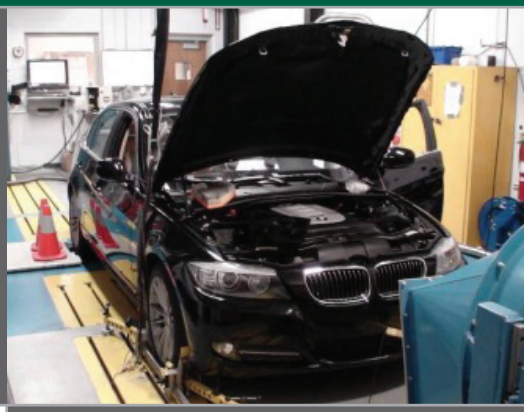
Oak Ridge National Laboratory at the
National Transportation Research Center

Vehicle Research

Fuels, Engines, & Emissions Research Center



The Fuels, Engines, and Emissions Research Center (FEERC) of Oak Ridge National Laboratory is a multidisciplinary facility in which experience, expertise and state-of-the-art instrumentation drive vehicle and powertrain research. The FEERC Vehicle Research Laboratory is well-equipped for analyses of catalyst, fuel, and hybrid electric system effects on performance.

Expertise

The overall FEERC team has been developed to encompass the many disciplines necessary for world-class fuels, engines, and emissions-related research, with experimental, analytical, and modeling capabilities. Staff members specialize in areas including combustion and thermodynamics, emissions measurements, analytical chemistry, catalysis, sensors and diagnostics, dynamometer cell operations, engine controls and control theory. FEERC engineers have many years experience in vehicle research, chassis laboratory development and operation, and have developed specialized systems and methods for vehicle R&D.

Selected Vehicle Research Topics

- In-use investigation of Lean NOx Traps (LNTs).
- Vehicle fuel economy features such as lean operation GDI engines, engine stop-start, smart alternators.
- Examination of PM from both stoichiometric and lean-burn GDI vehicles for gasoline and ethanol blends.
- Emissions and performance effects of intermediate ethanol blends and other bio-derived oxygenates and fuel additives.
- Engine mapping and system performance characterization in support of models such as PSAT and Autonomie.
- Catalyst function characterization and data collection in support of CLEERS.
- Effect of highway speed on fuel economy.
- Development and validation of driving tips. Quantifying fuel economy effects of maintenance and vehicle configurations such as dirty air intake filters, low tires, added luggage racks, etc.
- Analysis of vehicle energy use in support of the fueleconomy.gov website.
- Electric vehicle testing and characterization.
- Collection and analysis of IC engine exhaust gas condensate.
- Support of hybrid electric powertrain modeling and evaluation

Chassis Dynamometer

The FEERC Vehicle Research Laboratory is equipped with a Burke E. Porter 300 hp motor-in-the-middle, two-wheel drive, 48 inch, single roll AC motoring chassis dynamometer. The dynamometer meets the requirements of the U.S. EPA Specifications for Large Roll Chassis Dynamometers. The flexible driver's visual aid together with the control system facilitate performance of all standard Federal drive cycle tests, as well as European, Japanese or custom cycles. The laboratory has been cross checked against independent certification labs and results are in excellent agreement for fuel economy and vehicle emissions.

Distinguishing Capabilities

FEERC Laboratory & Equipment Highlights:

- Seven double-ended engine dynamometers up to 600 hp
- Four small engine test stands, including three dynamometers with 20-60 hp ratings.
- Vehicle chassis dynamometer
- Analytical chemistry laboratory
- Catalysis function laboratories
- Automated bench-top exhaust flow reactors and micro-reactors
- Access to electron microscopy

FEERC Expertise Highlights

- Emissions characterization and speciation, both gaseous and particle
- Non-linear dynamics and controls
- Engine controls
- Combustion
- Catalysis
- Fuels
- Emission control modeling
- Engine fundamentals and thermodynamics
- Electron microscopy

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Instrumentation and Equipment

The Vehicle Research Laboratory is further equipped with three dedicated emissions benches, each with conventional California Analytical Instruments gas analyzers. Two benches routinely measure raw emissions (e.g., engine-out and tailpipe emissions) and the third bench samples dilute exhaust from a constant volume sampling system (CVS, or dilution tunnel). The CVS is equipped with three critical flow venturis allowing several discrete flow rates ranging from 200 to 1050 cubic feet per minute. The CVS bag sampler is equipped with conventional analyzers (CO, CO2, NOx, THC) and has specialized systems in place to routinely measure PM, ethanol, aldehydes and HC speciation for hazardous air pollutants such as benzene, toluene, ethylbenzene, and xylene. Use of external fueling for vehicles, and heavily instrumenting them for temperatures, lambda, pressures etc. is routine. The laboratory temperature and humidity are regulated and measured. All continuous modal emissions data as well as additional sensors and vehicle controller network information can be acquired by an integrated data logger Data Acquisition System.

Specialized Particulate Matter Measurement & Characterization

FEERC employs several particle instruments including: a micro soot sensor and tapered element oscillating microbalance for mass concentration, an engine exhaust particle sizer and scanning mobility particle sizer for number-size distributions, a micro-orifice uniform deposit impactor for collection allowing composition study, and transmission electron microscopy for particle morphology. Standard filter methods are also employed. Solvent extractions using a microwave reactor and gas chromatography/mass spectrometry analysis are conducted for organic speciation of adsorbed hydrocarbons.

Special Measurements of Exhaust Chemistry, Catalyst Function, and Other Applications

FEERC operates several configurations of mass spectrometers and chromatographs as well as Fourier Transform Infrared Spectroscopy. Capillary electrophoresis has been used to analyze urea decomposition products. Exhaust volatile and semi-volatile constituent speciation can be performed. The SpaciMS, or "spatially resolved mass capillary input mass spectrometry," is an example of a diagnostic tool developed by FEERC staff that has provided extraordinary insights for numerous engine systems and catalyst devices. This tool enables spatial and temporal resolution of species in functioning environments such as catalyst channels, engine intake/exhaust runners, and fuel cells. It is complemented by fiber-optic based phosphor thermometry, allowing simultaneous species and temperature measurements in catalyst channels.

Partnerships and Collaborations

Like the FEERC team in general, the Vehicle Research Laboratory is engaged in both industry and government research on fuels, engines and emissions technologies. FEERC is designated a DOE National User Facility, which encompasses the Vehicle Research Laboratory. Although the majority of research efforts directly support the DOE mission, R&D is carried out for and with OEMs and other private or non-private partners. This includes research directly funded by private industry, cooperative research and development agreements (CRADAs) and other cooperative partnering.

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Selected Publications

J. M. Storey, "Exhaust Particle Characterization for Lean and Stoichiometric DI Vehicles Operating on Ethanol-Gasoline Blends," DRAFT SAE paper 2012-01-0437, April 2012.

J. F. Thomas et al., "Fuel Economy and Emissions of a Vehicle Equipped with an Aftermarket Flexible-Fuel Conversion Kit," ORNL/TM-2011/483, 2012.

P. Chambon, et al. "European Lean Gasoline Direct Injection Vehicle Benchmark," SAE 2011 World Congress, Detroit, Michigan, SAE paper 2011-01-1218, April 2011.

B. H. West et al., "Intermediate Ethanol Blends Catalyst Durability Program," ORNL/TM-2011/234, 2012.

J. E. Parks, et al., "Lean Gasoline Engine Reductant Chemistry During Lean NOx Trap Regeneration," 2010 SAE Powertrains, Fuels and Lubricants Meeting, SAE paper 2010-01-2267. October, 2010.

K. E. Knoll et al., "Effects of Mid-Level Ethanol Blends on Conventional Vehicle Emissions," ORNL/TM-2008/117, NREL/TP-540-43543, February, 2009.

B. H. West, et al., "Fuel Economy and Emissions of the Ethanol-Optimized Saab 9-5 BioPower," SAE Paper number 2007-01-3994, October 2007.

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