Setting the Stage
Diesel Technology Research at NIOSH

Diesel Technology Workshop
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Current diesel research at NIOSH

Extramural Research Program

- Academia, industry and other government agencies
  - ✓ Comparison of diesel and biodiesel emissions and health effects in underground mining (University of Arizona)

Intramural Research Program

Mining Sector

- Spokane Mining Research Division (SMRD)
  - ✓ Developing a Field- Portable DPM Monitor
- Pittsburgh Mining Research Division (PMRD)
  - ✓ Advanced strategies for controlling exposures to diesel aerosols

Oil & Gas Sector

- Health Effects Laboratory Division (HELD)
  - ✓ Fracking: Toxicological Effects of Silica & Diesel Exposure
- Western States Division (WSD)
  - ✓ Protecting Oil Workers through Enhanced Surveillance, Exposure Assessments, and Control Evaluations
- Division of Applied Research and Technology (DART)
  - ✓ Controls and Interventions for Hazardous Exposures in Oil and Gas Extraction

Safe mines - Healthy workers

NIOSH Mining Program mission…

To eliminate mining fatalities, injuries, and illnesses through relevant research and impactful solutions

NIOSH Mining Program research focus areas

Strategic Goals

Reduce Occupational Illness and Disease	Reduce Injuries and Fatalities	Disaster Prevention & Response
Diesel Assessment & Control	Health & Safety Management Systems	Atmospheric Monitoring & Control
Respirable Dust Assessment & Control	Musculoskeletal Disorder Prevention	Refuge Alternatives
Hearing Loss Prevention	Training Research & Development	Breathing Air Supplies
Thermal Stress	Illumination	Communications & Tracking
Cognitive Workload	Ground Control	Emergency Response & Rescue
Chronic Disease Surveillance	Electrical Machine Safety	Explosion Prevention
	Safety Culture	Fire Prevention & Control
	Surveillance	Ventilation

Safe mines - Healthy workers

CDC NIOSH

Reducing miner's occupational exposure to DPM has relied on extensive collaboration

- Industry partners - Completed field-testing in both domestic (17 mines) and international (6 mines in Canada and Australia) mines.

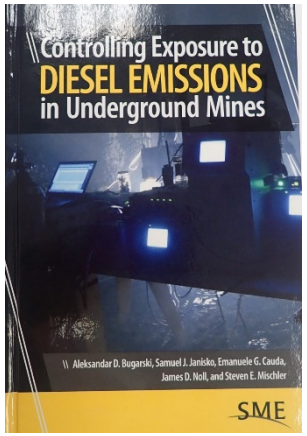
- Partnerships
  - Coal Diesel Partnership (1999) - UMWA, BCOA, NMA and NIOSH,
  - Metal/Nonmetal Diesel Partnership (2002) – USWA, NMA, NSSGA, MARG Diesel Coalition, IMA-NA and NIOSH,
  - Diesel Health Effects Partnership (2016) – MSHA and NIOSH Co-Sponsors.

A brief history….

- 1999 to 2019 - NIOSH investigates ways to reduce miner's exposure to diesel particulate matter (DPM) and gases in underground mines.
- Focus – to assist the mining industry and regulators with
  - selection, implementation, and acceptance of existing and emerging control technologies,
  - use of improved strategies and practices.
- Solutions include -
  - improved sampling and monitoring methods
  - engine and exhaust after treatment technologies,
  - alternative fuels,
  - filtration systems for enclosed cabs,

Results

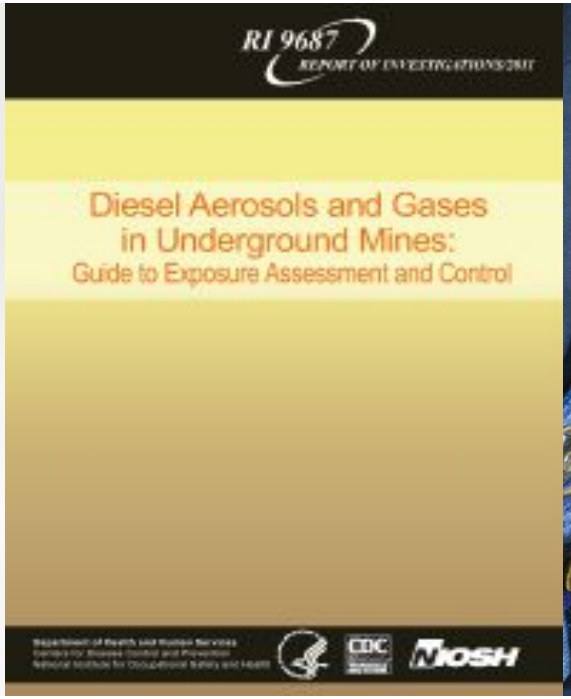
- Over 100 peer-reviewed publications, conference papers and presentations:
  - *Controlling Exposure - Diesel Emissions in Underground Mines*. Society for Mining, Metallurgy, and Exploration. 2012
  - *Diesel Aerosols and Gases in Underground Mines: Guide to Exposure Assessment and Control*. NIOSH RI 9687 Pub No. 2012-101



- From 2008 to 2017 over 14 diesel workshops held in US, China, Australia and Canada (over 40 since inception).
- Improved compliance sampling protocols based on NISOH Method 5040.
- Developed new interventions and strategies

Development and Commercialization of a Wearable Real-time Elemental Carbon (EC) Monitor

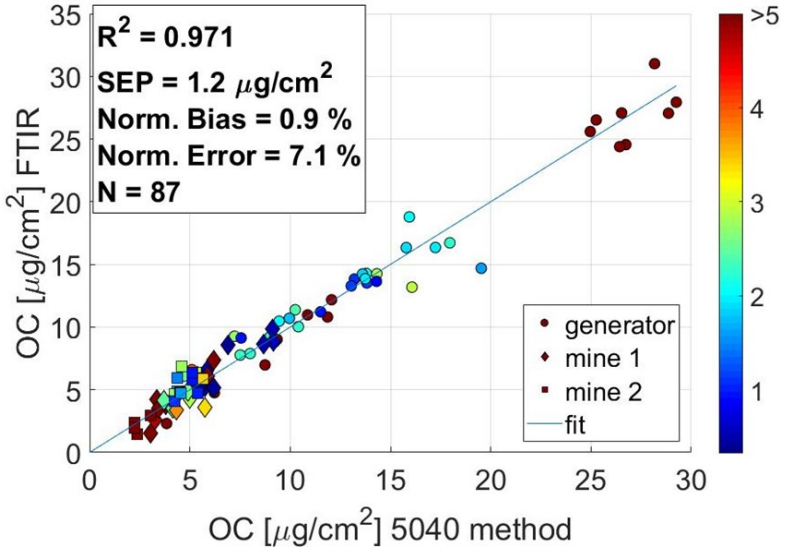
- Mines have incorporated Airtec into their DPM control strategy to
  - detect the presence of elevated concentrations of EC,
  - identify the shortcomings of engineering and administrative controls,
  - implement changes to reduce exposure levels
- Since initial commercialization, over 200 Airtec monitors have been sold worldwide.



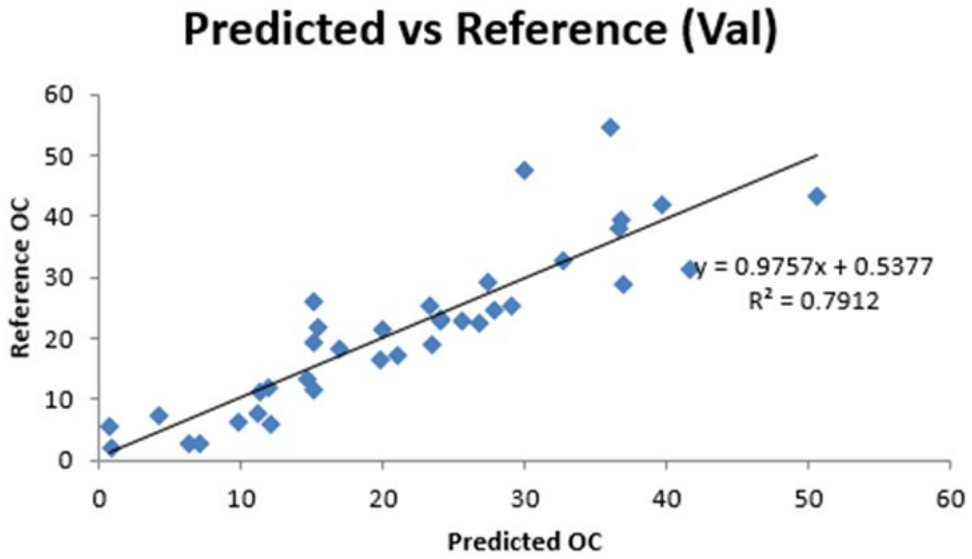
Research and Development of a Real-time EC/OC Monitor

- Airtec measures EC, then estimates OC from known EC/OC trends
  - accuracy of EC may be affected by high OC levels
- A new method is needed to mimic NIOSH 5040 measurement of both EC and OC
- FTIR and LIBS can both measure EC, and possibly OC as well
- Research is under way to refine these methods, and develop an EC/OC monitor

FTIR data (OC)



LIBS data (OC)

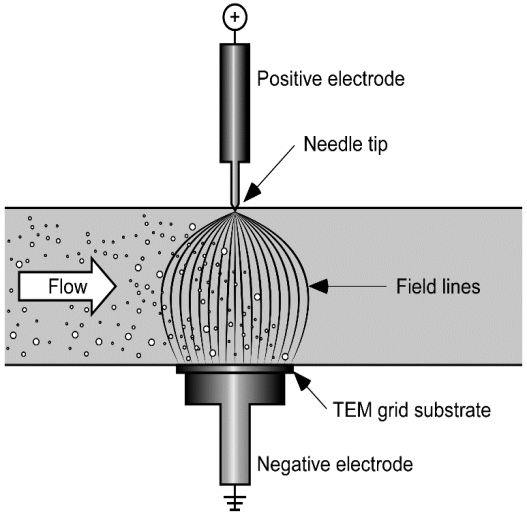


Development of a technique for direct tailpipe measurement of DPM

Direct tailpipe sampling of diesel vehicles in mines is used to

- identify the highest DPM emitters in a fleet of vehicles,
- determine the effectiveness of control measures
- BHP Billiton used the NIOSH-designed probe to evaluate its diesel fleet at several different mine sites.

Handheld Electrostatic Precipitator (ESP) Particle Sampler (ESPnano)



A sampling device used by industrial hygienists to characterize hazardous airborne particulate matter to investigate

- worker exposures to DPM and other airborne hazards [Tumolva et al. 2010; Saffaripour et al. 2015].
- engine soot morphology to evaluate the toxicity of engine-emitted particles [Saffaripour et al. 2015; Barone et al. 2012; Heejung et al. 2013].

Improvement in Compliance Sampling Methodology

Based on NIOSH research MSHA made changes to compliance sampling protocols including

- using a dynamic blank for correcting adsorption of vapor phase organic carbon in DPM compliance samples,
- calculating a conversion factor during each sampling event [73 Fed. Reg. 29058].

Aftertreatment Technologies for Diesel Emission Control

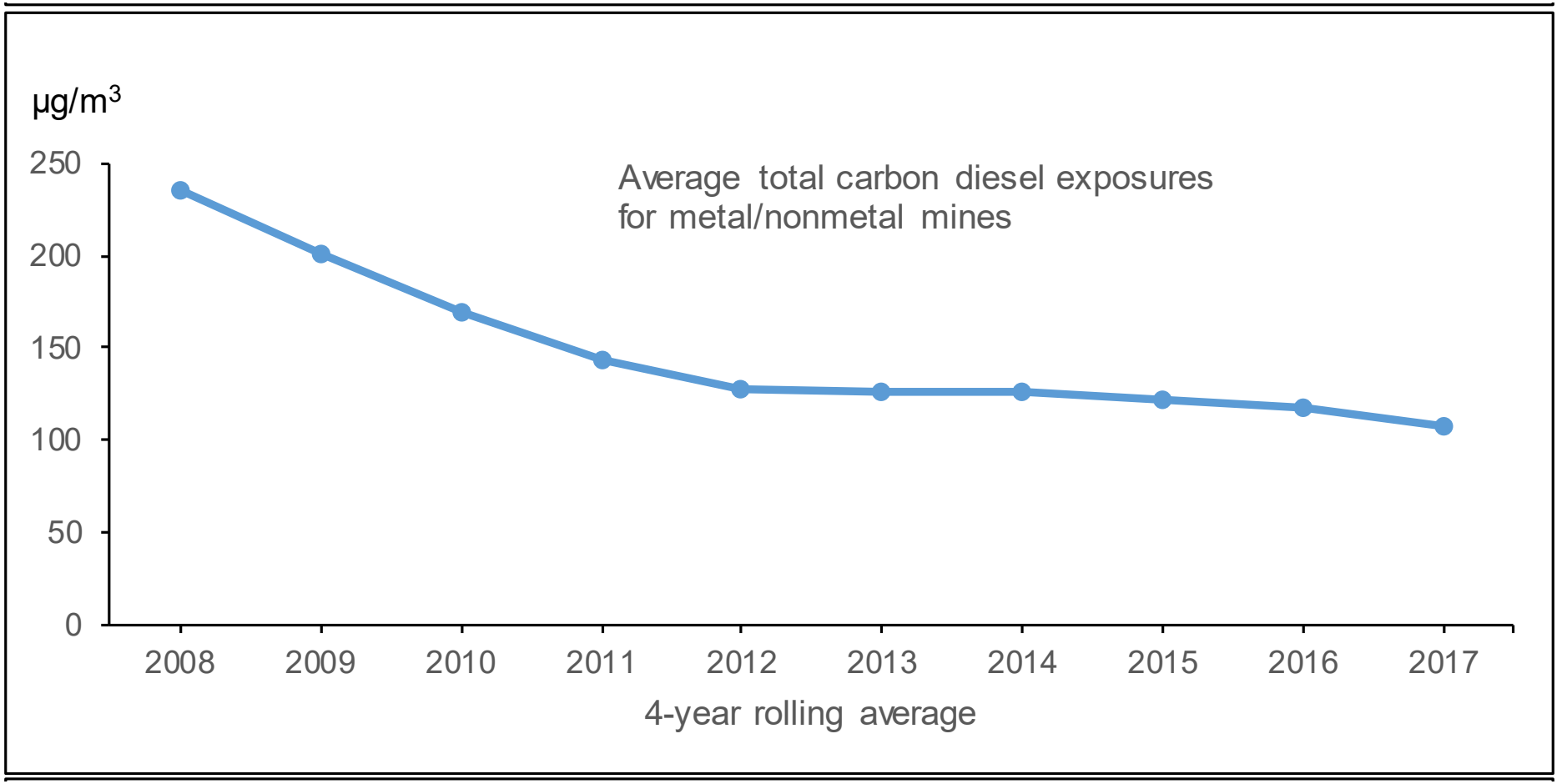
NIOSH evaluated diesel oxidation catalytic converters, particulate filters, and other systems to assist mine operators in the selection of exhaust aftertreatment systems

- Based on this research, diesel oxidation catalytic converters and other retrofit diesel particulate filter systems are being used in underground mines in the U.S.
- These systems are currently integrated into the diesel-power packages offered by major original equipment manufacturers

Alternative Fuel for Diesel Emission Control

- Studies conducted by NIOSH showed the potential of using fatty acid methyl ester (FAME)-derived bio fuels as a control strategy to reduce exposures of underground miners to DPM
- NIOSH collaborated with Newmont USA Limited to evaluate the effects of several biodiesel blends and ultralow sulfur diesel (ULSD) on airborne contaminants in the underground environment
- The results showed that the FAME biodiesel, when compared with ULSD, reduced DPM, TC, and EC mass concentrations.
- Additional follow-up laboratory studies conducted at NIOSH showed that the toxicity of aerosols is higher when engine is fueled with FAME B100 than with ULSD
- Burgess et al. found that the use of biodiesel in an underground mine can result in variable changes in health effect outcomes as compared with diesel fuel.

But what about the miner?



Safe mines - Healthy workers

NIOSH Mining Program – www.cdc.gov/niosh/mining