

# Setting the Stage

## Diesel Technology Research at NIOSH



Diesel Technology Workshop  
January 23, 2019  
Washington D.C.

Jessica E. Kogel, PhD

Associate Director for Mining  
National Institute for Occupational  
Safety and Health



*Safe mines - Healthy workers*



# 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**



*Safe mines - Healthy workers*

# NIOSH Mining Program research focus areas

## Strategic Goals

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



*Safe mines - Healthy workers*



## 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.

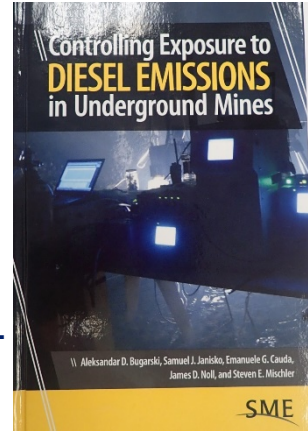


## A brief history....

- 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,

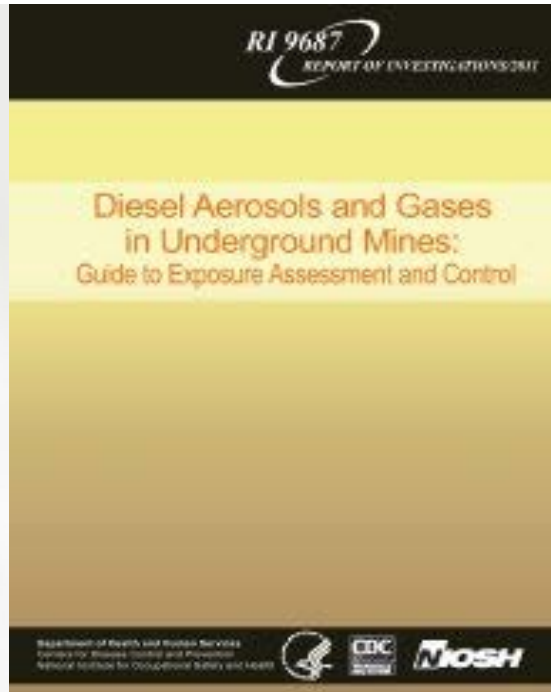
# Results

- 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 NIOSH 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.

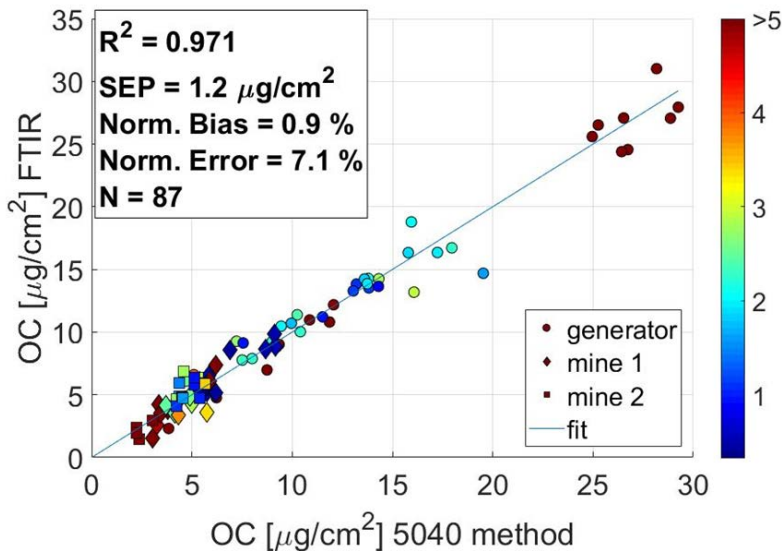




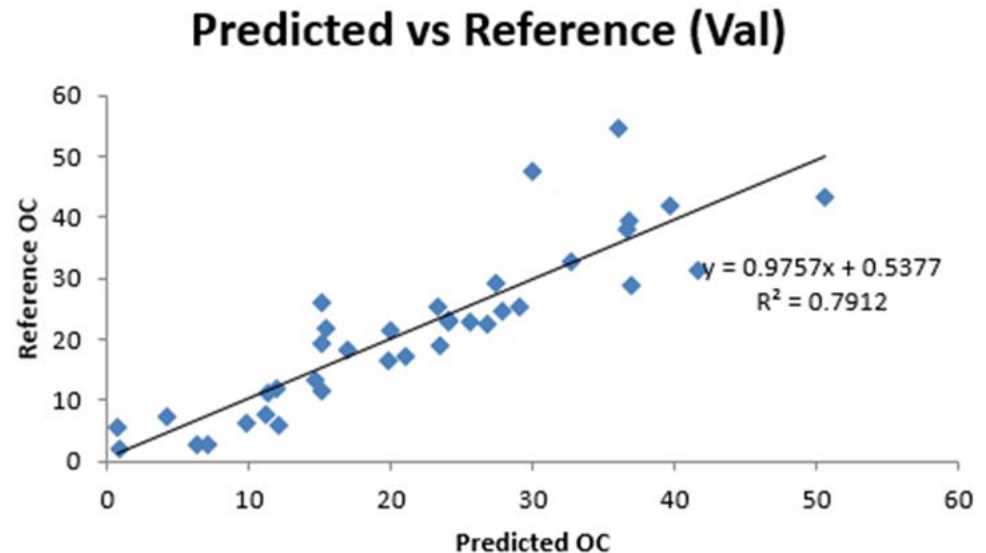
# Research and Development of a Real-time EC/OC Monitor

- 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)



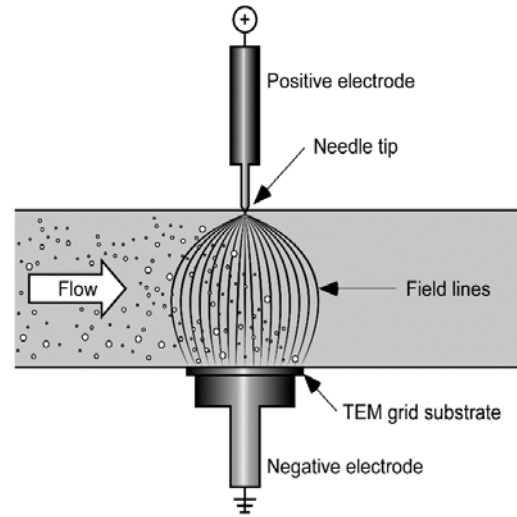
# Development of a technique for direct tailpipe measurement of DPM

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

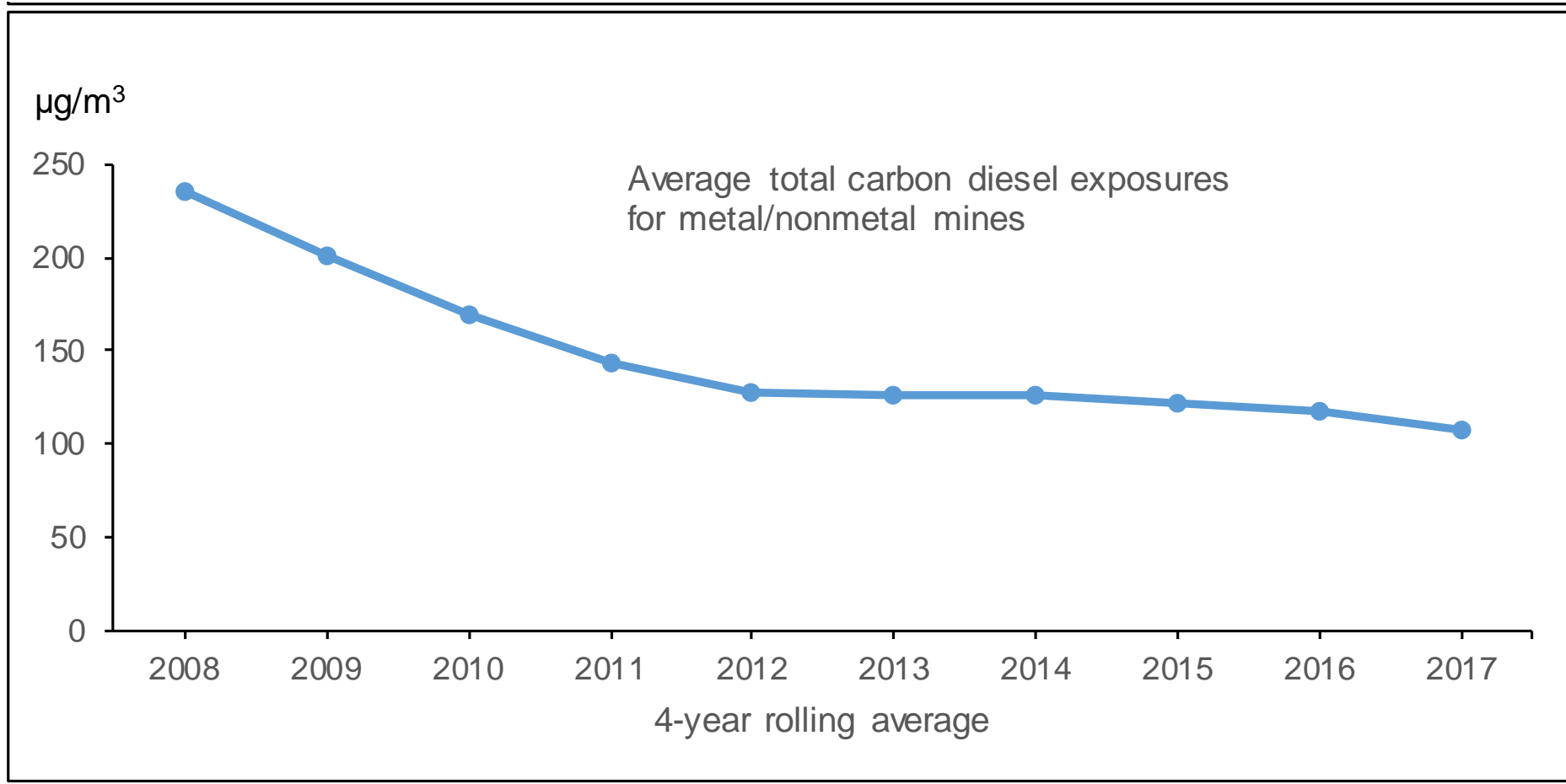
- Based on this research, diesel oxidation catalytic converters and other retrofit diesel particulate filter systems are being used in underground mines in the U.S.
- These systems are currently integrated into the diesel-power packages offered by major original equipment manufacturers



## 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](http://www.cdc.gov/niosh/mining)**

