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Diesel Particulate Matter Exposure in Mining

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Introduction

This session covers the trends in present and pending legislation involving Diesel Particulate Matter in underground mines and tunnels. The topic is of grave importance to the18,000 miners exposed to diesel exhaust fumes and particulate matter. The session will discuss background, sampling techniques, permissible exposure levels, personal protective equipment, environmental engineering controls, modifying ventilation systems, and Diesel Particulate Matter control plans and case studies. Specific recommendations will be provided to protect your workers and organization from Diesel Particulate Matter issues. Some attention will be provided to testing equipment and we will address some typical problems encountered in the evaluation of work environments.

Background

Particulate matter is probably the type of environmental chemical hazard most on the minds of U.S. citizens. Lead in paint, asbestos in schools, radon progeny in homes. Hanta virus in sheds, and diesel smoke are all current issues in the lay press. Industrial hygienists see many other emerging particulate matter issues, including exposures to beryllium, free crystalline silica, endotoxins, toxic fungal spores, and cadmium. This session will concentrate on free crystalline silica.

In the field of industrial hygiene, particulate matter (PM) is traditionally defined as small (less than 100 micrometers in diameter) pieces of solid materials, liquid droplets, or microbiological organisms. On the other end of the spectrum, particles smaller than about 0.001 micrometer start to act like gases, and thus are not treated as particulate matter.

Diesel Particulate Matter

Diesel-powered equipment is quite common at mining, tunneling, and construction sites in the United States. At many U.S. underground metal and nonmetal mines, the equipment needed to extract the limestone, gold, silver, salt or other ore is powered by diesel engines. Examples of such equipment include vehicles such as haul trucks, front-end loaders, hydraulic shovels, load-haul-dump units, face drills, and explosive trucks. Diesel engines are also used in support equipment, which might include generators, air compressors, crane trucks, ditch diggers, forklifts, graders, locomotives, lube units, personnel carriers, hydraulic power units, scalers, bull dozers, pumps (fixed, mobile, and portable), elevating work platforms, tractors, utility trucks, water spray units,

and welders. For the 18,000 miners who work in this confined underground world, exposure to diesel exhaust and particulate matter is just part of the job. Underground metal and non-metal miners are exposed to the highest levels of diesel particulate matter (DPM) compared with any other occupational group in the United States. They work in poorly ventilated environments, and traditionally this industry has relied on dated, highly polluting engines.

Exposed miners complain about acute health effects from the high levels of diesel exhaust, such as headaches and flu-like symptoms. According to one miner, "Some of the stresses you can feel—you don't need a gauge to measure this—your burning eyes, nose, throat, your chest irritation. The more you're exposed to, the higher this goes. There are about 200 of these underground metal and nonmetal mines in the United States, located in 30 states. The vast majority of the workers are not represented by a labor organization.

The emissions from diesel engines are a complex mixture of compounds, containing gaseous and particulate fractions. Diesel Particulate Matter (DPM) is less than 1 μm in diameter, small enough to penetrate deep into the lungs. DPM contains a carbon core and a surface that absorbs polycyclic aromatic compounds that include many known carcinogens. The specific composition of the diesel exhaust varies according to the type of engines being used, the usage pattern, and other factors, including type of fuel, load cycle, engine maintenance, tuning, and exhaust treatment. This complexity is compounded by the multitude of environmental settings where diesel-powered equipment is operated.

The U.S. Department of Labor has reported basic facts about diesel emissions that are of general applicability. The gaseous constituents of diesel exhaust include oxides of carbon, nitrogen, and sulfur; alkanes and alkenes (e.g., butadiene); aldehydes (e.g., formaldehyde); monocyclic aromatics (e.g., benzene, toluene); and polycyclic aromatics hydrocarbons (e.g., phenanthrene, fluoranthene). The oxides of nitrogen (NOX) also can precipitate into particulate matter. The particulate components of the diesel exhaust gas include the so-called diesel soot and solid aerosols, such as ash particulates, metallic abrasion particles, sulfates and silicates. The vast majority of these particulates are in the invisible submicron range of 100nm. Diesel particulate matter (DPM) has a solid core, mainly consisting of elemental carbon, and a very surface-rich morphology. This surface absorbs many other toxic substances that are transported with the particulates, and can penetrate deep into the lungs (66 Fed. Reg. 5715-5716, Jan. 19, 2001).

Scientific Evidence Prompts Federal Agencies to Act

In 1988, the US Department of Health and Human Services' National Safety and Health (NIOSH) issued a *Current Intelligence Bulletin* recommending that whole diesel exhaust be regarded as a potential carcinogen and controlled to the lowest feasible exposure level. In its bulletin NIOSH concluded that, although the excess risk of cancer in diesel-exhaust exposed workers has not been quantitatively estimated, it is logical to assume that reductions in exposure to diesel exhaust in the workplace would reduce the excess risk. NIOSH stated that "given what we currently know, there is an urgent need for efforts to be made to reduce occupational exposures to DEP [DPM]. That same year, a MSHA advisory committee issued a report on safety and health concerns related to the use of diesel-powered equipment in underground coal mines (Mine Health Research Advisory Committee, Final report of use of diesel in underground mines, April 30, 1985.) The report recognized the potential health hazards associated with underground miners' exposure to diesel

exhaust but also acknowledged some inadequacies in the exposure and health effects data. Consequently, MSHA asked NIOSH to assist with research and a risk assessment characterizing underground miners' exposure to DPM. In 1992, NIOSH and the National Cancer Institute (NCI) begin an analysis to determine the feasibility of an occupational mortality study of workers exposed to diesel exhaust. The study most directly affects metal and nonmetal miners but has value for any workers exposed to diesel exhaust and potentially the general public. The study proposed a cohort mortality study of underground miners and a nested case-control study of lung cancer. This group of workers was selected because they were exposed to high concentration of diesel engine exhaust, it was possible to make reasonable estimates of past exposure and control for potential confounding variables, and the cohort was large enough to achieve adequate statistical power. With some modifications, NIOSH and NCI determined the study would be feasible.

Diesel exhaust has long been known to contain carcinogenic compounds (e.g., benzene in the gaseous fraction and benzopyrene and nitropyrene in the DPM fraction), and a great deal of research has been conducted to determine if occupational exposure to diesel exhaust actually results in an increased risk of cancer. Evidence that exposure to DPM increases the risk of developing cancer comes from three kinds of studies: human studies, genotoxicity studies, and animal studies.

Industry Coalition Obstructs NIOSH/NCI Study

By 1995, scientists at NCI and NIOSH developed a study protocol and initiated peer review of the protocol. This progress was notable but not necessarily welcome by some mining companies. MSHA had already signaled its intention to regulate miners' exposure to DPM, and the mining allies did not want a government sponsored study that might add to the mounting evidence of the adverse health effects of DPM. The Methane Awareness Resource Group (MARG) Diesel Coalition, led by attorneys from Patton Boggs LLC, launched their assault on the epidemiological study.

MARG Strategy 1: Stop the Study Before It Begins

MARG's first attempt to halt the NIOSH/NCI diesel study began with objections to NIOSH's process for peer reviewers were acting as an advisory committee, as defined by the Federal Advisory Committee Act, but had not been established or administered accordingly. The MARG coalition used this as a reason to file suit in federal court to halt commencement of the study, asserting that the procedural problems compromised the peer review.

MARG also took its allegations to allies in the legislative branch and successfully lobbied to have NIOSH and NCI chastised by lawmakers. In September 1996, the following appeared in a Senate Appropriations Committee Report: "Concerns have been brought to the attention of the Committee regarding the design of a multiyear study…examining the health effects of diesel fumes on workers in underground noncarbon mines. The Committee…urges the Director of NIOSH and the NCI to make certain that the study meets the highest standard of scientific peer review in order to ensure that it provides a definitive answer to the question of whether diesel exhaust adversely affects the health of workers."

To remedy the situation, the NIOSH director transferred responsibility for reviewing the study protocol to a preexisting Federal Advisory Committee, the NIOSH's board of scientific counselors.

If MARG had a bona fide concern about the legitimacy of the original peer reviewers, the director's action should have resolved it. Instead, MARG amended its legal complaint, questioning the Federal Advisory Committee Act legality of NIOSH's board of scientific counselors.

The district court rejected MARG's claims, but the coalition appealed to the US Court of Appeals for the Fifth Circuit. The higher court upheld most of the district court's decision, except they agreed with MARG that NIOSH had failed to file the board of scientific counselors' charter with the appropriate congressional oversight committee.

The appeals court instructed the district court "to determine an appropriate remedy" for the Department of Health and Human Services' charter-filing mistake.

MARG Strategy 2: Control the Release of the Study Findings

A legal brief filed by the Department of Health and Human Services offered a straightforward remedy: file the board of scientific counselors' charter and documents related to the peer review with the appropriate congressional committee. In contrast, a MARG brief filed in 1999 had a punitive tone, urging the district court to take "strong and meaningful" injunctive relief. MARG's brief also included affidavits the coalition had solicited from congressmen William Gooding (R-Pa) and Cass Ballenger (R-NC), the Chairmen of the House Committee and Subcommittee, respectively, with jurisdiction over NIOSH.

In March 2000, the district court ordered NIOSH to: "*submit to the US House of Representatives Committee on Education and the Workforce all Diesel Study data requested by the Committee, as well as all draft reports, publications, and draft results or risk notification materials prepared in connection with the Diesel Study, for review and approval prior to finalizing and release and/or publication and distribution of such materials*" order by Richard T. Haik, US district judge, March 10, 2000.

Understandably, the Department of Health and Human Services appealed the district court's decision, and the court of appeals agreed that the ruling was too extreme. "The district court's order is tantamount to a use injunction because it authorizes the Committee to prevent the study's publication." They reminded the lower court and the litigants that MARG had received notice that the [board of scientific counselors] was reviewing the study protocol and were informed of and invited to every meeting of the [board of scientific counselors] panel. The case was remanded to the district court, which amended its order. This June 2001 court order continues to govern the NIOSH/NCI Diesel Study.

MARG Opposes MSHA DPM Rule

Notwithstanding their efforts to halt the NIOSH/NCI study and then control release of the results, MARG simultaneously attempted to use the pendency of the study as a rationale for halting regulatory action to protect miners' health. In October 1998, MSHA published a proposed rule to protect underground metal and nonmetal miners from DPM. MSHA documented that this population of workers was exposed to extremely high levels of DPM, that the exposures were associated with severe adverse health effects, and that feasible controls (e.g., low-sulfur fuels,

routine engine maintenance, particulate filters, modern engines, and ventilation) were available to protect miners' health.

Health standards promulgated by MSHA, like its sister agency the Occupational Safety and Health Administration (OSHA), must "adequately assure on the basis of the best available evidence that no miner will suffer material impairment of health or functional capacity…even if such miner has regular exposure …for the period of his lifetime." The architects of these laws clearly recognized that scientific knowledge is forever evolving and new information is always on the horizon. These statutes demand action by MSHA and OSHA to protect workers' health when credible evidence of harm exists, even if the exact nature or magnitude of the harm is not fully understood.

For the most part, mining industry representatives opposed the health standard proposed by MSHA. They argued that the scientific evidence justifying the rule was incomplete and accused the agency of acting prematurely. The mining industry representatives often referred to the NIOSH/NCI mortality study and urged MSHA to forego issuing a regulation until its completion. They also went back to their allies in Congress, lobbying to have the following language included in a 1999 House Appropriations Committee report: "The Committee believes that the promulgation of a proposed rule on diesel exhaust should be informed by the ongoing NIOSH/NCI study of Lung Cancer and Diesel Exhaust among Non-Metal Miners."

In writing and at public hearings before Department of Labor officials, MARG representatives reported that they were participating cooperatively with NIOSH and NCI researchers on the diesel study and suggested that their group eagerly awaited the study results. These public remarks and written comments neglected to mention their relentless efforts to halt the study.

MSHA Regulations

OSHA has not yet regulated worker exposure to diesel particulate matter. However, on January 19, 2001, the Mine Safety and Health Administration (MSHA) released a final rule governing diesel particulate exposure at underground metal/nonmetal mines (66 Fed. Reg. 5706 et. Seq., Jan. 19, 2001). *The MSHA health standard is designed to reduce the risks to workers of serious health hazards that are associated with exposure to high concentrations of DPM.* MSHA has concluded that underground workers exposed to current levels of DPM are at excess risk of incurring the following three kinds of material impairment: (1) sensory irritations and respiratory symptoms (including allergenic responses); (2) premature death from cardiovascular, cardiopulmonary, or respiratory causes; and (3) lung cancer (66 Fed. Reg. 5823, Jan. 19, 2001).

According to MSHA's risk assessment, DPM, rather than the gaseous fraction of diesel exhaust, is assumed to be the agent associated with any excess prevalence of lung cancer observed in the epidemiologic studies (66 Fed. Reg. 5774, Jan. 19, 2001). After a comprehensive evaluation of the available scientific evidence, the World Health Organization's International Agency for Research on Cancer concluded in 1996 that: "Carbon black is possibly carcinogenic to humans (Group 2B)." (See also, 66 Fed. Reg. 5820, Jan. 19, 2001.)

The agency's quantitative risk assessment described 47 epidemiological studies, with 41 showing some degree of association between occupational exposure to DPM and lung cancer. The estimates

of excess lung cancer deaths for a working lifetime at the mean full-shift exposure level (i.e., 808 µg/m³ TC) ranged from 83 to 800 per 1000 exposed workers.

DMP is a very small particle in diesel exhaust. Underground employees (e.g., those in mining, construction, and tunneling) who work in areas where diesel-powered equipment is used may be exposed to far higher concentrations of this fine particulate than any other group of workers. The best available evidence indicates that such high exposures put these miners at excess risk of a variety of adverse health effects, including lung cancer. Higher-than-average exposures have also been recorded in individuals who had long-term employment driving diesel-powered equipment, such as over-the-road truck drivers.

For both MSHA and OSHA selecting the appropriate exposure limit is a 2-step process. First, the agency needs to demonstrate that the new health standard will eliminate or reduce a significant risk," which has been interpreted to mean a cancer risk of 1 in 1000 workers. On the basis of this assessment, the scientific evidence will point to an exposure limit that will protect workers to this threshold.

Step 2, however, drives the decision, as the agencies are required to set an exposure limit that is technologically and economically feasible for the industry as a whole. As a result, in some occupational health standards, there remains a significant risk of harm despite the existence or a workplace regulation. In issuing its 2001 standard, MSHA was explicit that it would not eliminate the significant risk of harm to miners but would simply reduce their exposures to levels comparable to those of other highly exposed groups of workers.

MSHA's 2001 diesel standard for underground metal/nonmetal mines establishes an average 8-hour equivalent, full-shift, airborne concentration limit (CL) of 400 µg/m³ of total carbon, effective July 20, 2002 through January 19, 2006. The CL drops to 160 µg/m³ of total carbon, effective January 20, 2006. At this lower full-shift exposure limit, the agency still estimated at least 15 excess lung cancer deaths per 1000 miners exposed over a working lifetime. In assessing the risk, MSHA acknowledged the importance of the NIOSH/NCI study but asserted that in light of the overwhelming existing evidence of adverse health effects, it could not legally wait for the results. MSHA has recently reopened the rule and proposes using elemental carbon as a surrogate for DPM, rather than total carbon because of sampling and analytical difficulties experienced since the interim rule took effect. MSHA's rule drew immediate legal challenge from MARG and some mining companies.

Bush Administration Acquiesces to Industry Demands To Delay The Rule

MARG and other mine operators claimed that MSHA's rule was not feasible, and a sympathetic Bush administration capitulated to the industry. MSHA delayed enforcement of the exposure limit and other provisions and reopened the rule to propose a number of changes favored by the industry. MSHA also asked for public comment on "an appropriate DPM limit," signaling a willingness to revisit its determination that the 160 µg/m³ TC exposure limit was feasible for the mining industry. The public record was open until late October 2003, and the industry used the opportunity to press for changes that would weaken the existing rule.

MSHA received input from 14 organizations during the comment period, but noticeably absent from the submissions were comments from NIOSH or NCI. The researchers involved in the diesel study may have wanted to prepare a rebuttal; however, under an order issued by the federal district court in June 2001 (order by Richard T. Haik, US district judge, June 5, 2001), NIOSH would have been required to submit its comments first (and at least 90 days in advance) to the House of Representatives. MSHA's comment period was only open 45 days. The government scientists most capable of responding to the MARG-sponsored report were excluded from the process.

Assaults by MARG Influence MSHA Action, Miners' Health Suffers

For nearly a decade, an alliance of mining firms, led by the MARG Diesel Coalition, has employed a variety of tactics to impede scientific research on and public health protections for workers exposed to high levels of DPM. The tactics include the following: (1) Using the courts to delay progress on epidemiological studies and to impose unprecedented demands on public health scientists for advance access to date and documents; (2) Appealing to members of Congress, receiving assistance and endorsements from legislators for their campaign to oppose health protections for workers; and, (3) Using all means to access agency officials to advance their views and reiterate their claims of scientific uncertainty and regulatory infeasibility.

Diesel Particulate Case Study

In an industrial hygiene survey of 27 underground metal and nonmetal mines, the US Department of Labor's Mine Safety and Health Administration (MSHA) recorded 8-hour time-weighted average exposures (i.e., personal exposures) ranging from 100 µg/m³ TC (where TC = total carbon) to more than 3500 µg/m³ TC. Samples collected in different production areas of the mine (i.e., area samples) revealed similar results. The mean full-shift exposure in the production area of these 27 mines was 808 µg/m³ TC. In comparison, in 12 California communities, mean annual average exposures to particulate matter less than 2.5 µm in diameter ranged from 5 to 30 µg/m³.

A variety of adverse health effects are associated with exposure to diesel exhaust and particulate matter, from acute short-term effects to cancer and cardiovascular and cardiopulmonary disease. The evidence for excess risk of lung cancer includes studies of railroad workers, workers in the trucking industry, and other workers exposed to diesel emissions. The evidence linking exposure to diesel exhaust and particulate matter to adverse health effects continues to mount.

MARG success is not without consequences. At some metal and nonmetal mines, in particular those affiliated with MARG, workers are being exposed to extremely high levels of DPM despite a regulation that requires employers to reduce that exposure. At one gold mine, full-shift exposures are as high as 994 µg/m³ TC. At another, the sample results ranged from 660 µg/m³ TC to 1940 µg/m³ TC. Although these exposures are well above the permissible level, there is no record of an MSHA citation for these violations. Could it be that MARG's watchful eye makes MSHA uneasy about enforcing the DPM standard?

At mines not associated with MARG, however, the situation for DPM-exposed miners has improved. A salt mine near Wichita, Kansas for example, has reduced DPM exposures to the 40- to 80-µg/m³ TC range, compared with concentrations as high as 700 µg/m³ TC when MSHA's rule first took effect. This mine operator now uses soy-based fuel to run his underground equipment

(personal telephone communication between Celeste Monforton and Max Lily, Hutchinson Salt Company, May 12, 2002). Other companies have realized similar success with alternative fuels, filters, ventilation, and new engines.

Feasible Controls

MSHA documented that the population of workers exposed to extremely high levels of DPM, that the exposures were associated with severe adverse health effects, and that feasible controls (e.g., low-sulfur fuels, routine engine maintenance, particulate filters, modern engines, environmental cabs, and ventilation) were available to protect miners' health

The Supreme Court has interpreted "feasible" in the OSH Act as meaning "capable of being done, executed, or effected," both technologically and economically. In order for its rules to be deemed feasible, an agency must establish "a reasonable possibility that the typical firm will be able to develop and install engineering and work practice controls that can meet the [permissible exposure limit] in most of its operations." Given that feasibility determinations involve complex judgments about science and technology, our standard of review is deferential: the agency is "not obliged to provide detailed solutions to every engineering problem," but only to "give plausible reasons for its belief that the industry will be able to solve those problems in the time remaining." The fact that "a few isolated operations within an industry" will not be able to comply with the standard does not undermine a showing that the standard is generally feasible.

In the 2006 Rules, MSHA determined that several types of DPM control technologies were more widely available than the agency had previously thought. For example, the agency noted that by 2005, several mines were using biodiesel fuel, which reduces DPM emissions from diesel engines.

For its rules to be upheld, MSHA does not need to show that *every* technology can be use in *every* mine. The agency must only demonstrate a "reasonable possibility" that a "typical firm" can meet the permissible exposure limits in "most of its operations."

MSHA Explained that: "As we have maintained throughout this rulemaking, mine operators should determine the control or combination of controls that will be best suited to their mine-specific circumstances and conditions, and that controls need to be evaluated, selected, and implemented on a case-by-case application basis."

Use of Low-Sulfur Fuels (Biodiesel)

Air quality is a critical issue for workers who use diesel engines in confined spaces, and using biodiesel fuel in mining equipment is one way to help protect their health. Today, the Kansas Soybean Commission (KSC), Hutchinson Salt Company and National Biodiesel Board (NBB) hosted a tour of the salt company's mine in Hutchinson, Kansas. The Hutchinson Salt Co. is the first mine of any kind to use B100 (100 percent biodiesel).

Biodiesel is a renewable, alternative fuel to petroleum diesel, and is made from soybeans grown in the United States as well as other fats and vegetable oils. It burns cleaner, reduces emissions like particulate matter by 47 percent and cuts carcinogens 80-90 percent. Biodiesel is sulfur-free, non-flammable and biodegrades faster than sugar.

"We use B100 biodiesel in everything underground that runs on diesel," said Max Liby, VP of Manufacturing for the mine. "The main benefit is we've cleaned up soot in the air and have cut particulates. Workers, particularly the operators of the loaders, like the soy biodiesel much better because they say particulates do no get in their nostrils and the air is noticeably cleaner. Also, lubricity is much greater than if we used regular diesel fuel, so the injector pumps and injectors work more efficiently. The soy biodiesel actually cleans the injectors," he said.

Hutchinson Salt Co. began using biodiesel in June 2003, and used 31,229 gallons of B100 in the first year.

"Biodiesel is a great fuel for use inside mines," said Harold Kraus, soybean farmer and NBB Director. "It is made from a natural product, so the air mine workers breathe from B100 is also natural. Besides cutting emissions, biodiesel also has a pleasant odor when it burns," he said.

Soybeans are important to Kansas not only for the vegetable oil biodiesel comes from, but also for the animal industry, as Kansas is the largest producer of packed beef in the United States," Kraus said. "The animal industry is the largest user of soybean meal, for its feed, plus the waste fat from animals can be made into biodiesel," he said.

Biodiesel is the first and only alternative fuel to have fully completed the Health Effects testing requirements of the Clean Air Act. Dr. Bailus Walker, MPH, past president of the American Lung Association of Washington, D.C., said, "There is a recognition that petroleum-based products, with their toxins, are affecting the health of the people. There's no question about it; the epidemiological data is there, and it is solid. We need to explore in a more aggressive way alternative fuels. I would strongly recommend, as a health professional, we take a hard look at what is being accomplished with biodiesel."

The salt mine is one of more than 500 fleets using biodiesel. That number is expected to continue to rise, in part due to a biodiesel tax incentive bill that will take effect as law on January 1, 2005. The tax incentive should make biodiesel more accessible to the general public as it will significantly narrow the cost gap between biodiesel and regular diesel fuel, which will in turn fuel demand and supply.

Other biodiesel users include the Missouri Department of Transportation, all four branches of the military, NASA, Harvard University, the National Park Service, U.S. Postal Service, L.L. Bean and others. About 300 retail filling stations make various biodiesel available to the public, and more than 1,000 petroleum distributors carry it nationwide. Biodiesel offers similar fuel economy, horsepower and torque to petroleum diesel while providing superior lubricity.

The Hutchinson Salt Company's main product is highway salt for inclement weather. Clients include the states of Missouri, Kansas, Oklahoma, Iowa and Illinois, and the city of Chicago.

Particulate Filters & Filtration Systems

MSHA acknowledged that mine operators had problems using filters in the past, but the agency emphasized that filters are a highly effective tool for controlling DPM if they are properly selected, installed, and maintained. MSHA extensively discussed the pros and cons of all currently-available

filtering technologies, and it determined that several newer models of filters "are not subject to many of the difficult implementation issues that have slowed the adoption of some DPM controls. MSHA stated that it will continue to provide "extensive information" to mine operators about the proper procedures for selecting, installing, and maintaining their filtration systems. In summary, the agency concluded that "the mining industry as a whole can reduce DPM levels to the 2001 final limit of 160 $\mu g/m^3$ TC by May 20, 2008."

Modern Engines

Several commentors stated that the mines have been replacing older, dirtier engines with newer, EPA Tier engines. The EPA Tier engine requirements force engine manufacturers to build engines that comply with more stringent emission standards for NOx, DPM, and CO over a time period. The Tier schedule normally requires the larger horsepower engines to meet more stringent emission standards first, then the smaller horsepower engines. At this time, all new engines being sold in the United States in all horsepower ranges are meeting a minimum of a Tier 2 EPA emission standard.

MSHA agrees that this trend which the mine operators are following to replace older engines has been a feasible approach to reduce DPM exposure to meet the interim limit. However, in order to meet the final limit, mine operators must continue to evaluate their engine inventories to determine which engines need to be replaced as they become older, and new cleaner engines are available.

Environmental Cabs

Environmental cabs are a proven means to reduce worker exposure to DPM. While much of the construction-type equipment used in underground stone mines comes equipped with environmental cabs, the cabs on specialty mining equipment used in underground hard rock mining are less common, particularly in mines with narrow drifts or low seam heights. As mine operators realize the benefits of cabs, more and more pieces of equipment are being purchased or retrofitted with environmental cabs. These cabs provide protection for workers not only from diesel particulate but also from noise and dust.

Ventilation

All underground metal/nonmetal mines rely on ventilation to dilute and carry away diesel particulate matter and toxic gases as well as to provide fresh air to the miners. Based on the comments received from mine operators and from MSHA's own observations during mine inspections and compliance assistance mine visits, it is clear that ventilation is a key component of nearly every mine's DPM control strategy.

One commenter from a gold mine in Nevada stated that, "Ventilation is near its capacity. Further increases are likely to create fugitive dust problems from haulage vehicles." Another commented addressing conditions at a different multilevel metal mine indicated that increasing airflows in that mine's small and widely distributed working places would be difficult. Another commenter from a mining industry organization stated that a notable characteristic of underground stone mines is their large open spaces (room and pillar mining) that are ventilated naturally. To introduce forced ventilation in mines presently ventilated naturally would entail enormous costs in mine structures that would be needed to direct the ventilation inside the mine.

At many high-back room-and-pillar stone mines, MSHA observed ventilation systems that were characterized by (1) inadequate main fan capacity (or no main fan at all), (2) ventilation control structures (air walls, stoppings, curtains, regulators, air doors, brattices, etc.) that are poorly positioned, in poor condition, or altogether absent, (3) free standing booster fans that are too few in number, too small in capacity, and located inappropriately, and (4) no auxiliary ventilation for development ends (working faces). At some mines, the "piston effect" of trucks traveling along haul roads underground, along with natural ventilation pressure, provide the primary or only driving forces to move air.

MSHA Sampling Methods

MSHA inspectors determine compliance by analyzing a single sample drawn from active working areas. The compliance officer samples for DPM using a respirable dust sampler equipped with a submicrometer impactor, and analyzes the sample using the NIOSH 5040 method or "any methods of collection and analysis subsequently determined by NIOSH to provide equal or improved accuracy" for the measurement of DPM [30 CFR Part 57.5061 (b)]. The MSHA rule also provides that diesel fuel used to power equipment in underground areas may not have a sulfur content greater than 0.05 percent.

Because of the similarities in heavy equipment and working conditions between some underground mines and construction equipment and tunneling operations, construction companies should ensure that workers are not overexposed to DPM above 160 $\mu g/m^3$.

MSHA reasonably chose to use TC as a surrogate for DPM. Based on the results of several studies, MSHA determined that TC "accounts for 80-85% of the total DPM concentration when low sulfur fuel is used." The agency also noted that the "NIOSH 5040" method of analysis measures TC with "accuracy, precision, and sensitivity necessary to use in compliance sampling for DPM." Noting that samples taken pursuant to the NIOSH 5040 method meet NIOSH's "accuracy criterion" because they "come with 25 percent of the true TC concentration at least 95 percent of the time." Given that TC and DPM were tightly correlated, and MSHA had a reliable method of determining the amount of TC in a sample, it was not per se unreasonable for MSHA to use TC as a surrogate for DPM. However, as MSHA recognized in its 2001 Rules, TC is not always a perfect surrogate for DPM because TC measurements can be sensitive to interferences from other carbon-based sources, such as oil mist and tobacco smoke. MSHA has clearly stated in its rules that TC can still serve as a consistent and reliable surrogate for DPM as long as samples are taken in areas away from tobacco smoke and oil mist. Noting that cigarette smoke is "under the control" of mine operators, and therefore it can be prohibited during sampling periods; and that samples should be taken "upwind" of drilling that produces oil mist.

MSHA Hierarchy of Controls

Section 57.5060(e) prohibits the use of personal protective equipment to comply with the concentration limits; and Section 57.5060(f) prohibits the use of administrative controls to comply with the concentration limits.

MSHA is confident that feasible technology exists to reduce miners' exposures to DPM to the final limit my May 2008. Although most mines can feasibly comply with the existing DPM final limit of

308 µg/m³EC MSHA expects that some miners will continue to have to wear respiratory protection under the final limit of 160 µg/m³TC. By phasing in the 160 µg/m³TC final limit over two years, MSHA believes that many existing compliance difficulties can be successfully resolved as mine operators as mine operators are able to access alternative fuels and become more adept and familiar with DPFs (Diesel Particulate Matter Filters).

Other MSHA DPM Related Regulations

- Section 57.5060(a), addressing the interim concentration limit of 400 micrograms of total carbon per cubic meter of air;
- Section 57.5061, addressing compliance determinations
- Section 57.5071, addressing environmental monitoring;
- Section 57.5065, Fueling and idling practices;
- Section 57.5066, Maintenance standards;
- Section 57.5067, Engines;
- Section 57.5070, Miner training;
- Section 57.5075, Diesel particulate records;
- Section 57.5060(d), permitting miners to work in areas where the level of diesel particulate matter exceeds the applicable concentration limit with advance approval from the Secretary; and
- Section 57.5062, addressing the control plan.

Written Respiratory Program Requirements

A written respiratory protection program must be established when respiratory protection is needed. It must include worksite-specific procedures covering the following minimum program elements:

- Procedures for selection of proper respiratory-protective equipment including exposure assessment
- Procedures for medical evaluation of respirator wearers
- Procedures for fit testing of workers using tight-fitting respirators
- Procedures for proper respirator use during routine and reasonable foreseeable emergency situations

- Procedures and schedules for cleaning, disinfecting, storing, inspection, repairing, and discarding respirators

- Procedures to ensure adequate air quality, quantity, and flow of breathing air for atmosphere-supplying respirators

- Procedures for training workers on respirator use and respiratory hazards

- Procedures for regular program evaluation

In addition, a program administrator must be appointed to manage the program.

Both OSHA and MSHA standards require that these points be addressed. The American National Standard for Respiratory Protection, Z88.2-1992, is a voluntary consensus standard for the proper use of respiratory-protective equipment. This standard is published by the American National Standards Institute (ANSI). It specifies similar points for a program, but it enumerates them slightly differently. It is highly recommended that the American National Standard be consulted as well as the OSHA regulation. Specific OSHA regulations for General Industry and Construction are found in 29 CFR Part 1910.134. Specific MSHA regulations are found in 30 CFR Parts 56, 57 or 75; Subpart D—Air Quality and Physical Agents.

Summary

The material presented in this session is intended for persons concerned with establishing and maintaining a safety and health program concerning worker exposure to diesel particulate matter. It presented certain basic information for guidance purposes. However, it is not intended to be all-inclusive in content or scope. Simplified interpretations of certain federal regulations pertaining to the various subtitles were presented in this session. While these interpretations convey background information about the regulations, under no circumstances should they be used as the sole basis of a diesel particulate matter safety and health program. In all cases, the current federal regulations (whether you are under MSHA or OSHA regulations) as published in the Federal Register and later collected in the Code of Federal Regulations, should be carefully studied, and the rules and procedures in those regulations explicitly followed. Only they define the specific requirements that are in force. For additional information the reader should refer to the Bibliography.

It has been 10 years since NIOSH/NCI developed the protocol for the miners' mortality study. MARG succeeded in its effort to delay progress on the study and will now have an unprecedented opportunity to influence the content and release of the findings. Meanwhile, a legally promulgated DPM standard is on the books but enforced inconsistently by MSHA. The posturing by MARG, some mining companies, and MSHA goes on in air-conditioned offices while underground miners continue to breathe the highest level of diesel exhaust of any workers in the country.

It is the presenter's opinion that planning is the key to any project with safety and health of all personnel being elevated to the same level as engineering, budget, quality control, and scheduling. First and foremost the mine operator must adopt the mind set that they in fact want to resolve the issue of over exposure of their workers to diesel particulate matter. It is this presenter's opinion that the most practical and effective DPM controls that are available, such as DP filters/filtration

systems, low sulfur fuels, ventilation upgrades, improved maintenance procedures, enclosed environmental cabs with filtered breathing air, low-emission engines, and various work practices and administrative controls have the potential to achieve DPM exposures permitted by law. MSHA has consistently advised the industry that DPM controls should be selected based on a thorough analysis of the circumstances and conditions at each mine. There is no "one size fits all" solution to resolving the DPM exposure issue.

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