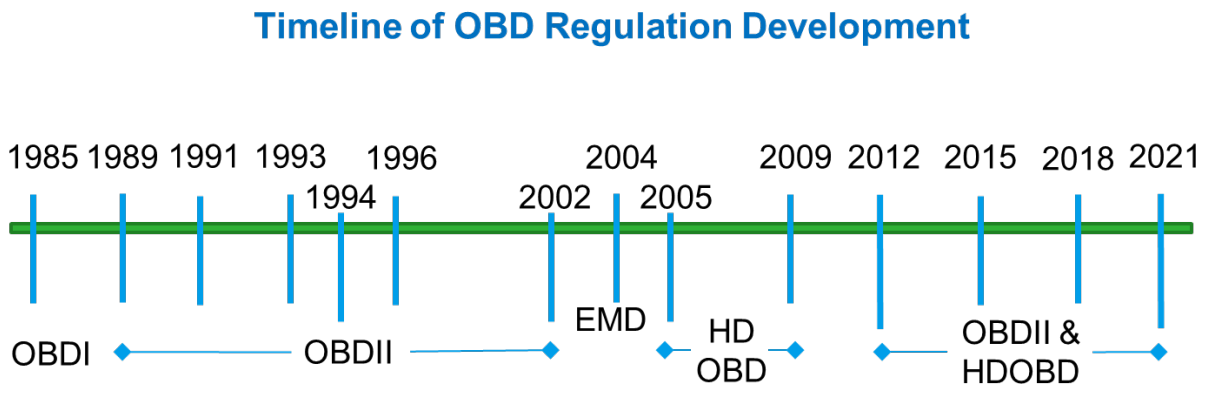


Figure 27: OBD Regulatory Development Timeline

In July of 2021, the Board approved proposed amendments to the OBD II and HD OBD regulations that helped strengthen and clarify the requirements for designing and developing robust OBD systems. Specifically, the majority of the proposed amendments are related to the implementation of an updated communication protocol known as Unified Diagnostic Services (UDS) that is used to transmit information from the vehicle to a diagnostic scan tool. The use of UDS for OBD communications will significantly increase the number of available fault codes for manufacturers to use, provide more information for emission-related malfunctions that are detected by the OBD systems, improve the usefulness of the generic scan tool to repair vehicles, and provide needed information to enforce in-use monitoring performance requirements. UDS implementation would be required for all 2027 and subsequent model year light- and medium-duty vehicles and engines, as well as heavy-duty vehicles and engines that use the ISO 15765-4 protocol. Notwithstanding, manufacturers would be permitted to implement UDS as early as the 2023 model year. This regulatory update effort was led by Emission Certification and Compliance Division (ECCD) OBD staff.

Heavy-Duty Omnibus Regulation

In 2020 and 2021, CARB developed new regulations (Heavy-Duty Low NO_x Omnibus regulation) to revamp the On-Road Heavy-Duty regulation and emission standards for 2024 through 2031 (more stringent standards, extend the full useful life and warranty, modify and

expand the applicability of PEMS-based standards and testing, etc.). ECCD heavy-duty certification and in-use program staff provided technical support to the Mobile Source Control Division's development of this regulation.

Heavy-Duty Greenhouse Gas Phase II Program

CARB developed the Zero-Emission Powertrain (ZEP) requirements for certifying Zero-Emission Powertrains and Heavy-Duty Electric and Fuel-Cell Vehicles. This will become essential for manufacturers to use to meet the Advanced Clean Trucks Regulation starting in 2024 and the Zero-Emission Airport Shuttle Regulation starting in 2026. CARB's heavy-duty certification staff collaborated closely with the Mobile Source Control Division in its development by providing technical support. In 2020 and 2021, a handful of manufacturers inquired about ZEP certification, however, no powertrains were certified as the program is currently voluntary until 2024.

Advanced Clean Cars II

In 2021, CARB developed new regulations (Advanced Clean Cars II regulation) to revamp On-Road Light-Duty criteria pollutant emission standards and ZEV regulations. The ACC II regulations propose to further scale down emissions from light-duty passenger cars, pickup trucks, and sport utility vehicles (SUVs), starting with the 2026 model year. The ACC II program would also require the sales of new battery-electric vehicles, hydrogen fuel cell electric vehicles, and plug-in hybrid-electric vehicles to increase from current levels to 100 percent of new light-duty vehicle sales by the 2035 model year. ECCD light-duty certification staff provided technical support to the Sustainable Transportation and Communities Division for development of this regulation.

Motorcycles

Starting in April 2018, CARB initiated updates to the regulations for on-highway motorcycles and has held four workshops to date. The proposed regulations will significantly reduce exhaust and evaporative emissions through more stringent emissions standards, improved test procedures, and the addition of on-board diagnostics to monitor performance of emission controls throughout the life of the motorcycle. Staff's concepts include requiring zero-emission motorcycle sales starting at 10% in 2028 and increasing to 50% by 2035, as well as a zero-emission motorcycle credit program to help ease this transition. The proposed regulations will be presented to the Board for consideration in December 2022. If adopted by the Board, new standards would be effective starting in 2025. ECCD staff are leading this effort.

Mobile Source Certification Fees

In 1988, the legislature gave CARB authority (Health and Safety Code [HSC] section 43019) to assess a fee for motor vehicles and engines (generally, cars, trucks, and motorcycles) that was capped at $4.5 million a year, but with annual adjustment of the cap based on the California Consumer Price Index (CPI). In 1990, CARB implemented this authority through

regulation that provides a formula to assess fees on a limited class of motor vehicle and engine manufacturers. Manufacturers of vehicles and engines not subject to an emission standard at the time were not included in the regulation. Today, the total amount collected is about $10 million which covers only about one quarter of the cost to implement the programs. On June 27, 2018, new legislation (SB 854) was passed and signed into law that allows CARB to adopt a schedule of fees to cover all or part of CARB's reasonable costs associated with certification, audit, and compliance of off-road or non-vehicular engines and equipment, aftermarket parts, and emission control components sold in the State. As such, this legislation provides CARB the authority to assess fees to cover its reasonable costs, with specific considerations, on all off-road and other mobile sources certification and compliance programs not currently covered under the existing fee regulation authority (HSC 43019). Certification and in-use staff developed a new fee assessment program, adopted by the Board in April 2020. The 1990 per vehicle fee assessment regulation was replaced on April 1, 2022 with a fee assessed at the time of application for certification. ECCD staff led this effort with support from Monitoring and Laboratory Division and Transportation and Toxics Division staff.

Enforcement Support

Enforcement is a critical element of compliance when it comes to deterring non-compliant activities. ECCD routinely supports the Enforcement Division (ED) by reviewing technical information, providing historical information on previously certified products, and advising on interpretation of regulatory requirements to identify specific noncompliances. Staff supported 13 different On-Road enforcement activities during 2020 and 2021 resulting in settlements from several companies include: Porsche AG and Porsche Cars North America, Inc., Volkswagen AG, Volkswagen Group of America, Inc., AUDI AG, and Navistar, Inc.

Off-Road Engine, Vehicle, and Component Certification and Compliance Program

The Off-Road program addresses emissions from engines and equipment that are not designed to be operated on roads and highways (See On-Road Vehicle, Engine and Component chapter). The types of equipment and vehicles in the off-road category include diesel compression ignition (OFCI) engines used in construction, agricultural, and industrial equipment; small off-road engines (SORE) below 25 hp used in applications such as lawn mowers, weed trimmers, chain saws, golf carts, specialty vehicles, pumps, and generators; large spark-ignition (LSI) engines, which are spark-ignition (i.e., Otto-cycle) engines greater than 25 horsepower and are used in a variety of equipment including forklifts, airport ground support equipment, sweeper/scrubbers, industrial tow tractors, generator sets, and small irrigation pumps; spark-ignited marine engines/watercraft (SIME/SIMW) used in boats or watercraft that use outboards or inboard engines; off-highway recreational vehicles (OHRV) comprised of off-road motorcycles, all-terrain vehicles, off-road utility vehicles (e.g., ranch vehicles), off-road sport vehicles, sand cars, and zero-emission golf carts; portable fuel

containers (PFC); and portable outboard marine tanks and components (OMT) fuel containers.

Below provides an overview of activities that ensure regulatory compliance for off-road engines, vehicles, and components.

Before the Sale: Certification and Approvals

The off-road certification and compliance program follows a similar approval path as the on-road programs (Figure 28).

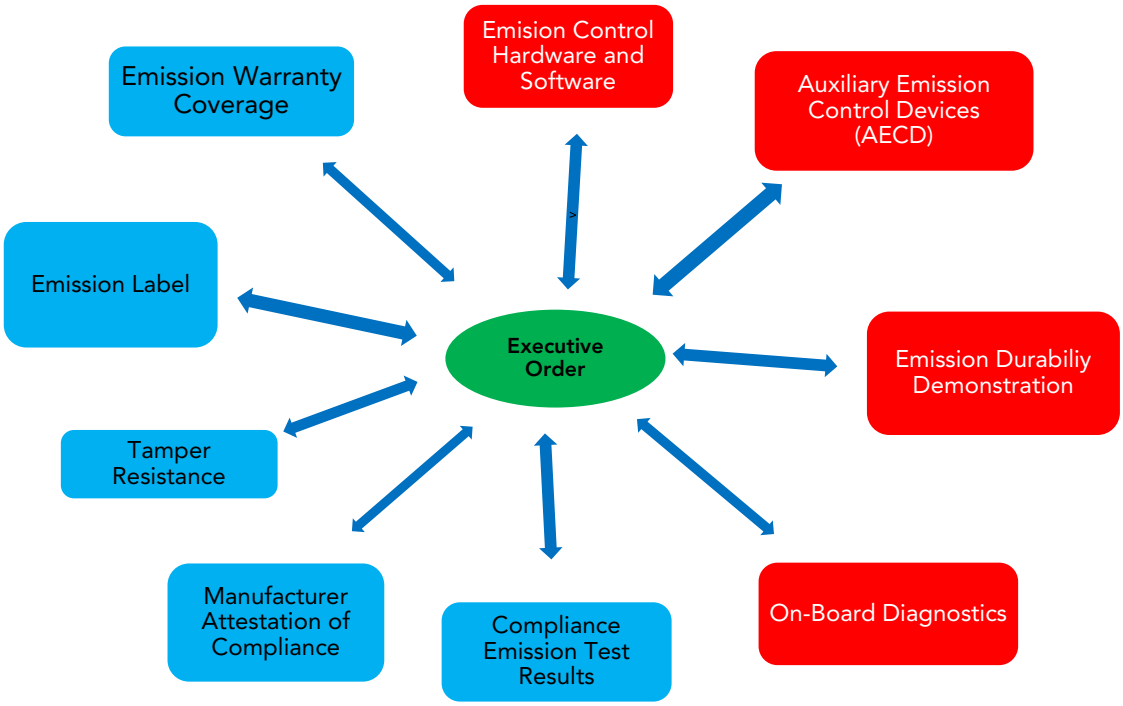


Figure 28: What goes into an Off-Road Approval

The Off-Road Program is diverse and covers small off-road engines that are in lawn and garden equipment, marine watercraft, large spark engines used in forklifts, compression ignition engines used in construction equipment and generators, off-highway recreational vehicles, portable fuel containers, portable outboard marine tanks and components, and evaporative components such as fuel tanks, fuel lines, carbon canisters, and pressure relief valves. Figure 29 provides an overview of the information required to be reviewed for product approval.

Type of Off-Road Manufacturer Information Required Application Submittal		
Manufacturer Registration	**Required** EPA Manufacturer Code Letter of Intent Electronic Signatures Letter	**If Applicable** Authorized Consultants Letter DMS (Document Management System) Users Worksheet DMS Training
Pre-Application	**Required** Certification Preview	**If Applicable** Durability Plan Production Line Test (PLT) Engine Sampling Plan DF Carry Across Worksheet AECD Declarations Template Tamper Resistance Method Engine Auxiliary Cooling Questionnaire Corporate Average Plan
Application	**Required** Cover Letter General Statements of Compliance AECD Statements of Compliance Emissions Test Data Durability Report Emissions Label Schematic or Photo Emission Warranty Statements Projected Production	**If Applicable** Application Templates Projected Average Banking and Trading (ABT) Report On Board Diagnostics-M (Exhaust-Marine only) Bond Worksheet (Evaporative) Evaporative/Refueling Application Template Ammonia Slip Values NTE Deficiency Declaration DPF Regeneration Strategy Description SCR inducement Strategy Description Electric and Off-Cycle Component Description Delegates Assembly Documentation
Post-Application	**Required** Annual Production Volume Report (PVR) Quarterly Production Line Testing Report	**If Applicable** Running Changes Field Fixes Annual ABT Report

Figure 29: Off-Road Certification Documents

For the past 30 years, regulations and oversight of the off-road category has grown. More stringent and complex requirements have been adopted encompassing a wider variety of engines, vehicles, and equipment leading to a significant increase in the work effort needed to ensure off-road engine and vehicle certification and compliance.

The off-road program issued 2,287 and 2,200 EOs during 2020 and 2021, respectively (Table 9).

Product Type	CARB Off-Road Program Number of Executive Orders Issued per Year	
	2020	2021
Portable Fuel Containers	2	2
Portable Outboard Marine Tanks and Components	0	2
Evaporative Components - SORE	73	20
Evaporative Components – Marine/OHRV	8	5
Compression-Ignition Engines	432	468
SORE - Exhaust	661	682
SORE - Evaporative	610	555
LSI - Exhaust	44	73
LSI - Evaporative	9	3
Spark-Ignition Marine Engine (SIME)	86	106
Spark-Ignition Marine Watercraft (SIMW)	120	129

OHRV – Green Sticker	101	108
OHRV – Red Sticker	138	44
Electric Golf Carts	3	3
Total	2,287	2,200

Table 3: Total Number of Off-Road EO Issued from 2018-2021

As with the on-road program, CARB strives to provide the most efficient processing time from application to issuance of the EO. CARB continues to review and evaluate its approval process. Figure 30 shows the average time from submittal to issuance of an EO in 2020 and 2021 for the off-road programs.

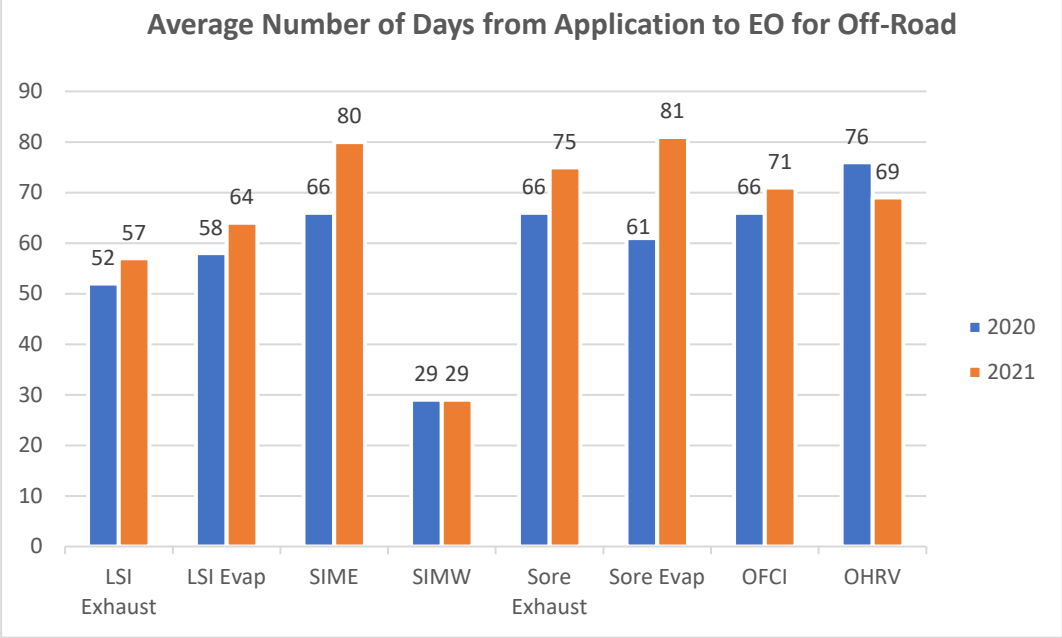


Figure 30: Average Number of Days to process an EO

Small off-road engines (SORE), spark-ignited marine engines/watercraft (SIME/SIMW), large spark-ignition engines (LSIE or forklifts)

Small off-road engines (SORE), spark-ignited marine engines/watercraft (SIME/SIMW), and large spark-ignition engines (LSIE or forklifts), unlike the on-road program, undergo a split approval process. Separate EOs are provided for the exhaust standards and the evaporative standards for each piece of equipment certified to be sold in California. Certification documents for each category are submitted by the manufacturer.

For exhaust certification, exhaust emissions data and analysis are conducted by the manufacturer to ensure durability and emissions compliance for each engine family. In regard to exhaust certification, focus is centered on verifying calculations with engineering judgment and understanding how an AECD may affect a system's configuration and ultimately may affect emissions during operation.

For evaporative emissions, there are two certification processes: an optional design-based certification using pre-certified evaporative components; and an evaporative performance-based equipment approval. Manufacturers without sufficient long-term assets in the United States are required to post a surety bond to CARB to cover enforcement obligations. Bond worksheets are reviewed to ensure manufacturer(s) meet the bond requirements.

The most common evaporative certification process is through design-based certification using pre-certified evaporative components, where verification of valid component EOs is performed to see if the listed component EOs on the application falls within the design constraints with the component EO issued. Gasoline fueled vehicles are required to meet the requirements to capture evaporative emissions utilizing a charcoal canister or other venting technology. CARB can conduct evaporative tests as necessary to verify that the equipment is complying with applicable standards.

To enable the design-based certification process, individual component manufacturers must obtain CARB approval for their components such as fuel tanks, fuel lines, carbon canisters, and pressure relief valves. SIMW and OHRV components only need to be certified once unless they are modified, so most component certification activity occurs in the years leading up to the implementation year of new evaporative emission standards: 2018/2019 for SIMW and SORE, and 2022 for OHRV. For SORE, components need to be renewed every four years although subsequent reviews can be a less stringent approval process unless there is a new standard. It is anticipated that the number of applications for certification of evaporative components will peak prior to the implementation year and then trend downward in subsequent years. After these components are certified, their Executive Order numbers are used to verify component design and when evaluating equipment applications.

In addition to vehicle and engine components, staff certify portable fuel containers (PFC) and portable outboard marine tanks and components (OMT) to reduce hydrocarbon evaporation. The PFC certification process has similar requirements to SORE evaporative certification. PFC manufacturers must conduct testing of 6 selected samples and the testing includes durability demonstrations conducted by the manufacturers involving pressure/vacuum cycling, UV exposure, a slosh test, and actuation test to ensure the product and its movable parts are sufficiently durable. The certifications are good for four years and renewals can be a less stringent approval process if there are no changes to the technology. For renewals, warranty information is requested from the manufacturer as an additional verification of the durability of the product. The OMT certification process is similar to the PFC certification process, but certification is only required once unless there is a new standard.

Below summarizes the number of applications received in 2020 and 2021. At times, the manufacturer does not complete the application process. In these cases, no Executive Order is issued.

CARB received 1,661 applications for off-road spark ignited products during the 2020 calendar year: 791 new spark ignited engines, 739 new evaporative systems, 99 running changes, and 32 close outs. CARB received 1,631 applications for off-road spark ignited products during the 2021 calendar year: 861 new spark ignited engines, 687 new evaporative systems, 62 running changes, and 21 close outs. The breakdown of the applications can be seen in Figure 31.

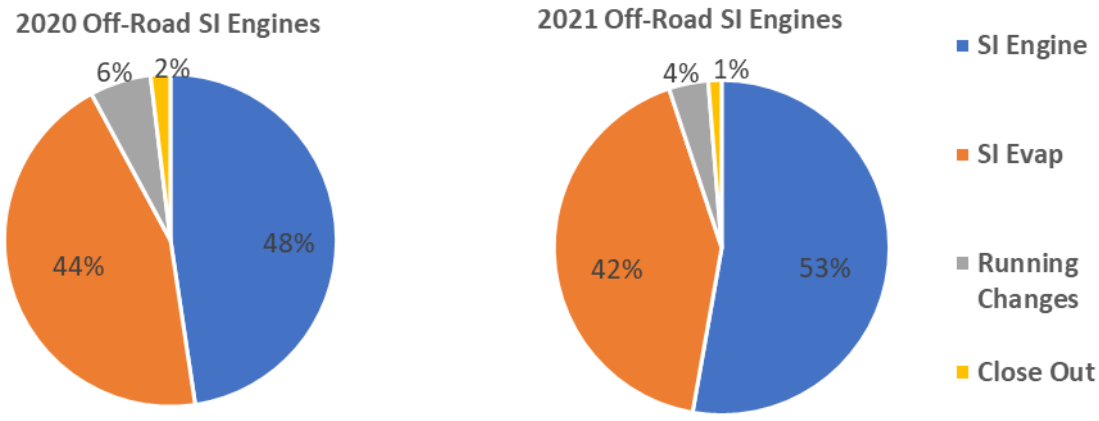


Figure 31: SORE, SIME/SIMW, and LSI Applications for 2020 and 2021

CARB received 151 and 51 applications for portable container and evaporative component products during 2020 and 2021, respectively. The breakdown of the applications can be seen in Figure 32.

	Total		New		Minor Modified EO/Renewal	
	2020	2021	2020	2021	2020	2021
Portable Containers (PFCs and OMT)	3	5	2	1	1	3
SORE Component	138	41	90	33	48	8
Marine Component	6	4	6	2	0	2
OHRV Component	4	1	4	1	0	0

Figure 32: Portable Container and Evaporative Component Applications for 2020 and 2021

In an effort to streamline the application document review process, individual approval numbers (not tied to a specific EO number) are issued for common items that can be used across many individual engine families certified by a manufacturer such as labels, warranty language, tamper resistance method (TRM), or PLT engine sampling plan. Manufacturers can then reference the approval number on their certification applications, as applicable. For SIME applications, if a manufacturer submits a sterndrive and inboard application using a common diagnostic system, the On-Board Diagnostics-Marine (OBD-M) system is reviewed once for compliance for all engine families affected. The total number of Correspondence Approval numbers issued in 2020 and 2021 per correspondence type can be seen in Table 10.

Correspondence	SSIE		LSIE		Marine	
	2020	2021	2020	2021	2020	2021
Label	141	104	14	8	21	36
Warranty	69	69	14	12	17	20
Tamper Resistance Method (TRM)	78	48	5	9	1	7
Production Line Test (PLT) Sampling Plan	3	9	1	5	3	2
Closeout Letters	27	16	2	2	3	3

Table 4: Approval for Repeat Activity for Multiple Products

CARB adopted a zero-emission equipment (ZEE) credit program in 2008 to accelerate the introduction of ZEE for professional users in support of further emission reductions from SORE. To that end, more ZEE families were certified in 2020 and 2021. The power source type for all the ZEE applications certified was a lithium-ion battery and a list of the families certified can be seen in Table 11 and Table 12.

Manufacturer Name	Executive Order	Family Name	Equipment Application	Power Source	Standard Battery Package

Andreas Stihl	U-U-015-1042	LA8XS.0004AF	Trimmer/Brushcutter, Edger, Split Boom System	Lithium-ion Battery	1124 Wh (four 281 Wh batteries)
Andreas Stihl	U-U-015-0999	LA8XS.0004AA	Trimmer/Brushcutter, Split Boom System	Lithium-ion Battery	1148 Wh, 1 battery
Andreas Stihl	U-U-015-1000	LA8XS.0004AB	Handheld Blower	Lithium-ion Battery	1148 Wh, 1 battery
Andreas Stihl	U-U-015-1039	LA8XS.0004AC	Chainsaw	Lithium-ion Battery	1124 Wh (four 281 Wh batteries)
Andreas Stihl	U-U-015-1040	LA8XS.0004AD	Handheld Blower	Lithium-ion Battery	1124 Wh (four 281 Wh batteries)
Andreas Stihl	U-U-015-1041	LA8XS.0004AE	Handheld Blower	Lithium-ion Battery	1148 Wh, 1 battery or 1522 Wh, 1 battery
Blount International, Inc.	U-U-264-0009	LBIIS.0001LM	Walk-Behind Lawnmower	Lithium-ion Battery	1944 Wh (Two 972 Wh batteries)
Blount International, Inc.	U-U-264-0010	LBIIS.0001BH	Handheld Blower	Lithium-ion Battery	972 Wh (One battery)

Table 5: ZEE Families Certified in 2020

Manufacturer Name	Executive Order	Engine Family Information	Equipment Application	Power Source	Standard Battery Package
Andreas Stihl	U-U-015-1075	MA8XS.0004AF	Trimmer/Brushcutter, Edger, Split Boom System	Lithium-ion Battery	1124 Wh
Andreas Stihl	U-U-015-1070	MA8XS.0004AA	Trimmer/Brushcutter, Split Boom System	Lithium-ion Battery	1148 Wh, 1 battery or 1522 Wh, 1 battery
Andreas Stihl	U-U-015-1071	MA8XS.0004AB	Handheld Blower	Lithium-ion Battery	1148 Wh, 1 battery or 1522 Wh, 1 battery
Andreas Stihl	U-U-015-1072	MA8XS.0004AC	Chainsaw	Lithium-ion Battery	1124 Wh (four 281 Wh batteries)
Andreas Stihl	U-U-015-1073	MA8XS.0004AD	Handheld Blower	Lithium-ion Battery	1124 Wh (four 281 Wh batteries)
Andreas Stihl	U-U-015-1074	MA8XS.0004AE	Handheld Blower	Lithium-ion Battery	1148 Wh, 1 battery or 1522 Wh, 1 battery
Andreas Stihl	U-U-015-1099	MA8XS.0004AG	Hedge Clipper	Lithium-ion Battery	681 Wh (three 227 Wh batteries) or 843 Wh (three 281 Wh batteries)

Andreas Stihl	U-U-015-1100	MA8XS.0004AH	Chainsaw	Lithium-ion Battery	1124 Wh (four 281 Wh batteries)

Table 2: ZEE Families Certified in 2021

Engines for Industrial Equipment (Compression-Ignition Engines)

Diesel-fueled or compression ignition engine (OFCI) approval follows the same process as heavy-duty on-road engines with some differences in exhaust emission standards, test procedures, and are not subject to OBD or GHG requirements. The applicable standards are based on the size and type of engine use (Table 13).

2015+ MY Standards				
Maximum Power (kW)	(NMHC+NOx/CO/PM in g/kW-hr)			
	NMHC+NOx	NOx	CO	PM
< 8	7.5	na	8.0	0.40
8 to <19	7.5	na	6.6	0.40
19 to <37	4.7	na	5.5	0.03
37 to <56	4.7	na	5.0	0.03
56 to<130	0.19	0.40	5.0	0.02
130 to <560	0.19	0.40	3.5	0.02
Mobile Machines (not Generator) > 560	0.19	3.5	3.5	0.04
Generator >560	0.19	0.67	3.5	0.03

Table 13: Off-Road Compression Ignition Tier IV Final Standards

For 2020, CARB received 1,069 applications for OCFI, 582 for new certification, 385 for running changes, and 102 for field fixes. In 2021 CARB received 985 applications for OCFI, 507 for new certification, 355 for running changes, and 123 for field fixes (the breakdown of which can be seen in Figure 33.)

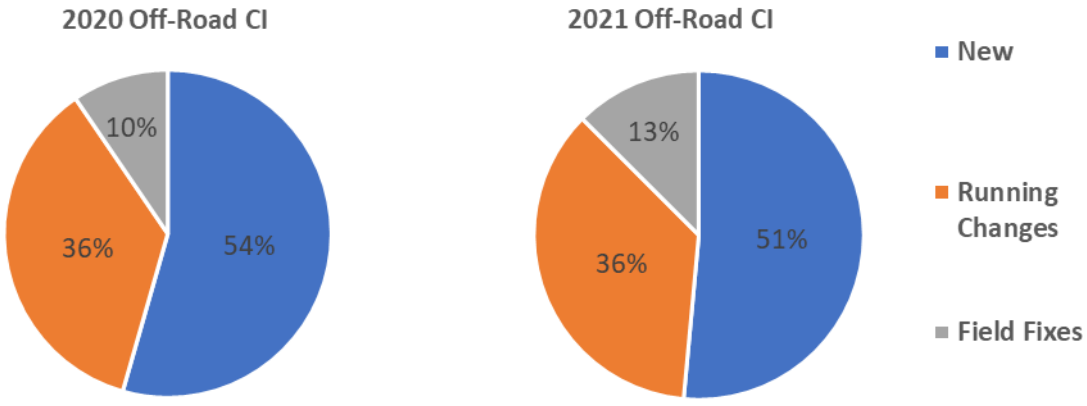


Figure 143: Off-Road Compression Ignition Applications received in 2020 and 2021

As of 2021, CARB had no capability to conduct confirmatory and AECD screening testing for heavy-duty compression ignition (CHID) products but as the new Riverside facility becomes operational, CARB will begin testing CIHD products before certification. Also, as part of the same on-road heavy-duty deterioration factor (DF) validation program, CARB initiated the DF validation program for OFCI which requires manufacturers to validate the DFs developed for programs utilizing Selective Catalyst Reduction (SCR). The DF is used to predict the deterioration in emission control by the component over its useful life. Initial testing and analysis found that in-use emission deterioration was far greater than that projected in the manufacturer-run durability programs. As a result, CARB staff developed an additional program to be run by manufacturers to validate the as certified DFs with testing of engines/vehicles in the field. To conduct this testing, the manufacturer must first submit a validation plan for CARB review and approval. Those reviews began in 2020 and the process is proving be a lengthy one with some reviews taking weeks to complete while other have taken several months. CARB staff have reviewed 23 DF validations for OFCI and expect to review several more as the DF validation program is ongoing and will be in place for the next several model years.

Off-Highway Recreational Vehicles

The OHRV segment is comprised of off-road motorcycles (OFMC), all-terrain vehicles (ATV), off-road utility vehicles (OFRUV) (e.g., ranch vehicles), off-road sport vehicles (OFRSV) (e.g., small-engine sand cars), sand cars (SCAR), and zero-emissions golf carts (EGC). The certification of OHRV is similar to highway motorcycles, with some differences in exhaust emission standards, evaporative emission standards, and test procedures. OHRVs are certified under two broad categories known as green sticker and red sticker. The green sticker refers to those vehicles that comply with CARB adopted emission standards. The red sticker refers to those OFMCs and ATVs that do not meet any CARB emission standards. While both are legal for sale in California, the use of red sticker OFMCs/ATVs is limited to private riding areas and to some public riding areas with seasonal restrictions to limit their usage in areas and times of the year where air quality is typically the worst.

In 2020, CARB received 260 applications for OHRVs, 215 for new certification, 25 for running changes, and 20 field fixes. In 2021, CARB received 196 applications for OHRVs, 137 for new certification, 35 for running changes, and 24 field fixes which can be seen in Figure 32.

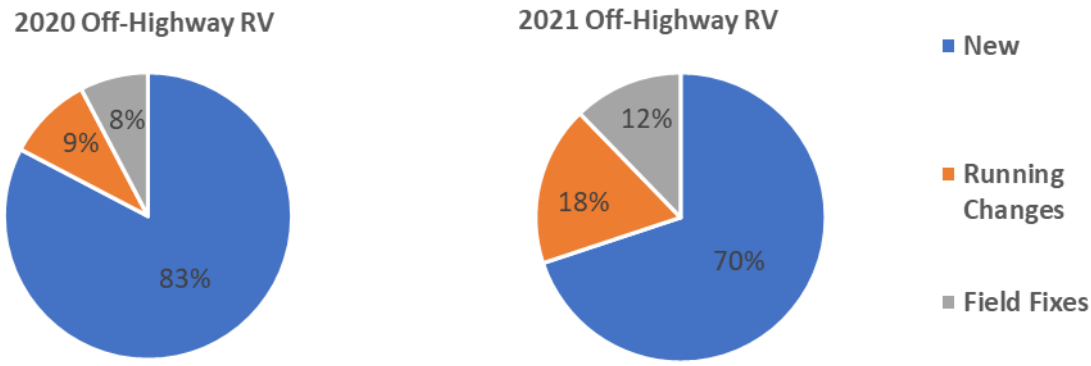


Figure 15: Applications for OHRV for 2020 and 2021

The phase-in of new evaporative emission standards starting with model year 2018 was a significant factor in manufacturers' shift to red sticker certification. Starting with model year 2018, OHRV manufacturers are required to certify to the new evaporative emission standards so that at least 75% of all OHRVs sold in model years 2018 through 2021 are compliant with the new requirements. Based on pre-pandemic projections, currently all manufacturers meet the phase-in requirement. The red sticker provisions will sunset in 2021 requiring manufacturers to meet evaporative standards on all applicable products.

CARB usually conducts about 4 confirmatory/screening tests per year for Off-Highway Recreational Vehicles. But in 2020 and 2021, due to pandemic-caused lab closures and laboratory staff's involvement with the acceptance of the new test lab at the Riverside location, testing was suspended. To illustrate the normal workload, Table 14 provides a summary of CARB confirmatory tests during 2015 to 2019.

2015 to 2019 CONFIRMATORY TESTING RESULTS					
CY	Arrived at Lab	Passed	Failed	Not Testable (test vehicle breakdowns)	% Passing
2015	12	10	2	0	83%
2016	6	5	0	1	83%
2017	0	0	0	0	N/A

2018	0	0	0	0	N/A
2019	1	1	0	0	100%
Total	19	16	2	1	84%

Table 16: OHRV Vehicle Testing, Model Years 2015 to2019

For OHRV vehicles with carbureted engines, Figure 34 shows the tamper resistance tests performed and the results during 2018 through 2021.

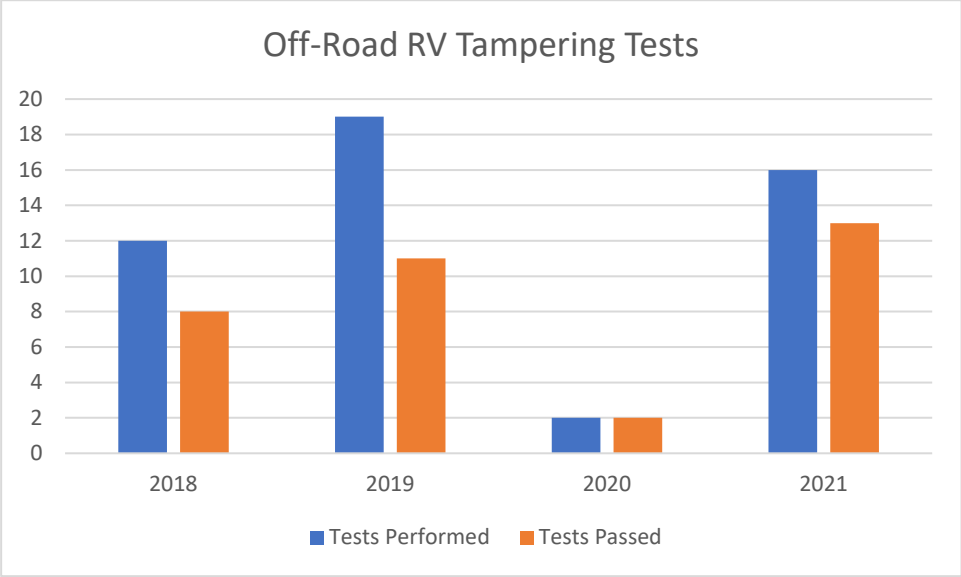


Figure 164: Tamper Resistance Tests, Model Years 2018-2021

What happens after the sale: Compliance Testing and Warranty

After Sales Compliance Testing

There are no requirements for traditional in-use testing for many of the SORE and other off-road certification categories, but staff do conduct studies on products that are purchased at the point of sale. CARB's evaporative compliance testing program is intended to identify products that do not meet diurnal emission standards once on the market. CARB staff acquire SORE test units from manufacturers, who purchase them in California stores or online and turn them over to CARB for testing. CARB staff purchase PFC samples from California stores for testing. Testing starts by filling the fuel tank or container with certification fuel and beginning the 140 day preconditioning period. Various durability tests are performed during preconditioning. The SORE and PFC test procedures involve 24 hour diurnal tests. The diurnal test is conducted in a sealed housing for evaporative determination (SHED), which varies in temperature from 65-105-65 degrees to simulate what happens in a typical day-

night-day cycle. For SORE testing, engines are run at maximum governed speed for 15 minutes prior to being placed in the SHED. Once in the SHED, 1-hour hot soak and 2-hour conditioning tests are performed prior to starting the diurnal test. For PFC testing, 24-hour hot soak and 24-hour conditioning tests are performed prior to starting the diurnal tests. The resulting evaporative emissions, quantified in grams of hydrocarbons, are measured using a Flame Ionization Detector for SORE testing and are measured gravimetrically for PFC testing. Failing tests are those that exceed the certification standard. In 2020, staff initiated, completed, or continued working on compliance tests for 35 SORE product families. In 2021, staff initiated and are continuing to work on compliance test for 17 SORE families.

Warranty and Corrective Action

In 2020, there were 2 recalls related to off-road affecting 1,397 individual vehicles/equipment. Both recalls involved hardware modifications to small off-road engines to resolve the issue.

In 2021, there were 9 recalls related to off-road affecting 11,036 individual vehicles/equipment. The recalls encompassed 5 compression-ignition engine families and 4 small off-road engine families. Out of the recalls that were performed, 78% involved hardware modifications and 22% involved software calibration changes to resolve the issue (Table 15).

# of Off-Road Recall Actions	
2020	2021
2	9
# of Off-Road Vehicles Affected	
2020	2021
1,397	11,036

Table 75: Off-Road Corrective Actions

Program Development and Enforcement Support

As a part of their regular duties, off-road certification and in-use experts are called in on or conduct regulation development, implementation of existing or new requirements, and support enforcement activities. This participation is essential to ensure complete coordination during the regulation development or to develop the needed information to support enforcement activities.

Program Development and Support

Small Off-Road Engine Exhaust Emission Regulations

SORE certification staff started work in 2017 to amend CARB's existing small off-road engine regulations, which were first adopted in 1990, to meet CARB's clean air goals. In December 2021, the Board approved a measure that will require most newly manufactured small off-road engines such as those found in leaf blowers, lawn mowers, and other equipment to meet zero-emission standards starting in model year 2024. Portable generators, including those in recreational vehicles, would be required to meet more stringent emission standards starting in model year 2024 and meet zero-emission standards starting in model year 2028. The new zero-emission standards apply to manufacturers and will impact new equipment (model year 2024 and later) only. Californians can continue to operate their current CARB-compliant SORE equipment. Monitoring and Laboratory Division certification staff led this effort.

Mobile Source Certification Fees

In 1988, the legislature gave CARB authority (Health and Safety Code [HSC] section 43019) to assess a fee for motor vehicles and engines (generally, cars, trucks, and motorcycles) that was capped at $4.5 million a year, but with annual adjustment of the cap based on the California Consumer Price Index (CPI). In 1990, CARB implemented this authority through regulation that provides a formula to assess fees on a limited class of motor vehicle and engine manufacturers. Manufacturers of vehicles and engines not subject to an emission standard at the time were not included in regulation. Today, the total amount collected is about $10 million which covers about 25% of the cost to implement the programs. On June 27, 2018, new legislation (SB 854) was passed and signed into law that allows CARB to adopt a schedule of fees to cover all or part of CARB's reasonable costs associated with certification, audit, and compliance of off-road or non-vehicular engines and equipment, aftermarket parts, and emission control components sold in the State. As such, this legislation provides CARB the authority to assess fees to cover its reasonable costs, with specific considerations, on all off-road and other mobile sources certification and compliance programs not currently covered under the existing fee regulation authority (HSC 43019). Certification and in-use staff developed a new fee assessment program, adopted by the Board in April 2020. The 1990 per vehicle fee assessment regulation will be replaced in April 2022 with a fee assessed at the time of application for certification. Emission Certification and Compliance Division (ECCD) staff led this effort with support from Monitoring and Laboratory Division and Transportation and Toxics Division staff.

Off-Road In-Use Compliance Pilot Program

In 2019, CARB began the off-road in-use compliance program and soon thereafter drafted and executed a two-year off-road contract designed to procure diverse diesel-powered heavy construction equipment. By the fall of 2020, the first pilot off-road in-use compliance test plan was approved and official testing for the program had begun. As of the end of

calendar year 2021, 29 pieces of equipment have been instrumented with data loggers to gather operational information and an additional five pieces of equipment have been instrumented with PEMS to gain insight on real-world pollution levels being emitted. Equipment in this field range from backhoes, wheel and track loaders, excavators, dozers, and skid steers and include engines from multiple engine manufacturers. ECCD In-Use staff are leading this effort.

Enforcement Support

Enforcement is a critical element of compliance when it comes to deterring non-compliant activities. ECCD routinely supports the Enforcement Division (ED) by reviewing technical information, providing historical information on previously certified products, and advising on interpretation of regulatory requirements to identify specific noncompliance. Staff supported 9 different enforcement activities for the off-road sector during 2020 and 2021 resulting in settlements from several companies including: Kawasaki Motors Corp., U.S.A.; Mitsubishi Turbocharger and Engine America Inc.; Husqvarna Consumer Outdoor Products N.A., Inc.; American Honda Motor Co., Inc.; and Kohler Co.

Aftermarket Parts and Alternative Control Technologies

California has anti-tampering laws that prohibit modification to certified on-road vehicles and off-road engines to ensure that the integrity of the original emission control systems is not compromised in use (California Vehicle Code Sections 27156 and 38391). However, modification to certified vehicles/engines can be a common occurrence for various reasons such as installation of aftermarket parts for performance gains, conversion of fleet vehicles to utilize a different fuel type for fuel cost savings; installation of aftermarket parts during repair; and regulated entities adding emission control systems to achieve mandated toxic emission reductions. The anti-tampering laws allow sale and use of such modifications provided they have been evaluated by CARB and determined to have no adverse impact on the certified emission control systems.

A total of 396 and 291 EOs and approval letters were issued respectively in 2020 and 2021 for the various aftermarket part and alternative control technologies (Table 16).

Product Type	CARB Aftermarket Parts and Control Technologies Program Number of Executive Orders Issued per Year	
	2020	2021
Experimental Permits	38	57
Aftermarket Parts (B, D, K series)	270	229
Diesel Emission Control Strategies (DECS) (DE series)	15	5
DECS- Locomotive	3	0
At-Berth Alt. Control Technology	0	0
Total	326	291

Table 16: Executive Orders issued for Aftermarket Parts and Control Technologies Program

The following sections will discuss the various types of exemptions provided from simple permits to demonstrate new technology prior to certification to complex approvals for aftermarket parts that are verified to reduce emissions.

Performance Parts, General Parts, Experimental Permits, and Alternative Fuel Retrofits

Aftermarket regulations provide paths for part manufacturers to obtain exemption from the anti-tampering laws, allowing the sale and use of exempted parts. The requirements balance the need for part manufacturers to substantiate that their parts do not reduce the effectiveness of the originally certified emission controls with the cost they would incur during demonstration testing. Table 17 provides the types of aftermarket parts and exemptions available.

Aftermarket Part Category (EO series)	Example
Experimental emission control device and vehicle (C)	Low-emission prototype vehicles, re-calibration
Add-on and modified part (D)	Supercharger, electronic control module programmer, gasoline catalytic converter, diesel particulate filter
On-highway motorcycle critical emission control part (K)	Catalytic exhaust system, oxygen sensor with tuner, high-flow exhaust system
Alternative fuel retrofit system (B)	Natural gas retrofit system, hybrid conversion system

Table 87: Aftermarket Part Category and Example

Table 18 provides the specific requirements that cover exemption applications.

Experimental Emission Control Device and Vehicle
California Health and Safety Code Section 43014
Add-On and Modified Part
Procedures for Exemption of Add-On and Modified Part(s) for On-Road Vehicles/Engines 13 CCR Section 2222 *https://ww2.arb.ca.gov/rulemaking/2020/ampts2020*
Procedures for Exemption of Add-On and Modified Parts for Off-Road Categories 13 CCR Section 2474 *https://ww3.arb.ca.gov/msprog/aftermkt/offroad/offroad.htm*
California Evaluation Procedures for New Aftermarket Catalytic Converters 13 CCR Section 2222 *https://ww3.arb.ca.gov/msprog/aftermktcat/aftermktcat.htm*

California Evaluation Procedures for New Aftermarket Non-Original Equipment Catalytic Converters for Off-Road Vehicles, Engines, and Equipment 13 CCR Section 2474 *https://ww3.arb.ca.gov/msprog/aftermkt/offroad/offroad.htm*
California Evaluation Procedure for New Aftermarket Diesel Particulate Filters Intended as Modified Parts For 2007 Through 2009 Model Year On-Road Heavy-Duty Diesel Engines 13 CCR Section 2222 *https://ww2.arb.ca.gov/evaluation-procedure-aftermarket-diesel-particulate-filters-road-heavy-duty-diesel-engines*
On-Highway Motorcycle Critical Emission Control Part
California Evaluation Procedures for Aftermarket Critical Emission Control Parts on Highway Motorcycles 13 CCR Section 2222 *https://ww3.arb.ca.gov/msprog/aftermkt/motorcycle1/motorcycle1.htm*
Alternative Fuel Retrofit System and Hybrid Conversion System
California Certification and Installation Procedures for Alternative Fuel Retrofit Systems for 2004 and Subsequent Model Year On-Road Motor Vehicles and Engines 13 CCR Sections 2030-2031 *https://ww3.arb.ca.gov/msprog/aftermkt/altfuel/altfuel.htm*
California Certification and Installation Procedures for Systems Designed to Convert Off-Road Vehicles, Engines, and Equipment to Use Alternative Fuels 13 CCR Section 2474 *https://ww3.arb.ca.gov/msprog/aftermkt/offroad/offroad.htm*
California Certification and Installation Procedures for Off-Vehicle Charge Capable Conversion Systems for 2000 and Subsequent Model Year Hybrid Electric Vehicles 13 CCR Section 2032 *https://ww3.arb.ca.gov/regact/2008/phev09/phev09.htm*

California Certification and Installation Procedures for Medium- and Heavy-Duty Vehicle Hybrid Conversion Systems 13 CCR Section 2208.2 *https://ww2.arb.ca.gov/our-work/programs/innovative-technology-regulation*

Table 98: Aftermarket Regulation Reference

Before the Sale: Certification

Experimental Permits

Manufacturers conduct pilot or demonstration programs to assess the viability of their new technologies before applying for certification. CARB's experimental permit program supports manufacturers in the development, fine-tuning, and testing of new technologies that have very low emission characteristics by issuing permits that allow operation of uncertified technologies on the road. The program also supports testing of field fixes and re-calibrations needed on previously certified products.

Performance, General Parts, and Alternative Fuel Retrofits

The exemption processes for the various aftermarket categories generally follow similar sequences but the specific testing obligations differ according to the original certification requirements, extent of the modification, and the program intent. For example, parts that affect a vehicle's exhaust and evaporative emission control systems require both tailpipe and evaporative emission tests. Regulations that support programs with emission reduction targets have more rigorous testing requirements to verify that emission control strategies produce quantifiable and long-lasting reductions compared to regulations that apply only the 'no adverse impact' standard. In addition, there are parts that are accepted to have no significant emission impact, such as throttle body spacers and ignition coils. These parts are evaluated through engineering analysis without any testing requirements. Figure 35 illustrates the general exemption process.

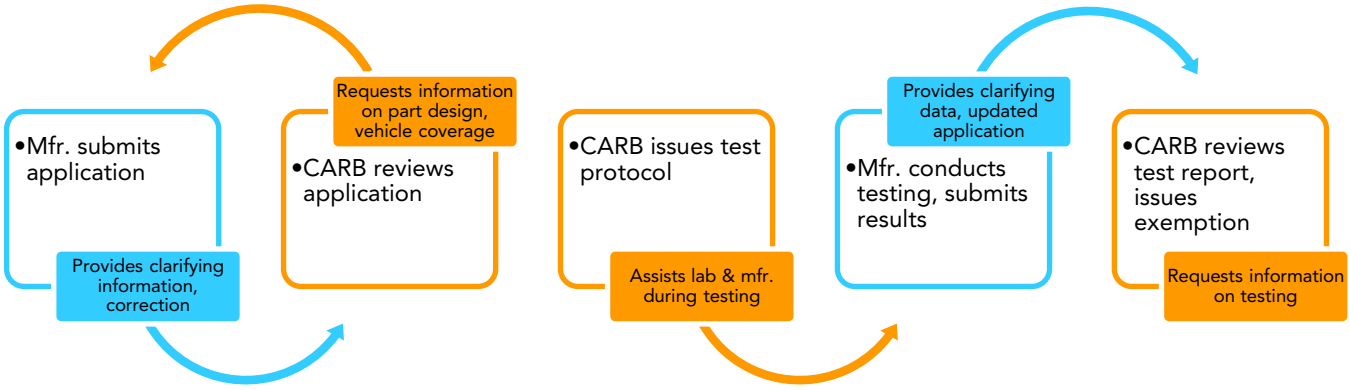


Figure 35: Aftermarket Exemption Process

The exemption process begins when a manufacturer submits an application. The application includes a detailed description of the part, explanation of its function, and a list of vehicles or engines it is designed to modify. During application review, CARB works with the manufacturer to gain clear understanding of how the part operates and its potential impact on the various vehicle/engine emission control systems. The application review is an iterative process where the manufacturer and CARB work together to answer all the questions on the part and the covered vehicles/engines. Once application review is complete, CARB issues a test protocol. The test protocol is determined by how the part is expected to affect the original emission controls and the breadth of the covered vehicles/engines. These parts are typically used on a wide variety of engines and vehicles, so the worst-case representative vehicles/engines are selected by CARB for manufacturer testing. The prescribed testing balances the need for an effective way to assess the emission impact of the part against the cost burden imposed on the manufacturer. During testing, CARB works with the independent testing laboratory and the manufacturer to resolve issues such as difficulties procuring test vehicles/engines, identifying test parameters, resolving vehicle diagnostic issues, and emission failures. Once testing is complete, CARB reviews the results and determines if confirmatory testing is needed, before making a decision to either issue or deny exemption. In 2020 and 2021, CARB received 1,070 exemption applications and issued 499 exemption Executive Orders (EO), as shown in Table 19. There were 286 manufacturers that submitted exemption applications (B, D, K series). The exemption applications covered 22 different aftermarket part types as shown in Figure 36. Seventy-eight (78) manufacturers submitted experimental permit applications in 2020 and 2021.

Aftermarket Part Category	Applications Received	EOs Issued	Manufacturers
Experimental permit (C)	103	95	78
Exemption (B, D, K)	1,070	499	286

Table 19: Aftermarket Applications and Executive Orders

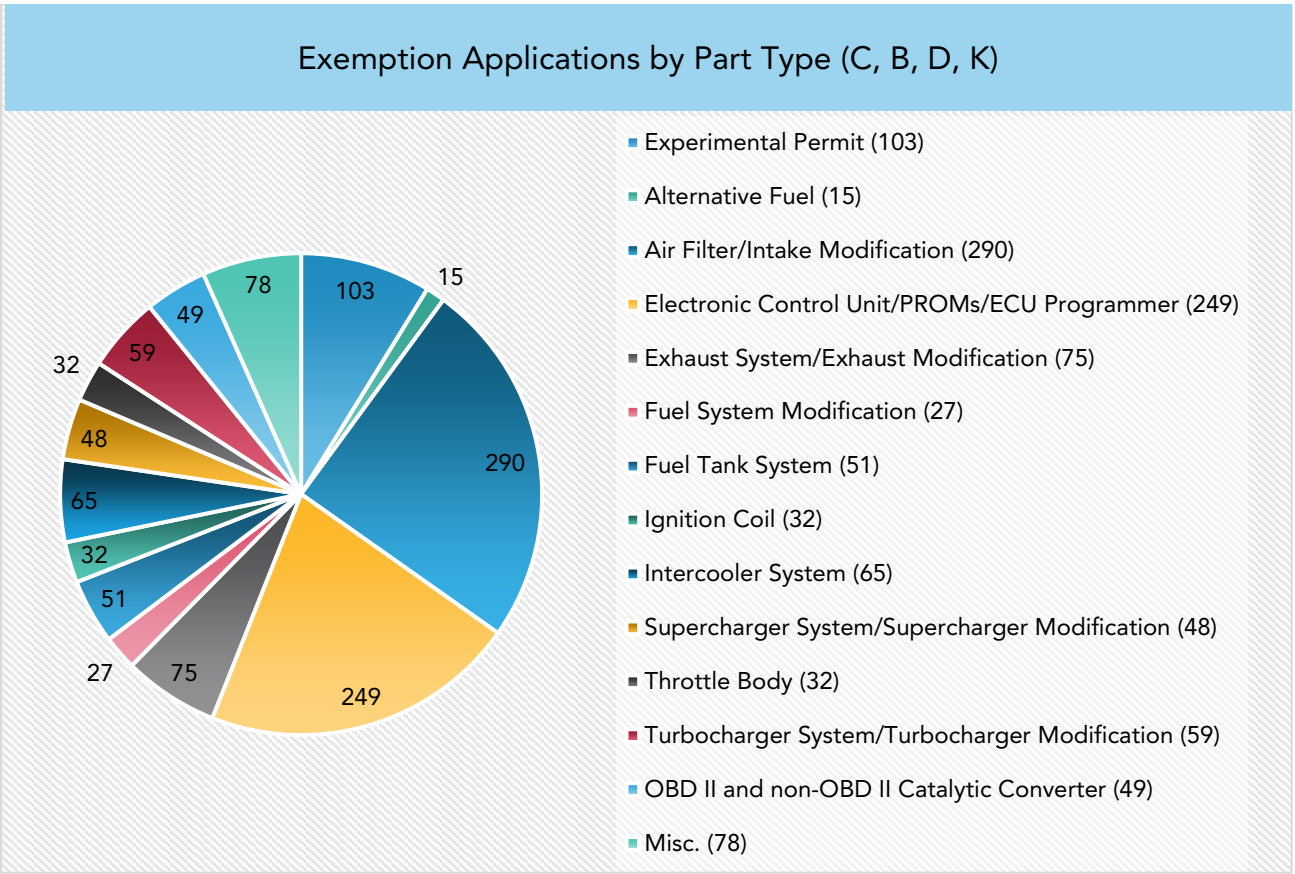


Figure 176: Exemption Applications by Part Type

CARB continually reviews its exemption process to eliminate delays and to provide the most efficient processing time from receipt of an application to issuance of an EO. The goal for the Aftermarket Parts Certification and Audit Branch is to work with manufacturers to have a complete application so that an EO can be issued. CARB targets 90 days from initial receipt of an application to complete its review and issue an EO. This 90-day period does not include the time a manufacturer may need to provide additional information on its device to

complete its application or to conduct emission testing. In 2019, 2020, and 2021, the average staff time from CARB receiving an application to issuing an EO were 76, 69, and 53 days, respectively, for the aftermarket programs.

What Happens After the Sale: Compliance Testing and Warranty

Aftermarket parts are monitored for quality and performance. Quality control and reporting provisions require manufacturers to establish and follow strict procedures to verify that production parts conform to specifications of the exempted parts. Manufacturers also document warranty data and track warranty claims for possible defect issues and submit reports to CARB. Production and in-use testing provisions allow CARB to verify emission compliance. Specific requirements are delineated in each regulation.

Catalytic Converter Audit Testing

As an essential part of the compliance program, in-use or audit testing checks the emission performance of a production part after it enters commerce. In 2020 and 2021, CARB continued its audit test program on aftermarket catalytic converters. CARB purchased off-the-shelf converters and tested them on representative test vehicles when new and after bench aging to 50,000 miles. Since 2012, CARB tested 53 converter systems and has required manufacturers to stop sales for converters identified to be noncompliant.

Warranty

Manufacturers are required to provide warranty for emission-critical aftermarket parts such as catalytic converters, particular filters, and alternative fuel conversion systems. Manufacturers track warranty claims and report to CARB as required.

Program Development and Enforcement Support

New Procedures for Exemption of Add-On and Modified Part(s) for On-Road Vehicles/Engines: In July 2020, staff proposed to the Board the new *Procedures for Exemption of Add-On and Modified Part(s) for On-Road Vehicles/Engines*. The new procedures are the result of a two-year coordinated effort by CARB and the aftermarket industry to update the existing 1990 exemption procedures. The new procedures streamline the application process by defining the scope of application, clarifying the information required in the application, and specifying the testing requirements. The new procedures detail paths for APCAB to effectively evaluate both complex and relatively simpler parts for their impact on today's modern vehicles and their emission control systems without undue burden. The new procedures took effect January 2022.

Compliance Assistance: CARB staff communicates directly with the public and outside agencies on matters related to aftermarket parts. Staff assists consumers seeking to verify the exemption status of various aftermarket parts. Staff also works with the Bureau of Automotive Repair on Smog Check questions and issues, including verifying legal emission control parts and identifying the best available catalytic converters to control emissions from

in-use vehicles. Staff also lends expertise to Section 177 states developing regulations or programs to require the use of California-exempted catalytic converters.

Certification requirements are the cornerstone of CARB efforts to control emissions. It is illegal to sell emission-related parts that modify certified vehicles/engines unless the parts have been exempted from the anti-tampering laws according to each aftermarket regulation. Compliance with aftermarket regulations is verified by the Enforcement Division (ED), and staff assists ED by providing background information on previously exempted products and elucidating regulatory requirements. CARB enforcement statutes follow the doctrine of "strict liability," which means a prohibited act is a violation no matter what the intent or care taken to avoid violations. By supporting CARB's ED program, staff helps to ensure that anticipated emission levels are maintained and that a level playing field is provided for all regulated entities.

Diesel Emission Control Strategies

In 2000, CARB adopted the Diesel Risk Reduction Plan (DRRP) following its identification of particulate matter (PM) emissions from diesel engines as a toxic air contaminant. One of the key strategies in the DRRP for mitigating diesel PM emissions is retrofitting in-use diesel engines with diesel emission control systems (DECS). To ensure that DECS are based on sound principles of science and engineering and achieve real and durable reductions of PM and oxides of nitrogen emissions, staff developed the *Verification Procedure, Warranty and In-Use Compliance Requirements for In-Use Strategies to Control Emissions from Diesel Engines* (Procedure), which the Board adopted in May 2002. The Procedure is used by staff to evaluate DECS through emissions, durability, and field testing. In addition, it permits further evaluation after installation through warranty and in-use compliance requirements. Verified device manufacturers have additional obligations regarding vehicle pre-installation assessment and training for authorized installers. Under this Verification Program, DECS have been installed on in-use vehicles to comply with various fleet rules and other regulations.

Before the Sale: Verification and Approval Process

The verification process incudes the waiver from the California anti-tampering law in addition to verification of real and durable emission reductions. Due to the unique nature of each application, this is typically an iterative process, with staff needing to ask the manufacturer for additional information or clarification due to insufficient information in the initial application. The process begins with submittal of a Preliminary Application. Once the Preliminary Application is determined by staff to be complete and valid, staff may issue a test plan, although some requests for changes to an existing verification may omit this step. Drafting and finalizing the test plan is typically an iterative process as well. Once the applicant has completed its testing, it submits the Final Application that includes all of its emissions, durability, and field test data. If the Final Application is complete and all test data and other documentation submitted comply with the requirements of the Procedure, an Executive Order or conditional verification letter is issued. Verifications are issued for on-

road, off-road, and stationary applications including such subcategories as rubber tire gantry cranes, locomotives, marine vessels, auxiliary power units (APU), and transport refrigeration units. Given the structure of the in-use fleet rules, activities for on-road, off-road, and APU based verifications have decreased over the last few years. Additional information regarding commercial harbor craft, stationary engine, and locomotive verifications is provided below.

Commercial Harbor Craft

The Commercial Harbor Craft (CHC) Regulation was adopted by CARB in 2007, and updated in March of 2022, to reduce toxic and criteria emissions to protect public health. Many communities surrounding where the vessels operate are disadvantaged communities. Addressing emissions from harbor craft is critical for the state to achieve its air quality and environmental justice goals. As there are certain requirements to use marine diesel particulate filters (DPFs) on Tier 3 and Tier 4 diesel engines under the amendments adopted by the Board in March of 2022, CARB staff anticipate approximately 400 sales per year of verified marine DPFs between 2024 and 2034. CARB approved a preliminary verification application for one of the marine DECS applicants in February 2022 and is evaluating applications from a number of other manufacturers for approval of marine DECS applications.

Stationary Engines

The Airborne Toxic Control Measure for Stationary Compression Ignition Engines (Stationary ATCM) was adopted in 2004 and last amended in 2011. The Stationary ATCM established emission standards and operating/reporting requirements for new and existing stationary diesel-powered compression ignition (CI) engines to be used in emergency standby and prime stationary applications. The purpose of the Stationary ATCM has been to reduce diesel PM and criteria pollutant emissions from stationary engines operating throughout California to protect the public health. The Stationary ATCM allows for use of the DECS that are verified through the CARB's DECS verification program to demonstrate compliance with the applicable emission standards for stationary engines. Local air districts in California generally implement the Stationary ATCM and CARB's DECS verification program in the engines permitting process to control and limit emissions from stationary sources. CARB has verified several DECS products for stationary applications over the recent years (see *https://ww2.arb.ca.gov/diesel/verdev/vt/stationary.htm*) and is currently evaluating approval of three new stationary DECS applications.

Locomotives

The 1998 Locomotive NOx Fleet Average Emissions Agreement in the South Coast Air Basin (1998 MOU), signed by CARB, Union Pacific Railroad (UP) and BNSF Railway (BNSF), accelerated the introduction of cleaner locomotives into the South Coast Air Basin. One avenue for reducing railroad emissions is CARB's incentives, which requires verification. Moyer guidelines require any locomotive modifications receiving funds to be verified. The Locomotive Verification pathway loosely follows 13 CCR 2700-2711, but generally consists of an initial application, a final report, and an approval letter instead of an Executive Order.

During the last two years, CARB verified three locomotive technologies which achieve U.S. EPA Tier 4 linehaul or switch exhaust emission standards for PM, NOx, CO, and HC.

In-Use Compliance/Warranty

Following the completion of the exemption/verification process, manufacturers can legally sell their DECS for use in California. Many states, besides California, use CARB's approval for in-use emission reductions within their jurisdictions. DECS have in-use compliance provisions to ensure manufacturers produce parts that meet the specifications disclosed in their exemption/verification applications and in-use emissions remain at levels specified during the exemption/verification process. Manufacturers are required to document warranty data and track warranty claims for possible defect issues and submit warranty reports to CARB annually. Manufacturers are required to submit annual sales and warranty reports to CARB by April 1 of each calendar year, or within 30 calendar days of the cumulative number of valid warranty claims for the same part or component of the DECS exceeding 4% of the cumulative sales and leases of the device. Where valid warranty claims exceed 4%, the Executive Officer may modify, revoke, or suspend the existing verification or order a recall. The number of warranty reports received and reviewed by CARB in different DECS categories can be found in Table 20.

DECS Category	2020 Reporting Year	2021 Reporting Year	Total
On-road			
Off-road			
TRU	6	6	12
Commercial Harbor Craft	1	1	2
Stationary	12	3	15
RTG Crane	3	2	5

Table 20: DECS warranty reports for reporting years of 2020 and 2021

In-use testing requirements are triggered after 100 and/or 300 sales. A detailed description of CARB's approach and activities to review and approve in-use compliance testing applications has been elaborated earlier in this report.

At-Berth Alternative Control Technology

The original Ocean-Going Vessel At-Berth Regulation (2007 At-Berth Regulation) was approved in December 2007 with compliance requirements that began in 2014. The 2007 At-Berth Regulation applies to container vessels, passenger vessels (cruise), and refrigerated cargo vessels (commonly known as "reefer") at six California ports: Los Angeles, Long Beach,

Oakland, San Diego, San Francisco, and Hueneme. Compliance requirements for vessels include visit requirements and emission or power reduction requirements, both which were phased in over time to the current reduction of 80 percent from the fleet's baseline power generation. In August 2020, CARB adopted the 2020 At Berth Regulation, which expanded upon the original regulation to include additional vessel categories and new ports and independent marine terminals. The 2020 At Berth Regulation requires container, reefer, cruise, roll-on/roll-off (ro-ro or auto carriers), and tanker vessels visiting regulated ports and independent marine terminals to reduce their auxiliary engine emissions through use of a CARB Approved Emission Control Strategy (CAECS). The 2020 Regulation also requires that regulated parties (vessels, terminals, and ports) coordinate to ensure that a CAECS is available and used for compliance for each visit a vessel makes to a regulated terminal. Emission control requirements of the 2020 At Berth Regulation will begin in 2023 for container, reefer, and cruise vessels; 2025 for roll-on/roll-off vessels; 2025 for tanker vessels at the Ports of Los Angeles and Long Beach; and in 2027 for tanker vessels at the remainder of tanker terminals statewide (mostly in Northern California).

To be used for compliance with the 2020 At Berth Regulation, an emission control technology must be CARB-approved. Additionally, shore power is defined as a CAECS in the regulation and is the primary path for compliance for the majority of already-regulated container, reefer, and cruise vessels. The most utilized CAECS besides shore power is capture and control. Capture and control technologies are designed to capture vessel exhaust either at the vessel stack, or from another connection point in the vessel exhaust system. The exhaust is diverted to an emission treatment unit to remove and control the regulated pollutants to levels which are outlined in the regulation.

The process for CAECS approval is included in the At Berth Regulation and relies on CARB's Recommended Emissions Testing Guidelines for Ocean-going Vessels. For each CAECS application, CARB staff works with the applicant to review and approve a test plan for the testing of the CAECS. Each test plan must include a description of the emission control strategy's principles of operation, a schematic of the components and operation, and a demonstration that the qualifying strategy relies on sound principles of science and engineering to achieve emission reductions. Also, the test plan must provide a description of the testing to be conducted to demonstrate emission reductions and durability. A timeline for all emission reduction testing and durability testing, including an estimate for the testing's duration and the number of vessel visits needed to complete proposed testing is required. After CARB approves an applicant's test plan, the applicant must submit a test report and EO application that includes the CAECS applicability, testing results demonstrating the emission reductions and durability, and the performance and durability information. Once CARB staff review and approve the application, an EO is issued. Each of these systems are unique and vary in complexity and strategy. Each EO is written to provide approved operating parameters and clarify reporting and recordkeeping requirements needed to ensure compliance with the strategy.

After approval, each CAECS system is required to conduct periodic monitoring to ensure in-use emission reductions are achieved. For example, an operator of a capture and control

system must submit in-use Continuous Emissions Monitoring System (CEMS) data showing the emissions during each vessel visit.

In 2020 and 2021 years, CARB received a single application for a new CAECS, and approved a test plan for another CAECS. CARB anticipates at least two additional test plan approvals in 2022. With the regulatory implementation underway through 2027, CARB anticipates additional applications in the coming years to help control emissions on newly regulated vessels and terminals. CARB currently reviews CEMS data from about 100 vessel visits annually but expects the number of CEMS reviews to increase alongside CAECS approvals.

Looking Ahead – Goals and Challenges

CARB has over 50 years of experience reducing mobile source emissions that have improved air quality and reduced climate pollutants. Through these efforts, the State and our most polluted regions have seen dramatic improvements in ambient air quality and, as a byproduct, CARB has helped California become a world leader in environmental policies and clean technologies. Even with our progress, many areas of the State continue to exceed current federal health-based ambient air quality standards that the State must legally meet; in addition, many near-source, low-income and disadvantaged communities continue to experience disproportionately high levels of air pollution and the resulting detrimental impacts to their health. Further, climate change is causing extreme heat, devastating wildfires, historic droughts, and torrential storms resulting in billions of dollars in property damage and threatening human health and the economy of the residents of California – the unprecedented number of acres burned by wildfires in 2020 reemphasizes that climate change is here now. These immediate threats of climate change demand action and have resulted in a number of State of California and CARB policies to date. Mobile sources including cars, trucks, tractors, and a myriad of other on-road vehicles and off-road equipment, contribute a majority of smog-forming oxides of nitrogen (NOx), the largest portion of greenhouse gas (GHG) emissions, and are a significant source of toxic air contaminants that directly impact community health. The 2016 Mobile Source Strategy was CARB's first integrated planning effort looking specifically at mobile sources to identify complementary policies to reduce emissions of criteria pollutants, greenhouse gases, and toxics. In October 2021, CARB adopted the 2020 Mobile Source Strategy which continues the multi-pollutant planning approach to illustrate the pathways forward for the various mobile sectors that are necessary in order to achieve California's numerous goals and targets over the next 30 years. In the 2020 Strategy, staff have identified a suite of strategy concepts, many of which CARB is actively pursuing through individual public processes, that will enable the State to achieve the technology trajectories identified through scenario planning and, consequently, meet California's many goals.

Many of the key elements of the 2020 Mobile Source Strategy rely on the MSCCP to ensure its goals are met. New technologies are under development for cars to meet more aggressive zero-emission sales requirements and strengthened pollutant controls for gasoline and diesel engines starting in 2026. The Strategy accelerates the transition of California truck

fleets to zero emission technology starting in 2023 through both manufacturer and fleet requirements. The Strategy directs CARB to develop cleaner off-road engine emission standards in 2027 and zero-emission and hybrid requirements in the late 2020s, cleaner marine engine standards (necessitating federal and international actions) in the late 2020s and zero-emission or hybrid technology requirements for certain vessel types like ferries and excursions.
Cargo Handling Equipment, and the transition to zero-emission small off-road equipment, forklifts, and transport refrigeration units starting in 2024.

It is clear that the MSCCP needs to continue to adapt to meet these new challenges ensuring engines, vehicles, and components comply with all California clean air standards. More program oversight is needed to ensure new zero-emission technology continues to meet the high-quality standards expected of traditional technology and the most stringent standards are met for existing technology at certification and during its life expectancy. As shown in this report, each program continues to grow and adapt to meet California's future clean air goals.

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