

RIVERSIDE, CA



# SOUTHERN CALIFORNIA HEADQUARTERS

Mary D. Nichols Campus



# A BUILDING FOR THE FUTURE

## Cutting-Edge Laboratory

The California Air Resources Board's (CARB) Southern California Headquarters Laboratory will be the state's leading center for assessing the environmental impacts of motor vehicles. The lab will provide air quality decision makers with state-of-the-art measurements of vehicle emissions, fuel analysis and research into vehicle-related pollutants.

CARB's mobile source emissions testing laboratories have played a key role in the success of California's clean air efforts. When originally established, the primary mission was to test and analyze motor vehicle emissions that were, and still are, the primary cause of smog in California. Staff has built upon this groundbreaking work to support CARB in its development and implementation of progressive strategies and programs to reduce the emissions of additional mobile source pollutants, including toxic air contaminants, fine particle pollution and greenhouse gases.

The new lab's expanded capabilities will support the transition to zero or near-zero emissions technology in all areas recognized as mobile sources through rigorous screening and regulatory testing. The Southern California Headquarters Laboratory is designed to accommodate testing for passenger cars, motorcycles, trucks and buses, lawn and garden equipment, small off-road engines and marine engines. From the largest heavy-duty vehicle to the smallest off-road engine and everything in between, the new lab is equipped to test them all.

In one facility, the laboratory houses light-, medium- and heavy-duty testing, along with space and support for portable instrumentation used for real-world, in-use emissions testing. Each area offers state-of-the-art equipment and provides expanded capabilities. This centralization provides more comprehensive, transparent and accessible test scheduling, test status and test results, as well as an overall expansion of testing capacity.

The new facility also includes a state-of-the-art chemistry lab to analyze motor vehicle exhaust emissions, evaporative emissions and transportation fuels samples. This lab provides data to evaluate



the toxicity, reactivity and climate change impacts of motor vehicle emissions; assess the effectiveness of control technologies; improve the emissions inventory for specific components of motor vehicle emissions; and enforce California's Clean Fuels specifications. The new instrumentation expands analytical capabilities and development of new test methods to support the foundation of future regulations.

## Design

To support the state's climate initiatives and determined to demonstrate the highest standards of sustainable practices, CARB designed and constructed the new Southern California Headquarters to be a green building for the future. By integrating sustainable and energy-efficient measures throughout, the facility was designed to achieve Leadership in Energy and Environmental Design (LEED) Platinum certification and California Green Building Standards Code (CALGreen) and was designed to be zero net energy (ZNE). At 402,000 square feet, it is the largest ZNE laboratory in the United States. Some of the energy-saving methods employed include:

- Chilled beam air conditioning in the office areas
- Automated lighting control
- Building management system that monitors the building's vital operations for problems and to maintain its "green" efficiency
- Solar arrays throughout to supply at least 3.5 megawatts of electricity
- Battery back up
- Central plant for chilled water
- Integrating sustainability and efficiency measures for regenerative dynamometers
- Orienting the light-duty lab wing perpendicular to predominant wind direction to reduce the possibility of testing exhaust being drawn back into the building
- Fresh outdoor air is conditioned via a dedicated outdoor air system to maintain the heating, cooling and humidity requirements of the testing spaces

## Looking to the Past

CARB's reputation as a world leader in vehicle emissions testing and clean air regulation is in large part the result of the work carried out in its labs by dedicated staff scientists, engineers and technicians. In 1967, CARB was created by joining two agencies, the Bureau of Air Sanitation and the Motor Vehicle Pollution Control Board (MVPCB). CARB inherited the MVPCB's Vehicle Pollution Laboratory located in Los Angeles, along with its talented scientists and engineers who had pioneered work in vehicle emissions testing. From 1973 to 2022, much of CARB's innovation and technological advances at curbing emissions has taken place in El Monte at the Haagen-Smit Laboratory, named after CARB's first chair and the chemist who first discovered the link between tailpipe emissions and smog, Dr. Arie Haagen-Smit. The new Southern California Headquarters Laboratory paves the way for CARB to continue its tradition of scientific excellence well into the future.





# EMISSIONS TESTING





The Southern California Headquarters Laboratory's emissions testing and chemistry laboratories work in concert to support CARB's Mobile Source Strategy, State Implementation Plan and other clean air programs for the protection of public health, air quality and climate. A wide array of testing and engineering services, test method development and software capabilities are provided to determine mobile source emissions from light- and medium-duty vehicles, heavy-duty vehicles and engines, small off-road engines (SOREs), motorcycles, marine vessels and all-terrain vehicles (ATVs).

## Light/Medium-Duty Vehicle Emissions Testing Services

7·Emissions test cells:

- 1·Research cell
- 1·Climate cell
- 3·Certification cells
- 2·Electric vehicle (EV)/On-board diagnostic (OBD) cells

Real-time OBD acquisition in all test cells

Chassis dynamometers, equipped with road-speed fans, capable of testing two-wheel and four-wheel drive vehicles up to 14,000 lbs. inertia weight

Bag sampling measurement of total hydrocarbons (THC), methane ( $\text{CH}_4$ ), carbon monoxide (CO), carbon dioxide ( $\text{CO}_2$ ), oxides of nitrogen ( $\text{NO}_x$ ), and nitrous oxide ( $\text{N}_2\text{O}$ )

Continuous dilute measurement of THC, CO,  $\text{CO}_2$ ,  $\text{NO}_x$ ,  $\text{N}_2\text{O}$ , black carbon, total and solid particle number, and particle size distribution

Dilute sampling for particulate matter (PM) mass and speciation; volatile organic compounds (VOCs) including hydrocarbons (HCs), carbonyls, and alcohols; and raw sampling for ammonia ( $\text{NH}_3$ )

Bag mini-diluter sampling system for ultra-low vehicle emissions

Road-to-lab replication of real-world driving cycles

## Motorcycle Emissions Testing Services

2·Test cells:

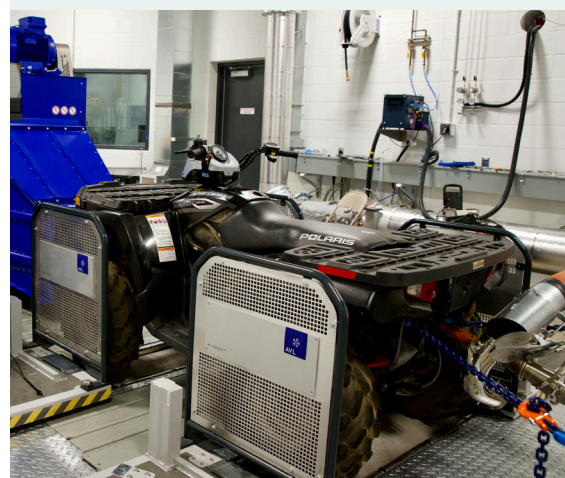
- 1·Research cell
- 1·Certification cell

Chassis dynamometers, equipped with road-speed fans, capable of testing 130-horsepower (hp) superbikes at 120 MPH

Bag sampling measurement of THC,  $\text{CH}_4$ , CO,  $\text{CO}_2$ ,  $\text{NO}_x$ , and  $\text{N}_2\text{O}$

Continuous dilute measurement of THC, CO,  $\text{CO}_2$ ,  $\text{NO}_x$ ,  $\text{N}_2\text{O}$ , black carbon, total and solid particle number, and particle size distribution

Sampling for PM mass, PM speciation and VOCs (HCs, carbonyls, and alcohols)







## Vehicle and Device Evaporative Emissions Testing Services

4 · Sealed housing for evaporative determination (SHED) enclosures:

- 1 · SHED sized for light-duty vehicles/motorcycles/  
small equipment
- 2 · SHEDs sized for medium-duty vehicles
- 1 · Running-loss SHED sized for medium-duty vehicle testing

Hot soak testing and single- to multi-day diurnal testing

Sampling for VOCs (HCs and alcohols)

Evaporative emissions testing of passenger cars, light- and medium-duty trucks, motorcycles, SOREs, watercraft, and portable fuel containers

Running loss evaporative emissions testing for passenger cars, light- and medium-duty trucks, and motorcycles



## Heavy-Duty Vehicle Emissions Testing Services

3 · Heavy-duty (HD) chassis dynamometers:

- HD I · Research test cell
- HD II · OBD/EV test cell
- HD III · Standard test cell

Each cell has a four-wheel drive dynamometer for testing heavy-duty vehicles from 14,000 to 100,000 lbs. inertia weight

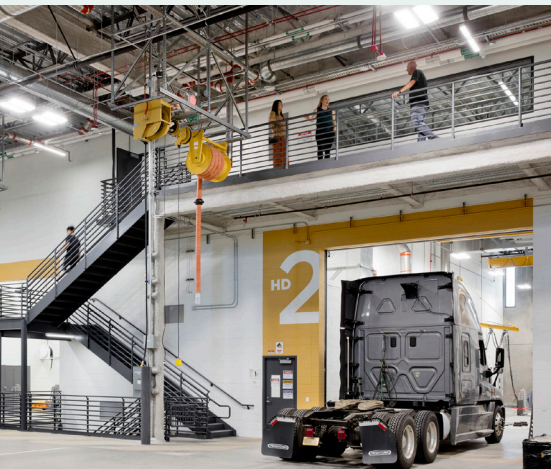
Bag and continuous sampling measurement of THC, CH<sub>4</sub>, CO, CO<sub>2</sub>, NO<sub>x</sub>, and N<sub>2</sub>O

Raw sampling capability (raw bench and Fourier transform infrared (FTIR) spectrometer) of THC, CH<sub>4</sub>, CO, CO<sub>2</sub>, NO<sub>x</sub>, NO<sub>2</sub>, NH<sub>3</sub>, N<sub>2</sub>O, aromatics, etc.

Sampling for PM mass, PM speciation and VOCs (HCs, carbonyls, and alcohols)

Real-time OBD acquisition in all test cells

Road-to-lab replication and advanced Not-to Exceed (NTE) testing software





## Heavy-Duty and Small Off-Road Engine Emissions Testing Services

3 State-of-the-art test cells for testing engines ranging from the smallest hand-held engines to large, on-road and off-road engines

SOREs: 1 test cell with 3 engine dynos

Heavy-duty engine (HDE) I: 1 100 to 400 hp HDE dyno

HDE II: 2 800 hp HDE dynos and summing gearbox

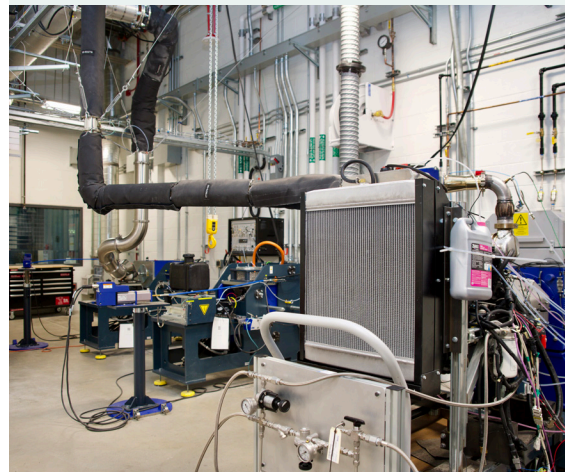
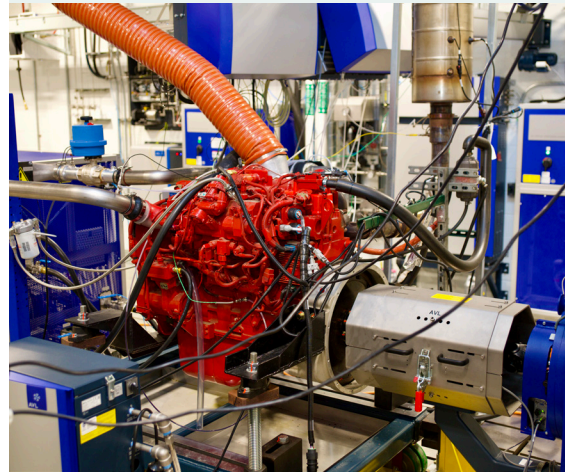
Greenhouse gas (GHG) Phase 2 testing with U.S. EPA Greenhouse Gas Emissions Model (GEM) simulation integrated into test cell automation software

Bag and continuous sampling measurement of THC, CH<sub>4</sub>, CO, CO<sub>2</sub>, NO<sub>x</sub> and N<sub>2</sub>O

Raw sampling capability in HDE I and HDE II (raw bench and FTIR) of THC, CH<sub>4</sub>, CO, CO<sub>2</sub>, NO<sub>x</sub>, NO<sub>2</sub>, NH<sub>3</sub>, N<sub>2</sub>O, aromatics, etc.

Sampling for PM mass, PM speciation and VOCs (HCs, carbonyls, and alcohols)

Real-time OBD acquisition in all test cells







## Testing Support Services

Data acquisition, process control support, and data storage are accomplished through the emissions lab's test automation system, the chemistry lab's information management system (LIMS), and the Vehicle Emission Database System (VEDS)

Capacity to house up to 30 vehicles for overnight preconditioning with canister preconditioning and EV charging

Fully equipped, 5-bay vehicle test preparation area used for inspections, diagnostics, test preparation, and repairs

Electronic and fabrication service using machining, tooling, 3D-printing process



## Portable Emissions Measurement Systems (PEMS) Testing Services

20 · Fully automated PEMS with real-time monitoring and control

14 · Light-duty and 4 heavy-duty testing slots with patch panels for gases

Sampling of tailpipe exhaust pollutants from various types of light- and heavy-duty, and off-road (locomotives, marine, construction, lawn and garden equipment, etc.) vehicles under real-world driving conditions

Measurement of gaseous emissions (NO, NO<sub>2</sub>, N<sub>2</sub>O, CO, CO<sub>2</sub>, THC, CH<sub>4</sub>, PM, NH<sub>3</sub>) and PM emissions

Measurement of exhaust flow and temperature, atmospheric conditions, altitude, global positioning system (GPS) for location and speed, fuel, wheel torque, and electrical power flow

Monitor engine parameters via link to engine electronic control module (ECM)

Tool for generating test routes and duplicating them in the test cell









# CHEMISTRY LABORATORY

The new Southern California Headquarters Laboratory chemistry laboratory includes state-of-the-art instrumentation and incorporates numerous features that will facilitate expanded analytical capabilities and enable development of new test methods, including:

- 3 Cleanrooms · 2 International Organization for Standardization (ISO) class 6 cleanrooms for PM and 1 ISO class 5 cleanroom for trace metals
- A separate laboratory to analyze GHGs and selected non-organic gases
- A hydrogen and alternative fuels lab, for analysis of highly flammable gas-phase samples

## Analysis of Motor Vehicle Aerosol Samples

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Determination of very low PM mass collected on filters

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Determination of the primary chemical composition of PM, including organic carbon and elemental carbon (OC/EC), anions and cations, and metals and elements.

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Determination of air toxics at parts per trillion (ppt) levels, including polynuclear aromatic hydrocarbons (PAHs), collected and speciated separately in semi-volatile and PM phases, and transition metals in PM

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Generation of aerosols of different sizes and chemical properties to verify the measurements of particle sizing and particle number instruments

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Specialized analyses, such as fingerprinting the molecular structure of ppt-level organic compounds and quantifying the markers emitted from brake wear





## Analysis of Transportation Fuels

Use of ASTM test methods for the determination of various fuel properties, including:

Sulfur, nitrogen, oxygenates, benzene and total aromatics, and olefins in gasoline

Carbon-hydrogen (C-H) ratio and Reid vapor pressure (RVP) of gasoline

Sulfur, nitrogen, and total aromatics and PAHs in diesel fuel

Red dye concentration in diesel fuels to identify off-road diesel

Distillation temperatures and density of petroleum products

Specialized analyses for other fuel properties, such as biodiesel content in diesel blends and hydrocarbon types in gasoline by multidimensional gas chromatography

## Analysis of Gas Phase Samples

Analysis of selected VOCs in vehicle exhaust and evaporative emissions using the California Non-Methane Organic Gas Test Procedures:

Speciated hydrocarbons, aldehyde and ketone compounds, and alcohols

Analysis of GHGs ( $N_2O$  and  $CH_4$ ) in vehicle exhaust emissions

Real-time analysis of ammonia and labile toxic VOCs from vehicle exhaust

Analysis of trace contaminants in purified gases (air and nitrogen):

$CO$ ,  $CO_2$ ,  $O_2$ ,  $N_2O$ ,  $NO_x$ , and  $CH_4$

## Emerging Capabilities

Quantification of trace (ppt) level organic compounds in non-exhaust PM

Determination of the organic compounds removed in the European Union Particle Measurement Programme (EU PMP) protocol

Characterization of physiochemical properties of particulate matter in the size range of 2.5-10  $\mu m$  emitted from non-motor vehicle exhaust sources

Determination of hydrocarbons in compressed natural gas/liquefied petroleum gas

Determination of carbon-14 in fuels

Determination of cetane number in diesel fuel

Determination of THC and speciated VOCs in hydrogen

Determination of hydrogen concentration in helium or nitrogen







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