



AGENDA

20th CRC ON-ROAD VEHICLE EMISSIONS WORKSHOP

Co-Sponsored by

California Air Resources Board
National Renewable Energy Laboratory
South Coast Air Quality Management District
US Environmental Protection Agency NRMRL
US Environmental Protection Agency OTAQ

Workshop Organizers

Mani Natarajan, Co-Chairman, Marathon Oil Company
Dominic DiCicco, Co-Chairman, Ford Motor Company
Alberto Ayala, California Air Resources Board
Brent Bailey, Coordinating Research Council
Richard Baldauf, US Environmental Protection Agency NRMRL
Kevin Black, Federal Highway Administration
Rob R. Graze, Jr., Caterpillar, Inc. Technical Center
John Koupal, US Environmental Protection Agency OTAQ
Fred Minassian, South Coast Air Quality Management District
Chris Tennant, Coordinating Research Council

Hyatt Regency Mission Bay, San Diego, California
March 22-24, 2010

This twentieth
CRC On-Road Vehicle Emissions Workshop
is dedicated to the memory of
our good friend and valued colleague,
Bob Gorse.



"I had the pleasure of interacting with Bob as I was beginning my career as a young assistant professor at West Virginia. Bob's insights and wisdom came through clearly in every discussion. When he spoke, I listened and paid close attention. I knew I would learn something important. What a loss indeed!"

--Alberto Ayala

I am pleased to hear that CRC is honoring Bob Gorse at this Workshop. Bob made significant contributions to the Workshop each year until his retirement from Ford. He was involved in the organization and execution of each of them. The best part was that it was a joyous occasion that Bob looked forward to each year. There was always an evening that a group would gather and go out to dinner with Bob's dad and brother who lived in San Diego. What a time we had eating, drinking and laughing.

Some nights, Bob would stay up late analyzing data until the early hours of the morning. He loved discussing the critical mobile source issues that there was no agreement on. He was one who truly had the CRC spirit.

It was a sad day when we all said goodbye to Bob. The church was packed to capacity and what was so wonderful was the outpouring of love from those that Bob had helped in his charitable endeavors. Bob was not only an excellent scientist but he remembered those that were not so fortunate. He was a wonderful friend that I will never forget.

-- **Tim Belian**



"I was tasked with the mighty and tall order of filling the shoes of Dr. Robert A. Gorse as he planned to depart Ford Motor Company for his next journey. Bob introduced me to Auto/Oil, CRC, ARB, EPA, all of his contacts, and the countless other internal/external activities - it was quite overwhelming. However, his personality, guidance and willingness to teach prepared me well for what lie ahead; I can only hope that he is looking down from above with a smile rather than laughter... God Bless You Bob!"

-- **Dominic DiCicco**

BAYVIEW BALLROOM

7:30 AM Registration in Bayview Ballroom Foyer

*Continental Breakfast in Pavilion*8:30 AM *Welcome from the Chairman: Mani Natarajan, Marathon Oil Company***SESSION 1: Historical Perspectives**8:40 AM *Introduction by Session Leader Alberto Ayala, California Air Resources Board*

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|---------|---|------------------|------------------------------------|
| 8:50 AM | The On-Road Vehicle Emissions Workshop - A CRC Historical Perspective | Brent Bailey | Coordinating Research Council |
| 9:00 AM | On-Road Measurements of Motor Vehicle Emissions | Robert Harley | University of California, Berkeley |
| 9:10 AM | The Success of Air Pollution Controls in California | Nehzat Motallebi | California Air Resources Board |
| 9:20 AM | Mobile Source Emission Reductions and CRC Work | Joseph Somers | US Environmental Protection Agency |
| 9:30 AM | Discussion | | |

9:40 AM **Poster Session and Demonstrations in Pavilion** (*see Pages 6-8 for Listings*)**SESSION 2: Emission Rates & Inventory**10:20 AM *Introduction by Session Leader Fred Minassian, South Coast Air Quality Management District; Co-Leader Matt Thornton, National Renewable Energy Laboratory*

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|----------|--|----------------------|------------------------------------|
| 10:25 AM | Air Quality Impact of Retrofitting In-Use Diesel Trucks to Meet Current Exhaust Emission Standards | Robert Harley | University of California, Berkeley |
| 10:40 AM | Understanding the Contribution of Emissions from Mobile Sources to Fine Particle Concentrations in Urban Environments | Allen Robinson | Carnegie Mellon University |
| 10:55 AM | Smartway Applications for Drayage Trucks | Mohamadreza Farzaneh | Texas Transportation Institute |
| 11:10 AM | Tracking an Anticipated 80% Reduction in Heavy-Duty PM Emissions over the Next Five Years: Calculation of Fuel-Based Emission Factors as Measured by a Mobile Platform | Jorn Herner | California Air Resources Board |
| 11:25 AM | Relevance of Black Carbon Particle Pollution for California's Climate Protection Efforts | Alberto Ayala | California Air Resources Board |
| 11:40 AM | Finding Evaporative Emissions through CRC E-77/2/3 and Colorado Department of Public Health and Environment Test Programs | David Hawkins | US Environmental Protection Agency |

11:55 AM **Lunch in Mission Ballroom**

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| 1:25 PM | A Top-Down Emission Inventory Evaluation for the Upper Midwest (withdrawn) | Stephen Reid | Sonoma Technology |
| 1:25 PM | On-Board Emissions and Fuel Consumption Comparison of Two Flex-Fuel Cars and a Gasoline Direct-Injected One Fuelled with Gasoline and Ethanol Blends | Guido Lenaers | VITO Flemish Institute |
| 1:40 PM | Fuel Usage and Emissions from Highway Mowing Activities in Upstate New York | Darrell Sontag | Cornell University |
| 1:55 PM | Comparison of Regulated and Unregulated Exhaust Emissions from Twelve Multi-Fuel Solid Resource Collection Vehicles from the City of Los Angeles | Arvind Thiruvengadam | West Virginia University |
| 2:10 PM | Real-World Cold Start Emissions from Vehicles in the UK On-Road Vehicle Fleet | Karl Ropkins | University of Leeds |
| 2:25 PM | General Discussion of Session 2 | | |

2:35 PM **Poster Session and Demonstrations in Pavilion** (*see Pages 6-8 for Listings*)

SESSION 3: Measurement Methods

2:55 PM *Introduction by Session Leader Mike Claggett, Federal Highway Administration*

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|---------|---|---------------------|-----------------------------------|
| 3:00 PM | Trends in Heavy-Duty Truck Emissions in the South Coast Air Basin | Gary Bishop | University of Denver |
| 3:15 PM | Investigation of the Ability of Remote-Sensing Devices to Detect Evaporative Emissions of Light-Duty Gasoline Vehicles: Fleet Projections | Tim DeFries | Eastern Research Group |
| 3:30 PM | An Inline Device for Mass, Size and Number Quantification of Soot | Rob Graze | Caterpillar, Inc. |
| 3:45 PM | Measuring Particulate Matter with an Electrical Tailpipe Particle Sensor (ETAPS) on Heavy-Duty Diesel Trucks | Brent Schuchmann | University of Denver |
| 4:00 PM | Calibration and Accuracy of Particle Number Measurement Systems | Barouch Giechaskiel | AVL List GmbH |
| 4:15 PM | Results of Simultaneous Transient Measurements of VOC Emissions and Particle Size Distributions from Diesel Engines by PRT-TOFMS and EEPS | Nobuhiro Yanagisawa | Isuzu Advanced Engineering Center |
| 4:30 PM | General Discussion of Session 3 | | |
| 4:40 PM | END OF DAY | | |
| 6:00 PM | Evening event at Evan's Garage - meet in front of hotel lobby at 6:00 pm to board coaches. | | |

DAY TWO

Tuesday, March 23, 2010

BAYVIEW BALLROOM

7:30 AM Registration in Bayview Ballroom Foyer
Continental Breakfast in Pavilion

8:00 AM **Keynote Speaker: Tom Cackette, Chief Deputy Executive Officer, California Air Resources Board**

SESSION 4: Particulate Matter Characterization

8:50 AM *Introduction by Session Leader Rich Baldauf, US Environmental Protection Agency*

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| 8:55 AM | Particulate Matter and Particle Number for In-Use Conformity Testing | Massimo Carriero | Joint Research Centre, European Commission |
| 9:10 AM | PM PEMS Validation with UCR's MEL as Part of the Federal Measurement Allowance Program for In-Use Heavy-Duty Diesel Vehicles | Kent Johnson | University of California, Riverside CE-CERT |
| 9:25 AM | Comparison of Particulate Mass Measured Concurrently Using Portable Particulate Measurement Device (PPMD) and Filter Media Under Real Urban Driving Conditions | Carol Wong | Hong Kong Environmental Protection Dept. |
| 9:40 AM | Characterizations of In-Use Real World Emissions of Diesel and CNG Refuse Trucks | Josias Zietsman | Texas Transportation Institute |
| 9:55 AM | Poster Session and Demonstrations in Pavilion (see Pages 6-8 for Listings) | | |
| 10:35 AM | Impact of B20 on Particulate Matter Emissions from Heavy-Duty Trucks - Analysis and Modeling of Size-Resolved Particle Number Concentration Data | Xun Wang | Cornell University |
| 10:50 AM | Particulate Emissions from California LEVII Certified Gasoline Direct Injection Vehicles | Sherry Zhang | California Air Resources Board |
| 11:05 AM | Exhaust Gas Inorganic Nanoparticle Emissions from Internal Combustion Engines | David Kittelson | University of Minnesota |
| 11:20 AM | General Discussion of Session 4 | | |

SESSION 5: Emission Control Measures

11:30 AM *Introduction by Session Leader Chris Tennant, Coordinating Research Council*

- 11:35 AM Characterization of a Non-Catalyzed, Electrically Heated DPF: Performance and Emission Control Tao Huai California Air Resources Board
- 11:50 AM Urea Dosage Strategies for SCR-Equipped On-Highway and Non-Road HDD Engines Marc Besch West Virginia University

12:05 PM **Lunch in Mission Ballroom**

- 1:30 PM DPF Options for On-Road Heavy-Duty Vehicles Louis Browning ICF International
- 1:45 PM CRC E-90 Project: Impact of E15/20 Blends on OBDII Systems Rob Klausmeier de la Torre Klausmeier Consulting
- 2:00 PM Oil Dilution Impacts and Emission Control System Durability and Poisoning Results from a Light-Duty Diesel Vehicle Operating on B20 Fuel Blends Matthew Thornton National Renewable Energy Laboratory
- 2:15 PM Application of Hybrid Technology: Theoretical Possibilities to Utilize Braking Work for Reduction of Energy Consumption and Pollutant Emissions Olavi Koskinen / presented by Erkki Lamminen Ministry of Transport, Finland
- 2:30 PM General Discussion of Session 5

SESSION 6: Portable PM Measurement

2:40 PM *Introduction by Session Leader Rob Graze, Caterpillar, Inc.*

- 2:45 PM In-Line, Real-Time Exhaust PM Emissions Sensor - OBD and DPF Control System Applications Mridul Gautam West Virginia University
- 3:00 PM PMP Compliant Particle Number Measurement Systems Using Ejector Diluters and Thermodenuders Erkki Lamminen Dekati Ltd.

3:15 PM **Poster Session and Demonstrations in Pavilion** (*see Pages 6-8 for Listings*)

- 3:35 PM Update on the Activities of the CRC PM Measurements Panel Matti Maricq Ford Motor Company
Hector Maldonado California Air Resources Board
Presented by Chris Tennant, CRC
- 3:50 PM Portable Emission Measurement Systems (PEMS) for PM Measurements: The Semtech Laser Aerosol Monitor (LAM) Lauretta Rubino Sensors Europe GmbH
- 4:05 PM Heavy-Duty In-Use Measurement Allowance Program Using Different Particulate Matter Portable Emissions Measurement Systems Imad Khalek Southwest Research Institute
- 4:20 PM Evaluation of Commercial On-Board Real-Time Particulate Measurement Systems: NYSERDA's PM-PEMS Program Tim Hansen Southern Research Institute

4:35 PM General Discussion of Session 6

4:45 PM **END OF DAY**

5:30 PM **Reception to celebrate workshop's twenty year landmark** [5:30-6:30 pm on the Pool Deck]

BAYVIEW BALLROOM

7:30 AM Registration in Bayview Ballroom Foyer
Continental Breakfast in Pavilion

SESSION 7: Fuel Effects

8:00 AM *Introduction by Session Leader Mani Natarajan, Marathon Oil Company*

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| 8:05 AM | Comprehensive Assessment of the Emissions from the Use of Biodiesel in California | Tom Durbin | University of California, Riverside CE-CERT |
| | | William Robertson | California Air Resources Board |
| 8:25 AM | Assessment of the Emissions from the Use of California Air Resources Board Qualified Diesel Fuels in Comparison with Federal Diesel Fuels | Maryam Hajbabaei | University of California, Riverside CE-CERT |
| 8:40 AM | Effects of Ethanol-Blended Gasoline on Air Toxics Emissions from Motorcycle Exhaust | Jiun-Horng Tsai | National Cheng Kung University |
| 8:55 AM | Ethanol Blend Effects on Direct-Injection Gasoline Vehicle PM Emissions | John Storey | Oak Ridge National Laboratory |
| 9:10 AM | Evaluation of NG Blends and Higher Blends in Conventional and Alternative Fuel Vehicles | Tom Durbin | University of California, Riverside CE-CERT |

9:25 AM **Poster Session and Demonstrations in Pavilion** (*see Pages 6-8 for Listings*)

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| 10:05 AM | Emissions and Fuel Consumption Test Results from a Plug-In Hybrid Electric School Bus | Jeff Gonder | National Renewable Energy Laboratory |
| 10:20 AM | CRC E-80 Exhaust and Evaporative Emissions Testing of Flex-Fuel Vehicles | Harold Haskew | Harold Haskew & Associates |
| 10:35 AM | General Discussion of Session 7 | | |

SESSION 8: Off Road

10:45 AM *Introduction by Session Leader Alberto Ayala, California Air Resources Board*

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| 10:50 AM | Emissions Field Testing of Non-Road Mobile Machinery: Development for the European Legislation | Pierre Bonnel | Joint Research Centre, European Commission |
| 11:05 AM | Revised Estimates of Emissions from Off-Road Diesel Construction Equipment in California | Dev Millstein | University of California, Berkeley |
| 11:20 AM | Measurement and Comparison of Locomotive Engine Emissions | Brandon Graver | North Carolina State University |
| 11:35 AM | In-Situ Emissions Testing of a Transportation Refrigeration Unit with CARB Diesel, Gas-To-Liquid and Level 2 Diesel Particulate Filter | Mark Burnitzki | California Air Resources Board |
| 11:50 AM | Field Study of PM _{2.5} Emissions from a Road-Widening Project | Stephen Reid | Sonoma Technology |
| 12:05 PM | Preliminary Results on "Drayage" Heavy-Duty Vehicles Testing within the Port of Houston Area Using Remote Sensing Devices (RSD), PEMS and PAMS Equipment | John Koupal | US Environmental Protection Agency |

12:20 PM General Discussion of Session 8

12:30 PM **Lunch in Mission Ballroom**

SESSION 9: Emission Trends and Modeling

2:00 PM *Introduction by Session Leader John Koupal, US Environmental Protection Agency*

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| 2:05 PM | Followup MOVES Review (E-68a) | Tom Darlington | Air Improvement Resource |
| 2:20 PM | Using MOVES to Model Regional Link-Level Emission Inventories in CONCEPT-MV | Christian Lindhjem | Environ International |
| 2:35 PM | Multi-Level Mixed Models for Longitudinal Analysis of Vehicle Emissions Deterioration | Yilin Liu | Cornell University |
| 2:50 PM | Accounting for Exhaust Gas Transport Dynamics in Instantaneous Emission Models Via Smooth Transition Regression | Oliver Gao | Cornell University |
| 3:05 PM | Modeling Heavy-Duty Vehicle Fuel Economy Based on Cycle Properties | Oscar Delgado | West Virginia University |
| 3:20 PM | Development of a Secure GPS Travel Activity Data Center to Support Vehicle Emissions Modeling and Air Quality Inventory Analyses | Jeff Gonder | National Renewable Energy Laboratory |
| 3:35 PM | General Discussion of Session 9 | | |

3:45 PM **OPEN DISCUSSION - Mani Natarajan, Chairman**

4:15 PM **END OF WORKSHOP**

Posters

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|---|---|--|
| The Application of Micro-Scale Emissions Models in Exposure Assessment: A Case Study of Diesel Transit Buses | Brian Gouge | University of British Columbia |
| Swedish Experience Of Real World Vehicle Emissions Using Portable Emission Measurement System | Lennart Erlandsson | AVL MTC |
| Development and Demonstration of a Next Generation Mobile Heavy-Duty Emissions Testing Laboratory | Daniel Carder
(presented by Ben Shade) | West Virginia University |
| Effective PM Measurement for I/M Programs | Antonio Multari | MAHA Germany |
| Characterization of Methane and Nitrous Oxide Emission Factors for On-Highway Vehicles Based on Near Road Measurements | Jorn Herner and Seong Park | California Air Resources Board |
| Trends in Speciated Volatile Organic Compound Emissions from In-Use Light-Duty Gasoline Vehicles in Southern California | Yanbo Pang | California Air Resources Board |
| Measuring In-Use Emissions from Ships by Portable Emissions Measurement Systems | M. Jusuf Khan | University of California, Riverside |
| Measurement and Comparison of Polycyclic Aromatic Hydrocarbon Emissions from Light-Duty Gasoline, Diesel, and CNG Vehicles—(withdrawn) | Shida Tang | NY State Dept. of Environmental Conservation |
| Quantifying Human Exposure to Fine Particulate Matter Inside a Vehicle | Brandon Graver | North Carolina State University |
| Two Decades of Real-World Emissions Testing of Heavy-Duty Vehicles by West Virginia University | Christopher Atkinson | West Virginia University |
| Evaluation of Light-Duty Diesel Aftermarket Performance Programmers | Donald Chernich | California Air Resources Board |

Development of a Heavy-Duty Chassis Dynamometer for Emissions Studies <i>[with optional tour of facility on Thursday morning 3/24]</i>	Tom Durbin	University of California, Riverside CE-CERT
Emissions from the PMP Diesel Car during Regeneration	Tao Huai	California Air Resources Board
Benefits and Challenges of Idle Stop on Heavy-Duty Transit Bus Applications	Magnus Lindback	ISE Corporation
A Comparison of OBDII Test Results of the Taxi Livery Fleet vs. the Non-Taxi Livery Fleet in New York State <i>[withdrawn]</i>	John Przybylowicz	NY State Dept. of Environmental Conservation
Time Alignment of Instantaneous Emissions Data	Karl Ropkins	University of Leeds
Emissions Implications of Old Imported Light-Duty Vehicles	Josias Zietsman	Texas Transportation Institute
Regulated Emissions of Heavy-Duty Diesel Engines - Past, Present and Future	Benjamin Shade	West Virginia University
Thermal Efficiency vs. Congestion Degree and Road Topography	Olavi Koskinen	Ministry of Transport
Methodology for Quality Assurance of Data from In-Use Measurements	Brandon Graver	North Carolina State University
Hydrogen Cyanide Exhaust Emissions from Gasoline Vehicles	Yong Yu	California Air Resources Board
Particulate Matter Emission Factors of Light-Duty Gasoline Vehicles	Sulekha Chattopadhyay	California Air Resources Board
Development and Application Verification Protocol for Auxiliary Power Units	Josias Zietsman	Texas Transportation Institute
Remote Sensing Measurements of Gaseous Emissions from Ocean-Going Vessels in Vancouver, B.C.	Carmen Bria	University of Puget Sound
Characterization of Filter Face Temperature Effects on Primary Particulate Matter from 2000 and Newer Model Year Light-Duty Gasoline Vehicles	Sulekha Chattopadhyay	California Air Resources Board
Fundamentals of Soot Measurements by Light Scattering	Donald Holve	Process Metrix LLC
Functional Data Analysis of Particle Size Distributions: Application to High-Frequency Exhaust Measurements from a Flex-Fuel Vehicle	Darrell Sonntag	Cornell University
Comparison of Particle Mass and Number Emissions from a Diesel Transit Bus across Temporal and Spatial Scales	Darrell Sonntag	Cornell University
An Analysis of PM Tunnel Blank Test Results	Mang Zhang	California Air Resources Board
Testing of an Independently Controlled Urea-SCR Aftertreatment System	Nigel Clark	West Virginia University
Urea-Based Selective Catalytic Reduction (SCR) for HDDVS: Chemistry, Physics, and Toxicology of Emissions	Alberto Ayala	California Air Resources Board
Low-Cost, Electronic PM Sensor for In Situ Post-DPF Vehicle Emissions Measurements	Jim Steppan	EmiSense
Open-Source Software: The Openair and PEMS 'R' Packages	Karl Ropkins	University of Leeds

Explorative Analysis of Ultrafine and Nano-Particle Emissions from Heavy-Duty Trucks with High Blend Bio-Diesel (B-80)	H. Oliver Gao	Cornell University
Effect of Biodiesel on Emissions from a Modern Marine Diesel Engine	Varalakshmi Jayaram	University of California, Riverside
Size-Resolved Particulate Matter Emissions from "Veggie" Cars Fueled on Straight Vegetable Oil in Real Driving Conditions	Darrell Sonntag	Cornell University
Impact of Biodiesel Blends on Off-Road Engines: The Case of Transportation Refrigeration Units	Tin Truong	California Air Resources Board
USBM/NIOSH Underground Mine Diesel Research Program: Past and Future Challenges	Emanuele Cauda	NIOSH
Measurement of Diesel Hydrocarbon Refueling Emissions for Emissions Inventory Modeling	David Hawkins	US Environmental Protection Agency
How Does MOVES Compare Model Results for Gaseous Exhaust Emissions from Light-Duty Vehicles in Relation to Independent Data	David Choi, presented by John Koupal	US Environmental Protection Agency
Near Road Gas and Aerosol Exposure Model with Application to LA Basin	Sang-Rin Lee	University of Iowa
Update on EPA's Motor Vehicle Emissions Simulator (MOVES)	John Koupal	US Environmental Protection Agency
Mathematical Prediction of Evaporative and Refueling Emissions from Older Vehicles with Ethanol-Containing Fuels	Sam Reddy	Evaporative Emissions Consulting
Mobile Source Emission Estimates Using Remote Sensing Data from Mexican Cities	Jose Aguilar-Gomez	National Institute of Ecology of Mexico
ACES: Characterization of Exposure Atmospheres and System Performance for a Chronic 2007 Compliant Diesel Exhaust Inhalation Study	Jacob McDonald	Lovelace Respiratory Research Institute

Demonstrations

Emisstar Demonstration	Michael Block	Emisstar LLC
TSI Demonstration	Bob Anderson	TSI Inc
Dekati - Particle Instruments Demonstration	Tyler Beck Erkki Lamminen	Dekati, Ltd. / Particle Instruments LLC
AVL Demonstration of On Board PM PEMS Instruments	Siegfried Roeck	AVL
Sensors, Inc. Demonstration	Rob Wilson David Booker	Sensors, Inc.



"When Bob's dad moved from Chicago to San Diego (presumably before Bob came along), he took the train. For many years he told Bob how impressed he was with the California mountains that the train went through, especially one wooden trestle. Bob had always wanted to see that trestle, so [one year] after the workshop I invited Bob to go to the Anza-Borrego desert to find the trestle. I located a dirt road that took us to the old railway tracks; then we guessed the direction to hike."

"After about 7 miles I was ready to turn around, but wouldn't you know it, around the next bend we could see the trestle in the distance. We slogged on - or rather I slogged on. Bob had been doing a lot of walking every day and was better prepared. We made it to the trestle and walked to the other side where the track goes into a tunnel."

"As I walked into the tunnel, I heard what sounded like a train whistle in the distance. Moving quickly out of the tunnel, I asked Bob if he had heard it. He thought it was back from where we started. A second whistle, however, sounded closer, so we went back across the trestle for safety's sake. Sure enough, a work train came out of the tunnel a couple of minutes later."

"The line, which had been closed for many years, was undergoing reconstruction so it could be reopened. We tried to thumb a ride back on the little two-man electric cart that followed the train, but no such luck. All in all, we had a great hike in the desert, saw the trestle Bob had wanted to visit for so long, and enjoyed the scenery along the way."

--*Steve Cadle*



Bob Gorse was a tireless volunteer and a member of the Board of Directors and the Community Advisory Council of the St. Louis Center, a residential facility for boys and adult men and women with intellectual developmental disabilities .



"I have known Bob Gorse from the auto/oil days of the nineties. I enjoyed my professional association with Bob, because he was not only a good scientist, but a good, caring human being. He had a flair for fuel/emission analyses using the EXCEL spreadsheet. He did not like anyone who wore a tie to the workshop. I remember in one of the earlier workshops, he chased me with a pair of scissors and wanted to cut my tie. But I removed it safely. Bob was a lot of fun to be with I enjoyed the few dinners we had together at the workshop. His demise is a huge loss to the scientific community".

-- *Mani Natarajan*

