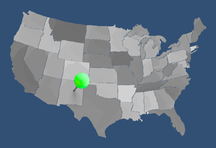
COMPARISON OF RESPIRABLE COAL MINE DUST (RCMD) AND RESPIRABLE CRYSTALLINE SILICA (RCS) MONITORING SYSTEMS



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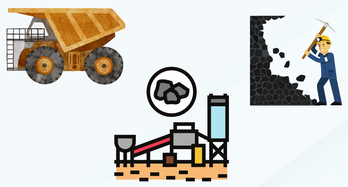
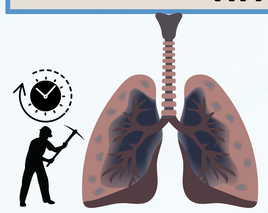
Introduction

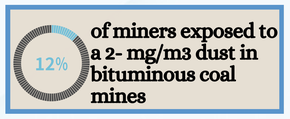
Mining operations



Underground miners are exposed to RCMD and RCS

Constant exposure may affect their health causing lung disease and even death [1] [2]

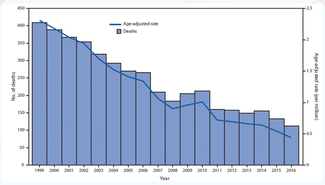




of miners exposed to a 2- mg/m3 dust in bituminous coal mines

are expected to have category 2 or greater coal workers pneumoconiosis (CWP) during a 40-years working life [3]

This has led to the necessity of creating better dust control techniques and dust monitoring systems



Graph 1. Age-adjusted coal workers' pneumoconiosis deaths and deaths per million persons aged ⩾25 years with coal workers' pneumoconiosis, † by year of death — United States, 1999–2016*
Source: National Vital Statistics System. https://wonder.cdc.gov.

Methods

NIOSH FAST

- ELF Escort pump
- 10 mm Dorr-Oliver cyclone
- 37 mm 4-piece cassette
- Fourier Transform Infrared Spectroscopy (FTIR)

Functional groups

NIOSH 7500

- ELF Escort pump
- 10 mm Dorr-Oliver cyclone
- 37 mm 5 µm PVC filter
- X-Ray Diffraction (XRD)

Mineral Composition

NIOSH 7603

- ELF Escort pump
- 10 mm Dorr-Oliver cyclone
- 37 mm 5 µm PVC filter
- Fourier Transform Infrared Spectroscopy (FTIR)

Functional groups

PDM3700

The Thermo Scientific™ Personal dust monitor (PDM)

- TEOM Filter
- Two (2) inlets
- WinPDM Software
- Temperature
- Ambient pressure
- Differential pressure
- Flow rate=2.2L/MIN
- Mass frequency
- Mass concentration

Ring-IR Dust Monitor

Ring-IR NIOSH coal and silica dust monitor

- Device RING-IR
- Two (2) inlets
- Cyclone

A.P.S 3321

Aerodynamic particle sizer

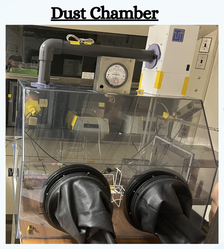
- Aerosol instrument manager
- Total concentration
- Size particles
- inlet pressure
- Box temperature

Equipment

Ring-IR

Fan

Dust Chamber



Air Compressor

Aerodynamic Particle Sizer

ELF Pump

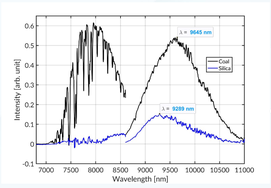
Sensor T°, %H

Aerosol Generator

SPS30 Sensors

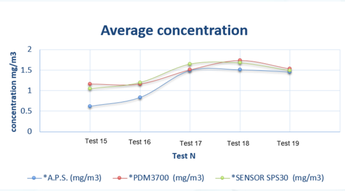
PDM 3700

Results



Graph 3. Comparison of IR Spectra of Coal and Silica Dust

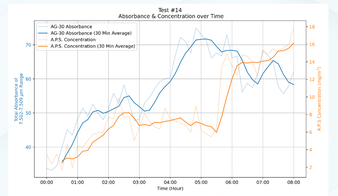
Using RingIR's AG-4000 instrument compares the broad IR absorption spectra of a coal dust and a silica dust



Graph 4. Average concentration A.P.S ,PDM3700, SENSOR SPS30

N test	*A.P.S.	*PDM3700	*SENSOR SPS30
TEST 15	0.619276117	1.162142885	1.04362016
TEST 16	0.834665333	1.161736721	1.195498118
TEST 17	1.490913833	1.506089541	1.648642446
TEST 18	1.508163	1.734164262	1.676645141
TEST 19	1.455605333	1.529708705	1.488611006

Table 1. Average concentration A.P.S ,PDM3700, SENSOR SPS30

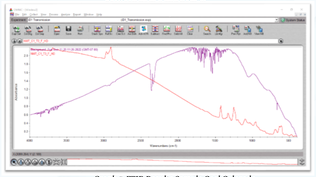


Graph 5. Absorption Data for 7.5-Micron Laser

shows data from Test #14. 49 Samples were captured at 10-minute intervals during an 8-hour period to simulate a full workday.

For each sample collected from the AG-30, the absorbance values between the 7.507-7.509-micron range were summed, this is plotted in the blue line. The orange line shows the corresponding A.P.S. concentration at the time the AG-30 sample was taken.

the absorbance and concentration increases until ~2.5 hours. We can also see that the AG-30 has an increase in Absorbance prior to the A.P.S. units increase in reported concentration between hour 3 and hour 6.



Graph 7. FTIR Results Sample Coal Colorado

Graph 6. Example of Experiment Heatmaps

Graph 8. Maximum Absorption Versus Mean AG-30 PDM Concentration

Conclusions

- To ensure the homogeneity of dust distribution within the chamber, the positions of the SPS30 sensors were strategically moved. One sensor was positioned near the inlet of the aerosol generator and the PDM3700, while the other three were placed in each corner of the chamber. This setup aimed to verify if consistent results and similar response curves could be observed among the three sensors.
- The project's initial phase successfully completed the design and construction of the chamber. This foundational step was crucial for the subsequent experiments and analyses
- The Ring-IR instrument was validated for coal, ensuring its accuracy and reliability for the intended measurements. Additionally, the validation process for the PDM3700 was also completed, further enhancing the credibility of the experimental results.
- A comparative analysis of concentration values across different experiments involving the A.P.S, Sensor SPS30, and PDM3700 was conducted, revealing similar outcomes. Furthermore, the NIOSH fast method was examined, and by utilizing the FTIR, the mass concentration of silica in the samples was accurately determined.

RingIR

Ring-IR coal and silica dust monitor

- Australian company
- Produce innovative spectrometers with distinct value-added integration such as superior compound detection, portability, automation, real-time data, qualitative reproducibility, high selectivity and sensitivity.
- Ring-IR is NMT collaborator
- Monthly report; Ring-IR and NIOSH
- Comparing device with SPS30 sensors, PDM3700, NIOSH FAST method

Project aim

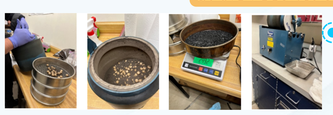
Create a platform to simulate underground coal mine conditions and test dust concentrations inside a dust chamber in different environmental conditions

Validate the Ring-IR silica and coal dust monitor by comparing the results from PDM3700, SPS30 sensor, and A.P.S

Conduct a four-way comparison with Ring-IR monitoring device, NIOSH 7500, NIOSH 7603, and NIOSH FAST

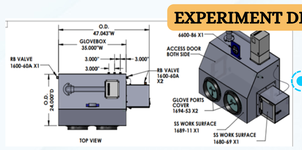
Experimental framework

SAMPLE PREPARATION



Crush, dry, grind, sieve, store.

EXPERIMENT DESIGN



- Material in A.G
- Speed 2
- Concentration= 02-4mg/m3
- Flow rate
  ELF Pump 2.5l/min
- Compressor = ON
- H.C.S = dry air H = 20%

ANALYSIS RESULTS

- OMNIC Series Software
- FAST–Field Analysis of Silica Tool software
- Analyze silica concentrations compared using statistical methods

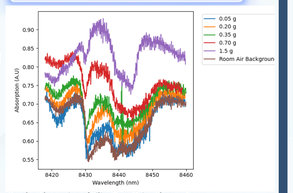
- Transfer data:
- Ring Ir, SPS30 sensirion , PDM3700 software.
- Fourier Transform Infrared (FTIR)
- TQ Analyst EZ Software

Challenge

Ring-IR device does not provide dust concentrations

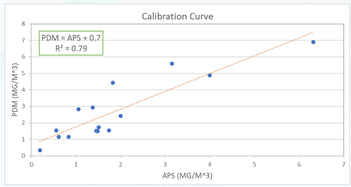
- Prepare calibration curves to determine concentrations from absorption data.

what equipment is to be used to obtain a calibration curve?



Graph 2.Absorption of Silica Dust Using Sb15170 Laser

Solution



Graph 3. Calibration curve

- Obtain calibration ratio for different sensors inside the chamber
- Compare target concentration with the actual concentration inside the chamber.
- Calibrate Ring-IR based on the calibration ratio and actual concentration.

Future work

- Develop additional calibration curves for silica to enhance the accuracy and reliability of measurements.
- Conduct further experiments with variations in time, simulating real shifts in underground coal mines. This will provide a more comprehensive understanding of silica exposure under different working conditions.
- Compare the results obtained from the Ring-IR, NIOSH 7603, NIOSH 7500, and NIOSH FAST methods. This comparison will help in evaluating the effectiveness and consistency of each method in assessing silica exposure in coal mines.

References

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Hygiene Association Journal, 53:8, 486–492, DOI: 10.1080/15298669291360012.
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Acknowledgments

- The research was funded by the National Institute for Occupational Safety and Health (NIOSH) (contracts #75D30119C06390 & #75D30120R67845)
- Ring-IR company for providing the opportunity to work on this research project
- We acknowledge Dr. Navid Mojtabai for all the support in our academic goals
- The students acknowledge Vanessa Salinas, Jason LeBoeuf for the contribution to this project

THANK YOU