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ABSTRACT BOOK
USING PARTNERSHIPS TO GATHER REAL-WORLD VEHICLE ACTIVITY AND EMISSIONS TO SUPPORT EPA’S MODELING EFFORTS

Carl Fulper, fulper.carlr@epa.gov

U.S. EPA, Office of Transportation and Air Quality, Assessment and Standards Division, Data and Testing Center, 2000 Traverwood Drive, Ann Arbor, MI 48105

The U.S. Environmental Protection Agency (EPA), through both Interagency Agreements (IAGs) and multiple Cooperative Research and Development Agreements (CRADAs), has been developing new sampling methodologies and new tools to improve efforts for gathering data on mobile sources (light-duty, heavy-duty on-highway vehicles and nonroad).

This presentation will provide an overall view of these partnerships, the advancements in multiple tools and data analysis methods. It will present some emerging data sources that EPA and its partners are presently gathering and analyzing. It will also present an overview on some of EPA’s future research needs.

A Look Forward: CA Heavy Duty Regulatory Plans and PEMS Implications

William Robertson

California is facing stringent and aggressive GHG and NOx reduction goals. Plans are underway to develop the next round of GHG and NOx requirements to continue the path to meeting these climate change and ambient air quality standards. ARB regulatory plans for the Heavy Duty sector include efforts toward a Lower In-Use Performance Level, a Low NOx Engine Standard, alignment with the Federal Heavy Duty Phase 2 GHG regulation, flexibilities for technology introduction, and promotion of early advanced technology penetration into select applications including transit and last mile delivery. Implications for the role of PEMS measurement and the direction of challenges to come will be discussed.
Surface Coatings on High-Voltage Electrodes of Electrostatic Particulate Matter (PM) Sensors

M. Boettcher, J. Fitzpatrick, B. Henderson, and L. Woo1
CoorsTek Sensors

B. Beckert, M. Beckert, K. Copenhaver, K. Ledford, and J. Nadler
Georgia Tech Research Institute (GTRI)

D. Bilby, M. Maricq, and J. Visser
Ford Motor Company

Particulate matter (PM) or soot sensing technologies are needed for feedback and control of exhaust after-treatment systems to meet increasingly stringent environmental regulations. Most commercial reference instruments for PM detection are not able to directly measure the high concentrations in typical exhaust. Instead, a representative exhaust sample is drawn and diluted. In-situ sensor technologies that directly measure exhaust and could meet the more stringent on-board diagnostic (OBD) requirements for self-diagnosis and reporting in automotive applications are typically based on either resistive techniques that detect soot accumulation or electrostatic methods that determine real-time particle concentrations.

A novel low-cost electrostatic PM sensing approach has been developed based on a concentric electrode design with a central cylindrical high-voltage electrode surrounded by an inner baffle that serves as the ground/negative terminal. The sensing principle is not completely understood, but seems to rely on capturing naturally charged combustion particles on electrode surfaces where a delay in sensor startup time occurs during initial operation. We present work investigating the influence of surface coatings on PM sensor performance.

Previous work indicated that dendritic Rh and Ni-Co coatings deposited onto the high-voltage electrodes of electrostatic PM sensors could potentially reduce the delay in startup time compared to bare control electrodes. However, morphological characterization did not provide clear indications of an underlying mechanism for altering the PM sensor performance. We present work with sol-gel and porous iron foam coatings that also seem capable of reducing the measured delay in startup time. Sol-gel coatings produced nanostructured surfaces that were robust to ultrasonication and cleaning; however, horizontal shrinkage was difficult to control leading to partial coverage of electrodes. Iron foam coatings were synthesized from iron powder and polymethyl methacrylate (PMMA) beads (spherical voids) solvated in molten polyethylene glycol (PEG) to again produce samples that were robust, but with better coverage due to less horizontal shrinkage.

1 Presenter
Sensor-Based Particulate Measurement: Some Tall Tales from the Trenches
Karl Ropkins k.ropkins@its.leeds.ac.uk; Andrew Burnette andrew.burnette@infowedge.com; David W. Miller davidmiller@3datx.com.

Current evidence indicates that a relatively small number of vehicles are responsible for the majority of excess in-use emissions, e.g. about 10% of the Diesel Particulate Filter (DPF) equipped vehicles are believed to contribute about 70% of excess particulate matter (PM) emissions. But conventional I/M measurements (snap-acceleration opacity) and other similar ‘stop-and-test’ procedures are not sensitive enough to measure the difference between a properly functioning and a moderately malfunctioning DPF system, and can even be cross-sensitive to the by-products of some modern emission control systems, e.g. NO₂ from Selective Catalytic Reduction.

As a result, one of the key elements of a more effective next-generation emissions ‘stop-and-test’ procedure for modern vehicles would be a new ‘SMOG Check’ system.

Here, using provisional data for several recent and on-going studies, we propose a sensor-array strategy based on the 3DATx parSYNC as an alternative to simply replacing one metric (opacity) with another. We present data on the effectiveness of this approach, and describe options to address cross-sensitivity. We also consider the analytical compromises required to build an instrument suitable for use in a commercial garage at a price-point that will make it viable, as well as the extended diagnostic capabilities of a multi-dimensional description of vehicle particulate emissions.

Improved PN measurement with PPS-M using dynamic trap switching
E. Saukko1, N. Kuittinen2, P. Karjalainen2, T. Rönkkö2, J. Keskinen2 and K. Janka1

1Pegasor Oy, Hatanpään Valtatie 34 C, Tampere, Finland
2Aerosol Physics Unit, Laboratory of Physics, Tampere University of Technology, Tampere, Finland

Keywords: PEMS, PPS-M, PN

Using two PPS-M sensors (Rostedt et al., 2014) at different response modes can be used to extract much useful information of the sampled exhaust in engine emission measurements, as shown by Amanatidis et al. (2016). This Dual PPS-M approach was used to extract particle size information and thus expanding the capability the PPS-M sensor.

In this work we present an advanced approach, first using dynamic trap setting to expand and improve the particle size information ability, and second, a time-multiplexed trap switching to achieve the Dual PPS-M functionality with a single PPS-M unit. The improved particle size information and simplified structure come at a cost of reduced temporal resolution.

The new operating mode can be used to improve the PN and PM response in emission measurements.
**System Integration of Novel NOx Sensors for Emissions Monitoring**


CoorsTek Sensors

R.F. Novak and J.H. Visser
Ford Motor Company

NOx sensors for automotive applications are being deployed, but there remain limited commercial options. Available NOx sensors are also much more expensive than their oxygen sensor counterparts, in part due to both a complicated multiple-cell design as well as the requirement for electronics that can measure low-current nanoampere signals. Therefore, a NOx sensor technology alternative that could reduce cost while meeting sensor performance requirements is greatly desired for automotive and other combustion applications.

We previously demonstrated ceramic solid-state electrochemical sensors using a novel alternating current (ac) method as opposed to the direct current (dc) methods used in commercial NOx and oxygen sensors. Our NOx sensors consist of a simple single-cell design with two electrodes separated by yttria-stabilized zirconia (YSZ) electrolyte, where both electrodes are exposed to the test gas and impedance behavior measured at pre-determined frequencies demonstrated fast, stable, reproducible responses to varying concentrations of NOx down to single part-per-million (ppm) concentrations. Previously, we also demonstrated a low-cost portable signal processing method using a digital voltage-current time differential method as well as advances in materials processing that allowed for a single-step high-temperature (1450°C) co-fire of the active sensor components, including lower melting temperature electrodes such as gold, along with an alumina substrate element that has embedded platinum resistive heaters.

We present recent system integration activities including sensor packaging and heater development and control for deploying in real-world vehicle exhaust environments. We will also discuss fabrication challenges including sensor-to-sensor reproducibility and moving towards designs more suitable for mass manufacturing.

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2 Presenter
Development of Compact Multi Gas Measurement System (NCEM©)

Takeshi Tange
NGK SPARK PLUG CO., LTD.
14-18 Takatsuji, Nagoya-shi, Aichi 467-8525, Japan

Air pollution is a serious global challenge and vehicle emission regulations continue to become increasingly stringent. With more and more focus being placed on real world emissions, some weaknesses of existing PEMS (Portable Emissions Measurement Systems), such as their complexity, weight, size, and power consumption are increasingly apparent. Therefore, we have developed a highly portable measurement system named NCEM which can complement high-accuracy PEMS. It allows easy measurement of PM, PN, NOx, and O2.

We previously confirmed that NCEM has good accuracy and repeatability compared to reference analyzers and PEMS in the case of high emission concentrations on a chassis dynamometer. This time we evaluated the performance of NCEM under real world driving conditions, and found the NOx measurement performance was very similar to current PEMS. In addition to that, we confirmed that NCEM could detect soot concentrations lower than the regulatory limits on chassis dynamometer tests.

From these results, we expect that NCEM has the potential to be a valuable screening tool.
Real-world Versus Certification Emission Rates for Light Duty Gasoline Vehicles

H. Christopher Frey
Tanzila Khan

Department of Civil, Construction, and Environmental Engineering
North Carolina State University
Campus Box 7908, Raleigh, NC 27695-7908

U.S. light duty vehicles are subject to the U.S. Environmental Protection Agency (EPA) emission standards. Emission compliance is determined by certification tests of representative vehicles for regulatory driving cycles and pollutants using chassis dynamometer measurements. The dynamometer based emission rates are adjusted to provide certification levels (CL), which must be lower than the standards for compliance. While the regulatory cycles are based on specific observations of real-world driving, and collectively cover a wide range of engine load, they are not necessarily representative of the on-road operation of a given vehicle. The purpose of this work is to assess the concordance of the CLs versus the real-world emission rates, and of the emission standards versus the real-world emission rates, for light duty gasoline vehicles (LDGV). The sensitivity of the comparisons was assessed based on three certification test factors: (a) cold start, (b) air-conditioning usage, and (c) certification useful life of vehicles.

Portable Emission Measurement Systems (PEMS) were used to measure hot stabilized exhaust emissions of 122 LDGVs on a specified 110 mile test route. Cold start emissions were measured with PEMS for a selected sample of 32 vehicles. Emissions were measured for carbon dioxide (CO₂), carbon monoxide (CO), hydrocarbons (HC) and nitrogen oxides (NOₓ). For each measured vehicle, a modal emission rate model was developed based on the Vehicle Specific Power (VSP). The VSP modal rates were weighted by the standard driving cycles and real-world driving cycles to estimate the respective cycle average emission rates (CAER). Measured vehicles were matched with the certification test vehicles for the comparison. For systematic trends in comparison, vehicles were classified into four groups based on Tier 1 and Tier 2 emission regulations, and vehicle type including passenger car and passenger truck.

Depending on the cycle-pollutant and the vehicle groups, the CLs are on average either significantly lower than or statistically the same as the CAERS. Compared to the CAERS, the emission standards are on average significantly higher or statistically the same, depending on the cycle-pollutant, vehicle group, and inclusion of cold start emissions in the CAERS. The CLs and thus the regulatory driving cycles and dynamometer measurements tend to underestimate the real-world emission rates. Therefore, emission inventories based on certification test results are potentially underestimated. The implications of certification tests with respect to real driving emissions are discussed.
PEMS measurements of particle number and mass emissions from loaders using conventional and renewable diesel fuels

P. Karjalainen1, A. Järvinen1, H. Wihersaari1, J. Nuottimäki2, M. Kytö3, J. Keskinen1, T. Rönkkö1
1Tampere University of Technology, Faculty of Natural Sciences, Aerosol Physics, Tampere, Finland
2Neste Oyj, Porvoo, Finland
3VTT Technical Research Centre of Finland Ltd, Espoo, Finland

Diesel powered loaders are used for maintenance purposes in residential, industrial and commercial areas. Because these machines are operated in close proximity to people, their emissions can contribute to non-wanted health effects. We studied nanoparticle emissions from two different loaders (Wille 355b and 855c, Vilakone Oy, Finland), both of emission level Stage 3A, in case of EN590 B7 (diesel containing 7 % fatty acid methyl esters) and renewable hydrogen threated vegetable oil (HVO, Neste MY Renewable Diesel) based diesel fuels under real working conditions. The main focus was to study the effect of renewable fuel on the particle emissions of loaders.

Measurements were conducted using Portable Emission Measurement System (PEMS, Järvinen et al 2015), which works as a platform for laboratory grade instruments. Two stage ejector dilution was used to extract the sample from the exhaust pipe. The first dilution stage was heated to 140 °C and the second stage was operated at outdoor temperature, approximately 15 °C. The total dilution ratio was approximately 150, primary being 9 and secondary 17. The PEMS and the measuring instruments were installed into a trailer towed by the machine. Particle number concentration was measured by a Condensation Particle Counter (CPC A20, Airmodus Oy) with the cut-point of 7 nm and the particle size distribution by an Engine Exhaust Particle Sizer (EEPS 3090, TSI Inc.) in the size range of 5.6-560 nm. Exhaust particle mass concentrations were evaluated based on particle number size distributions.

The measurement cycle was chosen to simulate average use of these machines. It consisted of idle, loading, towing the trailer at a constant speed, and towing the trailer and a blasting carpet at a constant speed to simulate plowing of snow. These two driving stages were conducted twice during the measurement cycle and the entire cycle was measured twice for each loader and fuel combination.

In general, the exhaust particle concentrations reduced when the fuel was changed from EN590 B7 to HVO. In case of the larger 855c model, the particle number concentrations did not change significantly when the fuel was switched, but the mass concentrations reduced by 20% to 25%, when the HVO was used. In case of the smaller 355b machine, the particle number concentrations reduced from 10% to 40% by HVO, except in case of loading where higher number concentrations were observed. The mass concentrations reduced by 20% to 70% in all cases, when the fuel was changed to HVO. This is easily seen in the Fig. 1, which represents one measurement cycle for smaller 355b machine operating on both fuels. In general, the decreasing mass concentrations resulted from decrease in particle size, and in case of 355b, also from decrease of particle number concentration. For instance under high load driving, the mode of the particle diameter was approximately at 50 nm for EN590 B7 but only at 35 nm for HVO.
Evaluation of THE CO2 Emission impactS OF USING vehicle speed limiters (VSL) on CLASS 8 heavy-duty ON-ROAD trucks

Phuong Ho, Phuong.ho@arb.ca.gov; Donald J. Chernich, don.chernich@arb.ca.gov; Wayne Sobieralski, wayne.sobieralski@arb.ca.gov; David C. Quiros, david.quiros@arb.ca.gov

Vehicle speed limiters (VSL) are a proposed strategy for reducing greenhouse gas emissions (GHG) by limiting top vehicle speeds on heavy-duty over-the-road trucks. In the Federal Phase 2 GHG Emissions and Fuel Efficiency Standards for Medium- and Heavy-duty Engines and Vehicles, the Greenhouse Gas Emissions Model (GEM) includes emissions reductions credits for vehicles with tamper-proof VSLs set at 55 to 65 miles per hour (mph). This study serves to evaluate the applicability and emissions impacts of VSLs on Class 8 vehicles at highway speed.

During the fall of 2016, California Air Resources Board (ARB) conducted over-the-road testing at various freeway speeds of a Class 8 truck having a combine vehicle weight of 34,880 pound and equipped with low rolling resistance tires on both the tractor and trailer. Testing was conducted in Fernley, Nevada on a 15-mile stretch of Interstate 80. The section of road was chosen because of its nearly flat elevation profile and because higher freeway speeds are allowed. During three days of testing, 12 coast downs tests were performed followed by 30 constant speed runs at speeds ranging from 48 to 84 mph. During each test run, the truck’s exhaust emissions were measured and recorded using a Sensors Semtech DS portable emissions measurement system (PEMS). Measured CO2 emission rates were highly dependent on vehicle speed and engine speed. Testing indicated an emissions “sweet spot” around 58 mph with a corresponding CO2 emission rate of 964 grams per mile (g/mile). CO2 emission rates decreased from 1005 g/mile at 48 mph to 964 g/mile at 58 mph then increased from 964 g/mile at 58 mph to over 1800 g/mile at 84 mph. Additional testing is planned in the spring of 2017 with two additional truck configurations.

The Development of PEMS and Other Methods for In-Use Monitoring
Yoann Bernard

Post-Dieselgate governments’ testing campaign in Europe and defeat-device screening techniques

In 2013, the ICCT conducted testing on three diesel cars sold in the US market. Even though US-standards are among the most stringent globally, two of these cars – a VW Passat and a Jetta - were found to emit 5 to 35 times the Nitrogen-oxides (NOx) limit on-road, even during routine driving. The Environmental Protection Agency (EPA) and the California Air Resources Board (CARB) then started a long investigation that eventually lead VW to admitting to the use of an illegal defeat device that sensed the when the car was being tested and altered the effectiveness of the emissions control system accordingly. VW also admitted to using similar strategies on 8 Millions vehicles sold in Europe.

Following VW’s admission, several member states of the European Union, including the UK, France, Germany, and The Netherlands initiated their own investigations focused not only on VW but on the entire diesel car fleet. Tests were conducted using a combination of
dynamometer and on-road testing. The test protocols varied, but in general they were designed with the purpose of finding suspicious emissions control behavior. In parallel, The ICCT has been conducting our own research with the purpose of developing a methodology to, as conclusively as possible, prove the existence of a defeat device test through vehicle testing. The methodology focuses not only on the testing of individual vehicles, but on techniques for screening the fleet to select vehicles for testing with the highest probability of having a defeat device.

This presentation will provide an overview and critique of the different member states’ testing campaigns and, in addition provide preliminary findings on the ICCT’s research aimed at developing a methodology to screen and test for defeat devices.

**ESTIMATING EMISSION RATES FOR A RETROFITTED SCR-BASED EMISSION CONTROL SYSTEM USING PEMS BASED MEASUREMENTS**

*Nikhil Rastogi; H. Christopher Frey*

Department of Civil, Construction, and Environmental Engineering
North Carolina State University, Campus Box 7908, Raleigh
NC 27695-7908, United States
Tel: 919-515-1155 Email: frey@ncsu.edu

A method is demonstrated to estimate in-use fuel use and emission rates (FUER) for a diesel electric locomotive retrofitted with Selective Catalytic Reduction (SCR) emission control system based on measurements with a Portable Emission Measurement System (PEMS). In-use measurements enable quantification of real-world FUER based on actual duty cycles, including the effect of transients in engine load. Space considerations restrict the use of highly sophisticated emission measurement systems onboard, thus, making PEMS a preferred instrument for in-use testing.

The locomotive has two engines: prime mover engine (PME) for traction and head end power engine (HEP) for hotel services. The SCR treats the combined exhaust from both engines. After retrofitting, the locomotive underwent a rail yard static load testing using a Global MRV Axion PEMS. Simultaneously, compliance measurements were made by Engine Fuel and Emissions Engineering (EF&EE) using the Ride-Along Vehicle Emission Measurement systems (RAVEM). The RAVEM system is a CFR Title 40 Part 1065 compliant instrument for measuring carbon dioxide (CO₂), carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOₓ) and particulate matter (PM).

This paper demonstrates a method to estimate in-use FUER based on exhaust flow from each engine based on the use of PEMS. Results based on PEMS have been benchmarked to results from the RAVEM. The method relies on measurement of PME intake air temperature, manifold absolute pressure, and revolutions per minute simultaneously with measurement of exhaust gas concentrations using PEMS. Engine air flow rate is estimated using the “speed-density” method in which volumetric efficiency is calibrated based on prior engine dynamometer tests of the prime mover. In prior work, HEP engine fuel use rates were recorded using a scantool and have been calibrated to engine load. The effect of the reactions occurring in the SCR system on exhaust CO₂ and NOₓ concentrations are quantified. The results based on PEMS data are...
comparable to those based on the RAVEM and are useful for benchmarking and evaluation of locomotive emissions. The demonstrated method will be applied to over-the-rail measurements of the retrofitted emission control system.

**DATA PROCESSING, ANALYSIS, AND DATABASING OF HEAVY-DUTY ACTIVITY STUDY RESULTS**

Carl Fulper

U.S. EPA, Office of Transportation and Air Quality, 2000 Traverwood Drive, Ann Arbor, MI 48105

fulper.carlr@epa.gov,

Michael Sabisch, Doug Jackson, Sandeep Kishan

Eastern Research Group (ERG), 3508 Far West Blvd, Suite 210, Austin, TX 78731

michael.sabisch@erg.com, doug.jackson@erg.com, sandeep.kishan@erg.com,

Kent Johnson, Thomas Durbin, Kanok Boriboonsomsin, George Scora, Daniel Sandez

University of California, CE-CERT, Riverside, CA

kjohnson@cert.ucr.edu, durbin@cert.ucr.edu, kanok@cert.ucr.edu, gscora@cert.ucr.edu, dsandez@cert.ucr.edu,

The U.S. Environmental Protection Agency (EPA), along with its contractor ERG, and through a Cooperative Research and Development Agreement (CRADA) with the University of California at Riverside, has been processing, analyzing, and databasing results from a heavy-duty vehicle study conducted by CE-CERT. Approximately 170 parameters were collected from 100 local-service heavy-duty vehicles over a one to three-month period each. This presentation describes approaches for reviewing the data to identify suspect results, flagging the results while preserving the original data, methods for processing the data and working with the entire dataset in a database format, and analyzing the data in order to characterize truck activity in terms of MOVES inputs (starts, soaks, and VMT distributions).

**FINDING “NORMAL” AND ‘HIGH EMITTING” EMISSIONS: EXPLORING NEW EMERGING SCREENING TOOLS AND METHODOLOGIES FOR GATHERING REAL-WORLD VEHICLE DATA**

Carl Fulper

U.S. EPA, Office of Transportation and Air Quality, Assessment and Standards Division, Data and Testing Center, 2000 Traverwood Drive, Ann Arbor, MI 48105

fulper.carlr@epa.gov

The U.S. Environmental Protection Agency (EPA) will explore how new emerging tools (equipment) and data analyses could be used to better understand how mobile sources are operating in the real-world. Major advancements in equipment that are not compliant with 40 CFR 1065 requirements (screening tools, mini-Portable Emission Measurement Systems, Portable Activity Monitoring Systems, etc.) will be explored that could be used to find “normal” and “high emitting” vehicles. This
presentation will also provide sampling methodologies and data analysis methods to conduct better screenings of the “normal” and “high” emissions from mobile sources.

**SOME OBSERVATIONS BASED ON COMPLEMENTARY international EvaluationS of EDAR Vehicle Emissions Remote Sensing Technology**

Karl Ropkins k.ropkins@its.leeds.ac.uk; Timothy H. DeFries Tim.DeFries@erg.com; Francis Pope f.pope@bham.ac.uk; David C. Green david.c.green@kcl.ac.uk; Jim Kemper jim.kemper@state.co.us; Sandeep Kishan sandeep.kishan@erg.com; Gary W. Fuller gary.fuller@kcl.ac.uk; Hu Li fuehli@leeds.ac.uk.; Jim Sidebottom jim@heatrsd.com; J. Stewart Hager stewart@heatrsd.com.

Here we report findings from two complementary blind evaluations of the vehicle emissions measurement capabilities of the EDAR remote sensing system.

The first study, by Colorado Department of Public Health and Environment and Eastern Research Group, was a simulated exhaust gas test that used conventional remote system auditing methods to investigate the accuracy of the EDAR. The EDAR measured CO, NO, CH₄ and C₃H₈ concentrations with high linearity, low bias, and low drift over a wide range of concentrations and vehicle speeds. Instrument accuracy was high (R² 0.996 for CO, 0.998 for NO; 0.983 for CH₄; and, 0.952 or better for C₃H₈) and detection limits are low (50-100 ppm for CO; 10-30 ppm for NO; 15-35 ppmC for CH₄; and, 100-400 ppmC₃ for C₃H₈).

The second study, by the Universities of Birmingham and Leeds and King’s College London, used the comparison of EDAR, PEMS and car chaser system measurements collected under real-world conditions to provide a measure of *in-situ* EDAR performance. Given the analytical challenges associated with aligning these very different measurements, the observed degrees of agreement (e.g. EDAR versus PEMS R² 0.924 for CO/CO₂; 0.969 for NO/CO₂; 0.826 for NO₂/CO₂; and early observations on PM measurement and car chaser experiments) were all highly encouraging and demonstrate that EDAR also provides a representative measure of vehicle emissions under real-world conditions.

**Potential Applications of mini-PEMS and Remote Sensing Devices for Heavy-Duty Inspection and Maintenance Programs**

Thomas D. Durbin, Yu Jiang, Kent C. Johnson, Georgios Karavalakis, Jiacheng Yang, Wayne Miller, Mark Carlock, Nigel Clark, David McKain, Hector Maldonado, and John Collins.

On-road heavy-duty (HD) vehicles represent one of the most important sources of emissions in urban areas. Although HD engines production engines are now equipped with advanced aftertreatment for the control of both nitrogen oxides (NOx) and particulate matter (PM) emissions, there is increasing interest in developing more comprehensive HD Inspection and Maintenance (I/M) program to ensure that the engines maintain these low emission levels throughout their useful life. A number of methodologies could be implemented into a HD I/M program, including On-Board Diagnostics (OBD), mini-portable emissions measurement systems [PEMS], remote sensing devices (RSD), tent systems, such as the On-road Heavy-duty vehicle emissions Monitoring System [OHMS], or chassis dynamometer emissions testing.
California is currently in the process of evaluating different alternatives for a more comprehensive HD I/M program. As part of this process the University of California at Riverside, in conjunction with the ARB, is conducting an exploratory pilot study to assess alternatives for an augmented HD I/M program that could be implemented in California. The exploratory pilot program will consist of testing 50 vehicles before and after repair on a chassis dynamometer. The 50 vehicles will be procured from one or more local repair facilities based on the need for emissions related repairs. I/M grade emissions analyzers will be used to evaluate the emissions benefits from various repairs based on a comparison of the before and after emissions measurements. For vehicles so equipped, the OBD system will be monitored before and after the repair to evaluate the effectiveness of the OBD in identifying emissions related issues and what benefits are obtained from OBD based repairs. Additionally, a remote sensing device (RSD) and a number of mini-PEMS systems will be evaluated in conjunction with the chassis dynamometer emissions measurements to evaluate their potential to be utilized in an I/M program to identify high emitters. The data from this exploratory pilot study will be used to evaluate the potential benefits and effectiveness of different I/M methodologies in more extensive models.

Heavy-Duty Diesel Inspection and Maintenance pilot – phase 2

Jeremy, Johnson, j-johnson@tti.tamu.edu, Josias, Zietsman, j-zietsman@tti.tamu.edu; Reza, Farzaneh, r-farzaneh@tti.tamu.edu; ; Tara, Ramani, t-ramani@tti.tamu.edu;

The Texas A&M Transportation Institute (TTI) completed a project titled Heavy-Duty Diesel Inspection and Maintenance Pilot Program for the North Central Texas Council of Governments (NCTCOG) and the Texas Department of Transportation (TxDOT). This study included pilot testing of a new technology, the OHMS (On-road Heavy-duty emissions Measurement System), which was also previously termed as the SHED (Streamlined Heavy-Duty Emission Determination) system, to assess its applicability to a potential heavy-duty diesel vehicle inspection and maintenance (I&M) program. The findings from this initial pilot indicated that the OHMS could be a viable option for an I&M program. However, it was also determined that further refinements to the system design were needed, along with additional field testing, to enable broad deployment of the system in the future. These activities were conducted through a second phase of the pilot project.

There were two main objectives for this Phase 2 study. The first objective was to refine and further test the OHMS design for enhanced measurement capabilities. The second objective was to deploy the improved design at a selected location through a field test, where real-world data would be collected.

As a first step, potential modifications to the design of the system were investigated, to enable optimal performance of the OHMS setup. Different shed designs were tested, validated against portable

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Information is available at:

http://www.nctcog.org/trans/air/hevp/DieselIM/
emissions measurement system (PEMS). Testing was conducted at the RELLIS campus of Texas A&M Transportation Institute. Design modifications included the location of the sampling tube and the duration of the sampling period in which the exhaust was monitored. The tests used a single test truck running through the shed over multiple days for validation.

After completing the initial testing, an optimally-designed OHMS setup was deployed for a field test. The system was setup for a two-week test at the same weigh station used for the Phase 1 pilot. The weigh station is located on northbound I-45 in New Waverly Texas, which is between Dallas and Houston, two major sources of truck traffic on I-45. Over the two-week period over 900 trucks passed through the shed.

The results of the test showed that, as with the previous OHMS installations, the technology is a viable option for a potential heavy duty I/M program. The OHMS technology is best suited as a screening tool for finding the high-emitters in the fleet. When strategically placed along areas of high truck traffic the system can be used to monitor the fleet, effectively identify the high emitters, and not force trucks to be pulled out of service for I/M testing.

**EVALUATION OF THE HEAT’s ON-ROAD INFRARED LASER RSD FOR EXHAUST EMISSIONS MEASUREMENTS**

**Tim DeFries, Sandeep Kishan**  
Eastern Research Group (ERG), 3508 Far West Blvd, Suite 210, Austin, TX 78731  
tim.defries@erg.com, sandeep.kishan@erg.com

**Carl Fulper**  
U.S. EPA, Office of Transportation and Air Quality, 2000 Traverwood Drive, Ann Arbor, MI 48105  
fulper.carlr@epa.gov

**Jim Kemper, Jim Sidebottom**  
Colorado Department of Public Health and Environment (CDPHE), 4300 Cherry Creek Drive South Denver, CO 80246  
jim.kemper@state.co.us, jamessidebo@gmail.com

During the last few years Hager Environmental and Atmospheric Technologies (HEAT) has developed a new remote sensing device (RSD) technology, which is called Emissions Detection And Reporting (EDAR), for measuring the instantaneous emissions of on-road vehicles. The technology is based on absorption measurements using infrared laser light, which distinguishes it from existing RSD technologies based on non-dispersive infrared and ultraviolet absorption of non-laser light sources.

While HEAT has performed in-house measurements to validate the performance of EDAR, no independent blind evaluations of EDAR by outside vehicle emissions laboratories had been made as of the beginning of 2015. EPA, CDPHE, and ERG participated in designing and conducting a detailed evaluation of the technology.
Evaluation tests were conducted at the Bandimere Speedway, Colorado on September 14 and 15, 2015. The accuracy, precision, limit of detection, and drift of the current EDAR instrument for measurement of exhaust CH₄, non-methane hydrocarbon, CO, and NO emissions will be presented.