

consistent 8.04 square centimeter deposit and eliminated leakage around the filter. The results of this project were prepared into a scientific publication "Sampling Results of the Improved SKC Diesel Particulate Matter Cassette" by James D. Noll, Robert J. Timko, Linda McWilliams, Peter Hall, and Robert A. Haney. This paper is being peer reviewed for publication in a scientific journal. The following abstract was prepared for the study results:

Diesel particulate matter (DPM) cassettes, manufactured by SKC, Inc., Eighty Four, PA, are designed to collect airborne particulates being emitted by diesel powered machinery. These devices, primarily used in underground metal/non-metal mines, enable officials to determine miner exposure to DPM. The SKC DPM cassette is a size selective sampler that was designed by researchers with the U.S. Bureau of Mines, now a part of the National Institute for Occupational Safety and Health (NIOSH), and SKC engineers to collect DPM. This cassette is preferred to a conventional respirable dust sampler because, if DPM is sampled in the presence of carbonaceous ore dust, the ore dust and DPM will collect on the quartz filter, causing the carbon attributed to DPM to be artificially high. In this study, NIOSH researchers investigated the ability of the SKC DPM cassette to collect DPM while preventing mineral dust from collecting on the filter. This cassette discriminated dusts and efficiently collected DPM in both laboratory and field evaluations. In the presence of carbon-based mineral dust having an average concentration of 8 mg/m³, no mineral dust was found on SKC DPM cassette filters. NIOSH researchers did discover that DPM deposits on filters that were manufactured prior to August 2002 were non-uniform and inconsistent across the filter surfaces. DPM deposit cross-sectional areas varied from 6 to 9 cm². To correct this problem, SKC modified the cassette. The resulting cassette produced areas of DPM deposit between 8.11 and 8.21 cm², a difference of less than 2%.

Specific control technology studies. Following the settlement agreement, MSHA was invited by various mining companies to evaluate the effectiveness of several different control technologies for diesel particulate matter. These control technologies included ceramic filters, bio-diesel fuel and a fuel oxygenator. Company participation was essential to the success of each study. Ceramic filters were evaluated in two mines, one where MSHA was the only investigator and one where NIOSH was the primary investigator. In the MSHA study, DPM on a production unit was evaluated with and without ceramic filters installed on the loader and trucks. In the NIOSH study a variety of ceramic filters were tested in an isolated zone.

Bio-diesel fuel was evaluated in two mines. In one mine, a 20 and 50 percent

recycled bio-diesel fuel and a 50 percent new bio-diesel were evaluated. In the second mine, a 35 percent recycled bio-diesel fuel and a 35 percent new bio-diesel fuel were evaluated.

The fuel oxygenator system was evaluated in one mine. The mine exhaust was sampled with and without the units installed. For the tests with the oxygenator units, the oxygenator units were installed on all production equipment.

Following is a summary of the five individual mine technology evaluation studies:

Kennecott Greens Creek Mining Company: The Mine Safety and Health Administration and Kennecott Greens Creek Mining Company participated in a collaborative study to verify the efficiency of catalyzed ceramic diesel particulate filters for reducing diesel emissions. The goal of the study was the identification of site-specific, practical mine-worthy filter technology.

This series of tests was designed to determine the reduction in emissions and personal exposure that can be achieved when ceramic filters are installed on a loader and associated haulage trucks operating in a production stope. Relative engine gaseous and diesel particulate matter emissions were also determined for the equipment under specific load condition.

The tests were conducted over a two-week period. Three shifts were sampled with ceramic after-filters installed; and three shifts were sampled without the after-filters installed. Personal samples were collected to assess worker exposures. Area samples were collected to assess engine emissions. Both gaseous and diesel particulate measurements were taken.

Sampling results indicate significant reductions in both personal exposures and engine emissions. These results also indicated that factors such as diesel particulate contamination of intake air, stope ventilation parameters, and isolated atmospheres in vehicle cabs as well as the ceramic diesel particulate filters may have a significant impact on personal exposures. The following findings and conclusions were obtained from the study:

1. The results of the raw exhaust gas measurements conducted during the study indicated that the engines were operating properly.

2. The ceramic filters installed on the machines used in this study did not adversely affect the machine operation. Even with some apparent visual cracking from the rotation of the filter media, the ceramic filters removed more than 90% of the DPM. The filters

passively regenerated during machine operation.

3. The Bosch smoke test provides an indication of filter deterioration; however, the colorization method does not quantify the results.

4. Personal DPM exposures were reduced by 60 to 68 percent when after-filters were used.

5. CO levels decreased by up to one-half when the catalyzed filters were being used. There appeared to be an increase in NO₂ when catalyzed filters are being used; however, it was unclear whether this increase was due to data variability, changes in ventilation rate, or the use of the catalyzed filters.

6. The use of cabs reduced DPM concentrations by 75 percent when after-filters were used and by 80 percent when after-filters were not in use.

7. Ventilation airflow was provided to the stopes through fans with rigid and bag tubing. Airflow was the same or greater than the Particulate Index, but typically lower than the gaseous ventilation rate.

8. The use of ceramic after-filters reduced average engine DPM emissions by 96 percent.

9. The reduction in personal exposure was not attributed solely to after-filter performance because other factors such as ventilation, upwind equipment use, and cabs also influence personal exposure.

Carmeuse North America, Inc., Maysville Mine: MSHA entered into a collaborative effort with NIOSH, Industry, and the Kentucky Department of Energy to test DPM emissions and exposures when using various blends of bio-diesel fuels in an underground stone mine. As part of its compliance assistance program, MSHA provides support to mining operations to evaluate diesel particulate control technologies. The study was initiated by the industry partner, with MSHA and NIOSH providing support for study design, data collection, and sample and data analysis. Project funding was provided by Carmeuse and Kentucky Department of Energy, through the Kentucky Clean Fuels Coalition.

The initial study was conducted in two phases, a 20% bio-diesel and a 50% bio-diesel blend of recycled vegetable oil, each mixed with 100% low sulfur No. 2 standard diesel fuel. Baseline conditions were established using low sulfur No. 2 standard diesel fuel. In a third phase of the study, a 50% blend of new soy bio-diesel fuel was tested.

Area samples were collected at shafts to assess equipment emissions. Personal samples were collected to assess worker exposure. These samples were analyzed by NIOSH using the NIOSH 5040