in the range of 11.62 to 41.50 µg/m^3 when the drill hole diameter was reduced from 152 to 112 mm.

The predicted total PM_{10} and $PM_{2.5}$ levels at the selected receptor positions were found to be in the ranges of 86.39 to 194.89 and 34.82 to 99.55 µg/m^3, respectively. Based on the modeling exercise, it is predicted that ground-level concentrations of PM_{10} and $PM_{2.5}$ may increase in the ranges of 3.2 to 23.1 and 2.1 to 8.9 µg/m^3, respectively, due to mining activities only when some of the closed mines will be operated in the region without controlled emission. The concentration of total PM_{10} would exceed the National Ambient Air Quality Standards (NAAQS) [3] of 100 µg/m^3 at the A2 to A7 and A9 sampling sites (Fig. 1). In contrast, the total $PM_{2.5}$ concentration would be greater than the recommended value of 60 µg/m^3 at the A5 to A9 sampling sites due to active mines and some of the closed mines around the fort operating without controlled emission. The modeling results showed that PM_{10} and $PM_{2.5}$ would be at their maximums within the mining locations. Dispersion and settling of air pollutants will take place going away from mining areas. Hence, PM levels in the fort location would be less than in mining areas.

We developed an automated and smart dry fog dust suppression system for the efficient control of fugitive dust emission from mining and industrial operations. The system consists of hybrid nozzles, sensors, actuators, controllers, screw compressors, air receiver, pumps, motors, and water arrangement with filtration facility (Fig. 2). Compressed air and water pass through atomization nozzles to form fine droplets (10 to 50 µm in size, with a mean of 20 µm). Fine water droplets agglomerate with submicrometer fugitive dust particles and then settle.

Total operation is automatic using a programmable logic controller and sensors, including under-belt, proximity, dust-measurement and water-level sensors. The system automatically starts only when the plant is in operation, and it effectively controls dust emission at source. The system does not affect the material handling process as it adds moisture at less than 0.1 percent of material weight. Power and water consumptions are low, and the system was capable of controlling dust emission from different mining activities of the study area.

Conclusions

Opencast mining activities around the Chittorgarh Fort are significant sources of air pollution in the region. It is estimated that PM_{10} and $PM_{2.5}$ concentrations may exceed the NAAQS, 2009 [3] at a few locations around the fort during the operation of the existing active mines and some of the closed mines in the future without controlled emission. Hence, effective control measures, including the developed intelligent dry fog system, shall be adopted to reduce air pollution levels around the fort during the operation of the closed mines for sustainable development of the region. ■

Selected references

1. United States Environmental Protection Agency (1995) User's guide for the fugitive dust model (FDM), Vol. I, User's Instruction, Region 10, Seattle, Washington, USA
2. Chaulya SK (2006) Emission rate formulae for surface iron ore mining activities. Environ Model Assess 11:361–370
3. Central Pollution Control Board (2009) National Ambient Air Quality Standard. Ministry of Environment, Forests and Climate Change, Government of India, New Delhi, India

Effectiveness of the CPDM in reducing overexposures to coal mine dust

Jay F. Colinet and Steven E. Mischler*

National Institute for Occupational Safety and Health, Pittsburgh Mining Research Division, Pittsburgh, PA, USA

*Corresponding author email: SMischler@cdc.gov

Full-text paper:
Mining, Metallurgy & Exploration (2022) 39:283–290, https://doi.org/10.1007/s42461-022-00563-7

Keywords: Personal dust monitor, Coal workers' pneumoconiosis, Respirable coal dust, Dust sampling

Special Extended Abstract

The Mine Safety and Health Administration (MSHA) promulgated a rule in 2014 that required numerous changes in compliance dust sampling requirements for coal mine operators. Two key parts of this rule were the lowering of the respirable coal mine dust standard from 2.0 mg/m^3 to 1.5 mg/m^3 and requiring operators of underground coal mines to use a continuous personal dust monitor (CPDM) for compliance sampling. The CPDM currently approved for compliance sampling is equipped with a display that provides miners with in-shift information on their respirable dust exposure. The goal was to provide an indication of a potential overexposure and empower the miner and mine operator to implement changes in controls and/or operating practices to prevent an overexposure from occurring.

MSHA inspector and mine operator sampling data from five years before the rule became effective was compared to sampling results for five years after the dust standard was lowered and CPDM use was required. The analysis indicates

Table 1 — Comparison of sampling requirements in the 1969 Act and 2014 MSHA dust rule.

Key sampling changes	1969 Act	2014 Rule
Frequency of operator sampling on each MMU	Bimonthly	Quarterly
Sampling duration	8 hours	Full shift
Number of valid samples per period	5 consecutive days or shifts for the DO[a]	Consecutive sampling to obtain 15 valid shifts for the DO[a] and then 15 valid shifts for the ODO[a] (not concurrent)
Number of valid DO samples per year	30 (5 samples x 6 sampling periods)	60 (15 samples x 4 sampling periods)
Production required for sample to be valid	50 percent of average production from the last 5 valid bimonthly samples	80 percent of average production over the last 30 production shifts
Silica dust	If quartz > 5 percent, reduce the respirable dust standard (10 ÷ % quartz)	If quartz > 100 µg/m³, reduce the respirable dust standard (10 ÷ % quartz)[b]
Health surveillance	Chest X-rays for underground miners	Chest X-rays and spirometry for underground and surface miners
Operator dust sampler	Gravimetric	CPDM (effective Feb. 1, 2016)
Respirable dust standard	2.0 mg/m³ (effective Dec. 30, 1972)	1.5 mg/m³ (effective Aug. 1, 2016)

[a]Designated occupation (DO) and other designated occupation (ODO) are defined in the Compliance Dust Sampling Results section.
[b]Reduced respirable dust standard cannot exceed the 1.5 mg/m³ standard.

that use of the CPDM has resulted in substantially lower percentages of samples exceeding the applicable respirable dust standard for these four occupations, and the data suggest that miners and mine operators are utilizing the in-shift dust exposure information provided by the CPDM to substantially reduce overexposures.

Background

Inhalation of respirable-sized coal mine dust, which is defined as smaller than 10 µm [1,2], can result in coal workers' pneumoconiosis (CWP), commonly known as black lung. Once contracted, there is no cure for this lung disease, so controlling dust exposure is key for protecting the health of miners.

In the United States, the Federal Coal Mine Health and Safety Act of 1969 (Public Law 91-173) established a respirable coal mine dust standard of 2.0 mg/m³ and required periodic sampling by mine operators and federal inspectors. In an effort to further reduce the respirable dust exposure of coal mine workers, MSHA promulgated a new federal dust rule in 2014 [3]. As noted in Table 1, operators are now required to collect more samples per year from each mechanized mining unit (MMU). Also, samples must be collected over the entire working shift and 80 percent of the previous 30-shift average production must be obtained during the sampling shift for the dust sample to meet the minimum production for a valid sample. The new sampling requirements are designed to provide a more realistic measure of miners' dust exposures.

A key component of the 2014 dust rule is the requirement for underground coal mine operators to use a CPDM for compliance dust sampling. Currently, the Thermo Fisher Scientific PDM3700 is the only sampler certified by MSHA as intrinsically safe and by NIOSH for meeting the CPDM requirements specified in the Code of Federal Regulations (CFR), Title 30, Part 74. During sampling with the CPDM, respirable dust concentrations are recorded and stored each minute in addition to the unit display that provides the wearer with up-to-date information on their dust exposure.

Methods

Compliance sampling data for four occupations that have historically had elevated dust exposures were downloaded from the MSHA website. These occupations included continuous miner operator, roof bolter operator, tailgate-side shearer operator and jacksetter. To assess the impact of the CPDM on compliance sampling, NIOSH compared inspector and operator sampling data, retrieved from MSHA, from two five-year time periods. The first period represents the last five years of sampling before any portion of the 2014 dust rule was implemented and encompasses samples collected between Aug. 1, 2009 through July 31, 2014. During this period, the gravimetric sampler was used for compliance sampling by MSHA inspectors and mine operators, with the dust standard at 2.0 mg/m³. The second five-year period represents sampling after all portions of the 2014 dust rule had been implemented and encompasses samples collected between Aug. 1, 2016 through July 31, 2021. During this period, MSHA continued to use the gravimetric sampler but mine operators used the CPDM, with the dust standard lowered to 1.5 mg/m³.

Results and discussion

Figure 1 shows the percentage of mine operator samples that exceeded the applicable dust standard for the five-year periods before (Grav 2.0) and after (CPDM 1.5) implementation of the 2014 dust rule. For the four occupations, the percentage of samples exceeding the standard dropped between 63 and 86 percent with operators using the CPDM, even under the more stringent sampling requirements, including increased sampling times and tonnage increases.

Figure 2 shows the average respirable dust concentrations calculated for each sampling period for the four occupations. Average dust concentrations were below 0.8 mg/m^3 for all sampling periods and both occupations from the continuous mining (CM) sections. Except for the roof bolter (RB) operator samples collected by the mine operators, average dust concentrations were slightly lower after implementation of the 2014 dust rule. For the longwall occupations, average dust levels decreased by 0.1 to 0.4 mg/m^3 after implementation of the 2014 dust rule. These decreases in average dust levels occurred despite the increases in tonnage produced and time sampled as noted in Table 1.

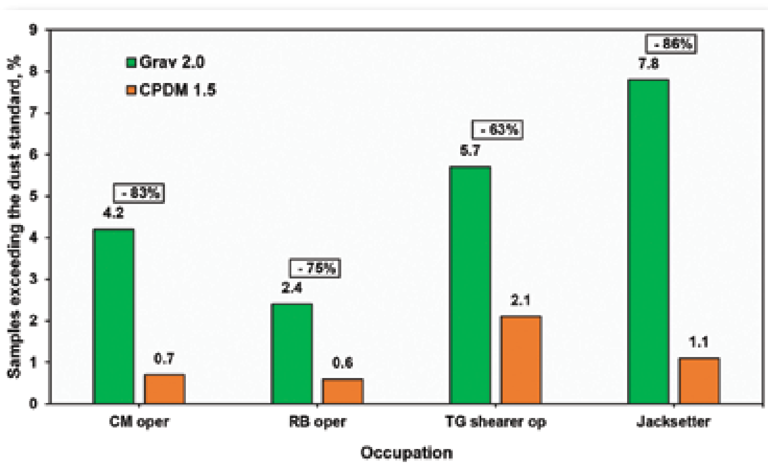

Fig. 1 Mine operator sampling results for the five years before and after the 2014 dust rule changes.

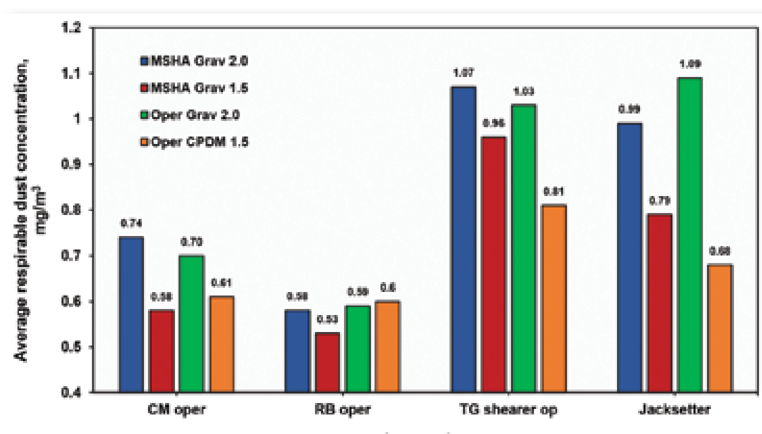

Fig. 2 Average respirable dust concentrations for the five years before and after the 2014 dust rule changes.

Conclusion

In 2014, MSHA enacted a dust rule that reduced the respirable dust standard to 1.5 mg/m^3, required mine operators to use a CPDM for compliance sampling and changed several other sampling requirements. The CPDM approved for use by MSHA and NIOSH has a display that provides in-shift information on respirable dust exposure to the wearer. Prior to using the CPDM, miners collected compliance dust samples with a gravimetric sampling pump that only displayed airflow rate and sampling time. NIOSH wanted to determine if miners and mine operators could use the dust exposure information provided by the CPDM to improve on maintaining compliance.

NIOSH downloaded compliance dust samples collected by inspectors and mine operators from the MSHA website for the five-year period prior to implementing the 2014 dust rule and the five-year period after all provisions of the dust rule had been implemented. Dust samples for continuous miner operators, roof bolter operators, tailgate-side shearer operators and jacksetters were analyzed.

With mine operators using the CPDM for compliance sampling, the percentage of samples exceeding the 1.5 mg/m^3 standard, collected by mine operators, when compared to the percentage exceeding 2.0 mg/m^3 for these four occupations was reduced by between 63 and 86 percent. These substantial reductions were realized despite the more stringent sampling requirements of the 2014 dust rule, such as the lowered standard, higher production requirements, full-shift sampling, and an increase in the number of samples required. The data suggest that miners and mine operators are utilizing the in-shift dust exposure information provided by the CPDM to substantially reduce overexposures. ■

Disclaimer

The findings and conclusions in the report are those of the authors and do not necessarily represent the official position of the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention. Mention of any company name, product, or software does not constitute endorsement by NIOSH.

Selected references

1. ACGIH (1994) Threshold limit values for chemical substances and physical agents & biological exposure indices. American Conference of Governmental Industrial Hygienists, Cincinnati, OH

2. ISO (1995) Air quality—particle size fraction definitions for health-related sampling. International Organization for Standardization, Geneva, Switzerland, ISO 7708:1995

3. 79 Fed. Reg. 24814 (2014) Mine Safety and Health Administration: Lowering miners' exposure to respirable coal mine dust, including continuous personal dust monitors; final rule. (To be codified at 30 CFR 70, 71, 72, 75, and 90.)