operator may keep the record elsewhere if the record is immediately accessible from the mine site by electronic transmission.

(2) Upon request from an authorized representative of the Secretary of Labor, the Secretary of Health and Human Services, or from the authorized representative of miners, mine operators must promptly provide access to any such training record. Whenever an operator ceases to do business, that operator must transfer the training records, or a copy, to any successor operator who must maintain them for the required period.

§ 72.520 Diesel equipment inventory.

(a) The operator of each mine that utilizes diesel equipment underground, shall prepare and submit in writing to the District Manager, an inventory of diesel equipment used in the mine. The inventory shall include the number and type of diesel-powered units used underground, including make and model of unit, type of equipment, make and model of engine, serial number of engine, brake horsepower rating of engine, emissions of engine in grams per hour or grams per brake horsepower-hour, approval number of engine, make and model of aftertreatment device, serial number of aftertreatment device if available, and efficiency of aftertreatment device.

(b) The mine operator shall make changes to the diesel equipment inventory as equipment or emission control systems are added, deleted or modified and submit revisions, to the District Manager, within 7 calendar days.

(c) If requested, the mine operator shall provide a copy of the diesel equipment inventory to the representative of the miners within 3 days of the request.

[FR Doc. 01–995 Filed 1–18–01; 8:45 am]

BILLING CODE 4510–43–P

DEPARTMENT OF LABOR

Mine Safety and Health Administration

30 CFR Part 57

RIN 1219–AB11

Diesel Particulate Matter Exposure of Underground Metal and Nonmetal Miners

AGENCY: Mine Safety and Health Administration (MSHA), Labor.

ACTION: Final rule.

SUMMARY: This rule establishes new health standards for underground metal and nonmetal mines that use equipment powered by diesel engines.

This rule is designed to reduce the risks to underground metal and nonmetal miners of serious health hazards that are associated with exposure to high concentrations of diesel particulate matter (dpm). DPM is a very small particle in diesel exhaust. Underground miners are 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.

The final rule for underground metal and nonmetal mines would establish a concentration limit for dpm, and require mine operators to use engineering and work practice controls to reduce dpm to that limit. Underground metal and nonmetal mine operators would also be required to implement certain ‘‘best practice’’ work controls similar to those already required of underground coal mine operators under MSHA's 1996 diesel equipment rule. These operators would also be required to train miners about the hazards of dpm exposure.

By separate notice, MSHA has published a rule to reduce dpm exposures in underground coal mines.

DATES: The provisions of the final rule are effective March 20, 2001. However, §57.5060 (a) will not apply until July 19, 2002 and §57.5060 (b) will not apply until January 19, 2006.

FOR FURTHER INFORMATION CONTACT: David L. Meyer, Director, Office of Standards, Regulations, and Variances, MSHA, 4015 Wilson Boulevard, Arlington, VA 22203–1984. Mr. Meyer can be reached at dmeyer@msha.gov (Internet E-mail), 703–235–1910 (voice), or 703–235–5551 (fax). You may obtain copies of the final rule in alternative formats by calling this number. The alternative formats available are either a large print version of the final rule or the final rule in an electronic file on computer disk. The final rule also is available on the Internet at http://www.msha.gov/REGSINFO.HTM.

SUPPLEMENTARY INFORMATION:

I. Overview of the Final Rule

This Part: (1) Summarizes the key provisions of the final rule; and (2) summarizes MSHA's responses to some of the fundamental questions raised during the rulemaking proceeding—the need for the rule, the ability of the agency to accurately measure diesel particulate matter (dpm) in underground metal and nonmetal mine environments, and the feasibility of the requirements for this sector of the mining industry.

(1) Summary of Key Provisions of the Final Rule

The final rule applies only to underground areas of underground metal and nonmetal mines.

The final rule requires operators: (A) To observe a concentration limit where miners normally work or travel by the application of engineering controls, with certain limited exceptions, compliance with which will be determined by MSHA sampling; (B) to observe a set of best practices to minimize dpm generation; (C) to limit engines newly introduced underground to those meeting basic emissions standards; (D) to provide annual training to miners on dpm hazards and controls; and (E) to conduct sampling as often as necessary to effectively evaluate dpm concentrations at the mine. A list of effective dates for the provisions of the rule follows this summary.

(A) Observe a limit on the concentration of dpm in all areas of an underground metal or nonmetal mine where miners work or travel, with certain specific exceptions. The rule would limit dpm concentrations to which miners are exposed to about 200 micrograms per cubic meter of air—expressed as 200_{DPM} µg/m ^{3}. However, the rule expresses the limit so as to reflect the measurement method MSHA will be using for compliance purposes to determine dpm concentrations. That method is specified in the rule itself. As discussed in detail in response to Question 2, the method analyzes a dust sample to determine the amount of total carbon present. Total carbon comprises 80–85% of the dpm emitted by diesel engines. Accordingly, using the lower boundary of 80%, a concentration limit of 200_{DPM} µg/m ^{3} can be achieved by restricting total carbon to 160_{TC} µg/m ^{3}. This is the way the standard is expressed:

> After January 19, 2006 any mine operator covered by this part shall limit the concentration of diesel particulate matter to which miners are exposed in underground areas of a mine by restricting the average eight-hour equivalent full shift airborne concentration of total carbon, where miners normally work or travel, to 160 micrograms per cubic meter of air (160_{TC} µg/m ^{3}).

All underground metal and nonmetal mines would be given a full five years to meet this limit, which is referred to in this preamble as the ‘‘final’’ concentration limit. However, starting July 19, 2002, underground metal and nonmetal mines have to observe an ‘‘interim’’ dpm concentration limit—expressed as a restriction on the concentration of total carbon of 400 micrograms per cubic meter (400_{TC} µg/m[3]). The interim limit would bring the concentration of whole dpm in underground metal and nonmetal mines to which miners are exposed down to about 500 micrograms per cubic meter. No limit at all on the concentration of dpm is applicable for the first eighteen months following promulgation. Instead, this period would be used to provide compliance assistance to the metal and nonmetal mining community to ensure it understands how to measure and control diesel particulate matter concentrations in individual operations.

In general, a mine operator has to use engineering or work practice controls to keep dpm concentrations below the applicable limit. The use of administrative controls (*e.g.,* the rotation of miners) is explicitly barred. The use of personal protective equipment (*e.g.,* respirators) is also explicitly barred except in two situations noted below. An operator can filter the emissions from diesel-powered equipment, install cleaner-burning engines, increase ventilation, improve fleet management, or use a variety of other readily available controls; the selection of controls is left to the operator's discretion.

Special extension. The rule provides that if an operator of a metal or nonmetal mine can demonstrate that there is no combination of controls that can, due to technological constraints, be implemented by January 19, 2006, MSHA may approve an application for an additional extension of time to comply with the dpm concentration limit. Such a special extension is available only once, and is limited to 2 years. To obtain a special extension, an operator must provide information in the application adequate for MSHA to ensure that the operator will: (a) Maintain concentrations at the lowest limit which is technologically achievable; and (b) take appropriate actions to minimize miner exposure (*e.g.,* provide suitable respiratory protection during the extension period).

It is MSHA's intent that primary responsibility for analysis of the operator's application for a special extension will rest with MSHA's district managers. District managers are the most familiar with the conditions of mines in their districts, and have the best opportunity to consult with miners as well. At the same time, MSHA recognizes that district managers may need assistance with respect to the latest technologies and solutions being used in similar mines elsewhere in the country. Accordingly, the Agency intends to establish within its Technical Support directorate in Arlington, Va., a special panel to consult on these issues, to provide assistance to district managers, and to give final approval of any application for a special extension.

Special rule for employees engaged in inspection, maintenance or repair activities. The final rule provides that with the advance approval of the Secretary, employees engaged in such activities may work in concentrations of dpm exceeding the applicable concentration limit. However, the Secretary may only approve such work under three circumstances: when the activities are to be conducted are in areas where miners work or travel infrequently or for brief periods of time; when the miners work exclusively inside enclosed and environmentally controlled cabs, booths and similar structures with filtered breathing air; or when the miners work in shafts, inclines, slopes, adits, tunnels and similar workings that are designated as return or exhaust air courses and that are used for access into the mine or egress from the mine. Moreover, to approve such an exception, the Secretary must determine that it is not feasible to reduce the concentration of dpm in these areas, and that adequate safeguards (including personal protective equipment) will be employed to minimize the dpm exposure of the miners involved.

An operator plan providing such details must be submitted; it is MSHA's intent to review these in the same manner as applications for a special extension. Such plans can only be approved for one year, but may be resubmitted each year.

Compliance determinations with concentration limit. Measurements to determine noncompliance with the dpm concentration limit will be made directly by MSHA, rather than having the Agency rely upon operator samples. Under the rule, a single Agency sample, using the sampling and analytical method prescribed by the rule, is explicitly deemed adequate to establish a violation.

The rule requires that if an underground metal or nonmetal mine exceeds the applicable limit on the concentration of dpm, a diesel particulate matter control plan must be established and remain in effect for 3 years. The purpose of such plans is to ensure that the mine has instituted practices that will demonstrably control dpm levels thereafter. Reflecting current practices in this sector, the plan does not have to be preapproved by MSHA. The plan must include information about the diesel-powered equipment in the mine and applicable controls. The rule requires operator sampling to verify that the plan is effective in bringing dpm levels down below the applicable limit, using the same sampling and analytical methods as MSHA, with the records kept at the mine site with the plan to facilitate review. Failure of an operator to comply with the requirements of the dpm control plan or to conduct adequate verification sampling is a violation of the rule; MSHA is not be required to sample to establish such a violation.

(B) *Observe best practices.* The rule requires that operators observe the following best practices to minimize the dpm generated by diesel-powered equipment in underground areas:

- Only low-sulfur (0.05% or less) diesel fuel may be used. The rule does not at this time require the use of ultra-low sulfur fuel by the mining community. MSHA is aware that the Environmental Protection Agency issued final regulations addressing emissions standards (December 2000) for new model year 2007 heavy-duty diesel engines and the low-sulfur fuel rule. The regulations require ultra-low sulfur fuel be phased in during 2006–2010.
- Only EPA-approved fuel additives may be used.
- Approved diesel engines have to be maintained in approved condition; the emission related components of non-approved engines have to be maintained in accordance with manufacturer specifications; and any installed emission devices have to be maintained in effective operating condition.
- Equipment operators are authorized and required to tag equipment with potential emissions-related problems, and tagged equipment has to be promptly referred for a maintenance check by persons qualified by virtue of training or experience to perform the maintenance.

(C) *Limit newly introduced engines to those meeting basic emission standards.* The rule requires that, with the exception of diesel engines used in ambulances and fire-fighting equipment, any diesel engines added to the fleet of an underground metal or nonmetal mine after January 19, 2001 must either be an engine approved by MSHA under Part 7 or Part 36, or an engine meeting certain EPA requirements on particulate matter specified in the rule. Since not all engines are MSHA approved, this ensures a wide variety of choice in meeting the engine requirements of this rule.

(D) *Provide annual training to miners on dpm hazards and controls.* Mines using diesel-powered equipment must annually train miners exposed to dpm in the hazards associated with that exposure, and in the controls being used by the operator to limit dpm concentrations. An operator may propose including this training in the Part 48 training plan.

(E) *Conduct sampling as often as necessary to effectively evaluate dpm concentrations at the mine.* The purpose of this requirement is to assure that operators are familiar with current dpm concentrations so as to be able to protect miners. Since mine conditions vary, MSHA is not requiring a specific schedule for operator sampling, nor a specific sampling method. The Agency will evaluate compliance with this sampling obligation by reviewing evidence of operator compliance with the concentration limit, as well as information retained by operators about their sampling. Consistent with the statute, the rule requires that miners and their representatives have the right to observe any operator monitoring—including any sampling required to verify the effectiveness of a dpm control plan.

Summary of Effective Dates. As of March 20, 2001, operators must comply with the requirement that new engines added to a mine's inventory be either MSHA approved or meet the listed EPA standards.

As of March 20, 2001, underground metal and nonmetal mine operators must comply with the requirement to provide basic hazard training to miners who are exposed underground to dpm and the best practice requirements listed above under (B).

As of July 19, 2002, underground metal and nonmetal mine operators must also comply with the interim dpm concentration limit of 400 micrograms of total carbon per cubic meter of air.

Finally, as of January 19, 2006, all underground metal and nonmetal mines have to comply with a final dpm concentration limit.

MSHA intends to provide considerable technical assistance and guidance to the mining community before the various requirements go into effect, and be sure MSHA personnel are fully trained in the requirements of the rule. A number of actions have already been taken toward this end. The Agency held workshops on this topic in 1995 which provided the mining community an opportunity to share advice on how to control dpm concentrations. The Agency has published a ''toolbox'' of methods available to mining operators to achieve reductions in dpm concentration, often referred to during the rulemaking proceedings. MSHA also developed a computer spreadsheet template which allows an operator to model the application of alternative engineering controls to reduce dpm, which it has published in the literature and disseminated to the mining community. The Agency is committed to issuing a compliance guide for mine operators providing additional advice on implementing the rule.

A note on surface mines. Surface areas of underground mines, and surface mines, are not covered by this rule. In certain situations the concentrations of dpm at surface mines may be a cause for concern: *e.g.,* production areas where miners work in the open air in close proximity to loader-haulers and trucks powered by older, out-of-tune diesel engines, shops, or other confined spaces where diesel engines are running. The Agency believes, however, that these problems are currently limited and readily controlled through education and technical assistance. The Agency would like to emphasize, however, that surface miners are entitled to the same level of protection as other miners; and the Agency's risk assessment indicates that even short-term exposures to concentrations of dpm like those observed may result in serious health problems. Accordingly, in addition to providing education and technical assistance to surface mines, the Agency will also continue to evaluate the hazards of diesel particulate exposure at surface mines and will take any necessary action, including regulatory action if warranted, to help the mining community minimize any hazards.

(2) Summary of MSHA's Responses to Several Fundamental Questions About This Rule

During the rulemaking proceeding, the mining community raised some fundamental questions about: (A) The need for the rule; (B) the ability of the agency to accurately measure diesel particulate matter (dpm) in underground metal and nonmetal mine environments; and (C) the feasibility of the requirements for this sector of the mining industry. MSHA gave serious considerations to these questions, has made some adjustments in the final rule and its economic assessment as a result thereof, and has provided detailed responses in this preamble. These responses are briefly summarized here.

(A) *The need for the rule.* MSHA has to act in accordance with the requirements of the Mine Safety and Health Act. Section 101(a)(6)(A) of the Act specifies that any health standard must:

> * * * [A]dequately 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 to the hazards dealt with by such standard for the period of his working life.

The Mine Act also specifies that the Secretary of Labor (Secretary), in promulgating mandatory standards pertaining to toxic materials or harmful physical agents, base such standards upon:

> * * * [R]esearch, demonstrations, experiments, and such other information as may be appropriate. In addition to the attainment of the highest degree of health and safety protection for the miner, other considerations shall be the latest available scientific data in the field, the feasibility of the standards, and experience gained under this and other health and safety laws. Whenever practicable, the mandatory health or safety standard promulgated shall be expressed in terms of objective criteria and of the performance desired. [Section 101(a)(6)(A)].

Thus, the Mine Act requires that the Secretary, in promulgating a standard, based on the best available evidence, attain the highest degree of health and safety protection for the miner with feasibility a consideration. (More information about what constitutes ''feasibility'' is discussed below in item C).

In proposing this rule, MSHA sought comment on its risk assessment, which it published in full as part of the preamble to the proposed rule. In that risk assessment, the agency carefully laid out the evidence available to it, including shortcomings inherent in that evidence. Although not required to do so by law, MSHA had this risk assessment independently peer reviewed, and incorporated the reviewers recommendations. The reviewers stated that:

> * * * principles for identifying evidence and characterizing risk are thoughtfully set out. The scope of the document is carefully described, addressing potential concerns about the scope of coverage. Reference citations are adequate and up to date. The document is written in a balanced fashion, addressing uncertainties and asking for additional information and comments as appropriate. (Samet and Burke, Nov. 1997).

Based on the information in that risk assessment, the agency made some tentative conclusions. First, its tentative conclusion that miners are exposed to far higher concentrations of dpm than anybody else. The agency noted that median concentrations of dpm had been observed in individual dieselized metal and nonmetal underground mines up to 180 times as high as average environmental exposures in the most heavily polluted urban areas and up to 8 times as high as median exposures estimated for the most heavily exposed workers in other occupational groups. Moreover, MSHA noted its tentative conclusion that exposure to high concentrations of dpm can result in a variety of serious health effects. These health effects include: (i) Sensory irritations and respiratory symptoms serious enough to distract or disable miners; (ii) premature death from cardiovascular, cardiopulmonary, or respiratory causes; and (iii) lung cancer. After a review of all the evidence, MSHA tentatively concluded that:

(1) The best available evidence is that the health effects associated with exposure to dpm can materially impair miner health or functional capacity.

(2) At levels of exposure currently observed in underground mining, many miners are presently at significant risk of incurring these material impairments over a working lifetime.

(3) The reduction in dpm exposures that is expected to result from implementation of the rule proposed by the agency for underground metal and nonmetal mines would substantially reduce the significant risks currently faced by underground metal and nonmetal miners exposed to dpm.

During the hearings and in written comments, some representatives of the mining industry raised a number of objections to parts of MSHA's proposed risk assessment, thus questioning the scientific basis for this rulemaking. It has been asserted that MSHA's observations of dpm concentrations in underground metal and nonmetal mines do not accurately represent exposures in the industry. It has been asserted that if dpm concentrations are not this high in general, or only on an intermittent basis, then the agency is incorrect in determining that the conditions in these mines put miners at significant risk of material impairment of their health. Moreover it has been asserted that there is insufficient evidence to establish a causal connection between dpm exposure and significant adverse health effects, that the agency has no hard evidence that reducing exposures to a particular level will in fact reduce the risks, and that it has no rational basis for selecting the concentration limit it did. In addition, it has been asserted that the risks of dpm exposure at any level are not well enough established to provide the basis for regulation at this time, and that action should be postponed pending the completion of various studies now underway that might shed more light on these risks.

MSHA has carefully evaluated all of these comments, and the evidence submitted in support of these positions. The agency's risk assessment has been modified as a result.

Exposures of underground metal and nonmetal miners. MSHA has clarified the charts of exposure measurements in Part III of this preamble to ensure that they fully reflect all studies in the record.

MSHA has not and does not claim that the actual exposure measurements in the record are a random or fully representative sample of the industry. What they do show is that exposures far higher than those which have been observed in other industries can and do occur in an underground mining environment.

Moreover, MSHA also placed into the record of the proposed rule several studies it had recently conducted in which dpm concentrations for several underground metal and nonmetal mines were estimated based upon the actual equipment and dpm controls currently available in those mines. Those simulations were performed using a software tool known as the Estimator (described in detail in an appendix to Part V of the preamble of the proposed rule, and since published in the literature (Haney and Saseen, April 2000). These studies of specific mines demonstrated that the type of equipment found in such mines, even after the application of current ventilation and controls, can be expected to produce localized high concentrations of dpm. The agency acknowledged that these simulations were conducted in mines that were not typical for the industry (they were chosen because the agency thought dpm concentrations might be particularly difficult to control in these mines, which turned out not to be the case); nevertheless, they indicate what is likely to be the case in at least some sections of many underground metal and nonmetal mines. To the extent that an individual mine has no covered mining areas with concentrations higher than those observed in other industries, it will not be impacted by the concentration limit established through this rulemaking. That is because the rule does not eliminate exposures, or even to reduce them to a safe level, but only to reduce them to the levels observed in other industries.

The nature of risks associated with dpm exposure. Although there were some commenters who suggested that symptoms reported by miners working around diesel equipment might be due to the gases present rather than dpm, there was nothing in the comments that changed MSHA's conclusions about the health problems associated with dpm exposure.

There are a number of studies quantifying significant adverse health effects—as measured by lost work days, hospitalization and increased mortality rates—suffered by the general public when exposed to concentrations of fine particulate matter like dpm far lower than concentrations to which some miners are exposed. The evidence from these fine particulate studies was the basis for recent rulemaking by the Environmental Protection Agency [1] to further restrict the exposure of the general public to fine particulates, and the evidence was given very widespread and close scrutiny before that action was made final. Of particular interest to the mining community is that these fine particulate studies indicate that smokers and those who have pre-existing pulmonary problems are particularly at risk. Many individual miners in fact have such pulmonary problems and are especially susceptible to the adverse health effects of inhaling fine particles.

Although no epidemiological study is flawless, numerous epidemiological studies have shown that long term exposure to diesel exhaust in a variety of occupational circumstances is associated with an increased risk of lung cancer. With only rare exceptions, involving relatively few workers and/or observation periods too short to reliably detect excess cancer risk, the human studies have consistently shown a greater risk of lung cancer among workers exposed to dpm than among comparable unexposed workers. When results from the human studies are combined, the risk is estimated to be 30–40 percent greater among exposed workers, if all other factors (such as smoking habits) are held constant. The consistency of the human study results, supported by experimental data establishing the plausibility of a causal connection, provides strong evidence that chronic dpm exposure at high levels significantly increases the risk of lung cancer in humans.

Moreover, all of the occupational studies indicating an increased frequency of lung cancer among workers exposed to dpm involved exposure levels estimated, on average, to be far below levels observed in underground mines. Except for miners, the workers

[1] The basis for the $PM_{2.5}$ NAAQS was a large body of scientific data indicating that particles in this size range are responsible for the most serious health effects associated with particulate matter. The evidence was thoroughly reviewed by a number of scientific panels through an extended process. The proposed rule resulted in considerable public attention, and hearings by Congress, in which the scientific evidence was further discussed. Moreover, challenges to the EPA's determination that this size category warranted rulemaking were rejected by a three-judge panel of the DC Circuit Court. (ATA v. EPA, 175 F.3d 1027, D.C. Circuit 1999).

included in these studies were exposed to average dpm levels below the limit established by this rule.

As noted in Part III, MSHA views extrapolations from animal experiments as subordinate to results obtained from human studies. However, it is noteworthy that dpm exposure levels recorded in some underground mines have been of the same order of magnitude that produced tumors in rats.

Based on the scientific data available in 1988, the National Institute for Occupational Safety and Health (NIOSH) identified dpm as a probable or potential human carcinogen and recommended that it be controlled. Other organizations have made similar recommendations. Most recently, the National Toxicology Program listed dpm as ''reasonably anticipated to be a human carcinogen'' in the Ninth Edition (Year 2000) of the National Report on Carcinogens.

The relationship between exposures and risks. Commenters noted MSHA's caution about trying to define a quantitative relationship between dpm exposure and particular health outcomes. They roundly attacked the agency's benefit analysis and a NIOSH paper reviewing quantification efforts as implying that such a relationship could be established in a valid way.

As MSHA acknowledged in the preamble to the proposed rule, the scientific community has not yet widely accepted any exposure-response relationship between the amount of dpm exposure and the likelihood of adverse health outcomes (63FR 58167). There are, however, two lung cancer studies in the record that show increasing risk of lung cancer with increasing levels of dpm exposure. Quantitative results from these studies, both conducted specifically on underground miners, can be used to estimate the reduction in lung cancer risk expected when dpm exposure is reduced in accordance with this rule. Depending on the study and method of statistical analysis used, these estimates range from 68 to 620 lung cancer deaths prevented, over an initial 65-year period, per 1000 affected miners with lifetime (45-year) exposure to dpm.

NIOSH and the National Cancer Institute (NCI) are collaborating on a cancer mortality study designed to provide additional information in this regard. The study is projected to take about seven years.

Notwithstanding this situation, MSHA believes the Agency is required under its statute to take action now to protect miners' health. As noted by the Supreme Court in an important case on risk involving the Occupational Safety and Health Administration, the need to evaluate risk does not mean an agency is placed into a ''mathematical straightjacket.'' *Industrial Union Department, AFL–CIO* v. *American Petroleum Institute,* 448 U.S. 607, 100 S.Ct. 2844 (1980). The Court noted that when regulating on the edge of scientific knowledge, absolute scientific certainty may not be possible, and:

> so long as they are supported by a body of reputable scientific thought, the Agency is free to use conservative assumptions in interpreting the data * * * risking error on the side of overprotection rather than underprotection. (Id. at 656).

This advice has special significance for the mining community, because a singular historical factor behind the enactment of the current Mine Act was the slowness of the mining community in coming to grips with the harmful effects of other respirable dust (coal dust).

It is worth noting that while the cohort selected for the NIOSH/NCI study consists of underground miners (specifically, underground metal and nonmetal miners), this choice is in no way linked to MSHA's regulatory framework or to miners in particular. This cohort was selected for the study because it provides the best population for scientists to study. For example, one part of the study would compare the health experiences of miners who have worked underground in mines with long histories of diesel use with the health experiences of similar miners who work in surface areas where exposure is significantly lower. Since the general health of these two groups is very similar, this will help researchers to quantify the impacts of diesel exposure. No other population is likely to be as easy to study for this purpose. But as with any such epidemiological study, the insights gained are not limited to the specific population used in the study. Rather, the study will provide information about the relationship between exposure and health effects that will be useful in assessing the risks to any group of workers in a dieselized industry.

Because of the lack of a generally accepted dose-response relationship, some commenters questioned the agency's rationale in picking a particular concentration limit: 160_{TC} µg/m^3 or around 200_{DPM} µg/m^3. Capping dpm concentrations at this level will eliminate the worst mining exposures, and bring miner exposures down to a level commensurate with those reported for other groups of workers who use diesel-powered equipment. The proposed rule would not bring concentrations down as far as the proposed ACGIH TLV^R of 150_{DPM} µg/m^3. Nor does MSHA's risk assessment suggest that the proposed rule would completely eliminate the significant risks to miners of dpm exposure.

In setting the concentration limit at this particular value, the Agency is acting in accord with its statutory obligation to attain the highest degree of safety and health protection for miners that is feasible. The Agency's risk assessment supports reduction of dpm to the lowest level possible. But feasibility considerations dictated proposing a concentration limit that does not completely eliminate the significant risks that dpm exposure poses to miners.

The Agency specifically explored the implications of requiring mines in this sector to comply with a lower concentration limit than that being adopted. The results, discussed in Part V of this preamble, indicate that although the matter is not free from question, it still may not be feasible at this time for the underground metal and nonmetal mining industry as a whole to comply with a significantly lower limit than that being adopted. The Agency notes that since this rulemaking was initiated, the efficiency of hot gas filters has improved significantly, the dpm emissions from new engines continue to decline under EPA requirements, and the availability of ultra-low sulfur fuel should make controls even more efficient than at present.

The agency also explored the idea of bridging the gap between risk and feasibility by establishing an ''action level''. In the case of MSHA's noise rule, for example, MSHA adopted a ''permissible exposure level'' of a time-weighted 8-hour average (TWA_8) of 90 dBA (decibels, A-weighted), and an ''action level'' of half that amount—a TWA_8 of 85 dBA. In that case, MSHA determined that miners are at significant risk of material harm at a TWA_8 of 85 dBA, but technological and feasibility considerations preclude the industry as a whole, at this time, below a TWA_8 of 90 dBA. Accordingly, to limit miner exposure to noise at or above a TWA_8 of 85 dBA, MSHA requires that mine operators must take certain actions that are feasible (*e.g.,* provide hearing protectors).

MSHA considered the establishment of a similar ''action level'' for dpm—probably at half the proposed concentration limit, or 80_{TC} µg/m^3. Under such an approach, mine operators whose dpm concentrations are above the ''action level'' would be required to implement a series of ''best practices''—*e.g.,* limits on fuel types, idling, and engine maintenance. Only one commenter supported the creation of an Action Level for dpm. However, this commenter suggested that such an Action Level be adopted in lieu of a rule incorporating a concentration limit requiring mandatory compliance. The agency determined it is feasible for the entire underground mining community to implement these best practices to minimize the risks of dpm exposure without the need for a trigger at an Action Level.

Some of the comments suggesting that the agency had no rational basis for setting the exposure limit at 160_{TC} µg/m^3 seem to suggest that the statute itself does not provide the Agency with adequate guidance in this regard. The Agency recognizes that the Supreme Court has scheduled argument on a case that raises the question of how specific a regulatory statute must be with respect to how an agency must make standards determinations in order to be deemed a constitutional delegation of authority from the Congress. A decision is not expected until 2001. However, unless and until determined otherwise, MSHA presumes the Mine Act does pass constitutional muster in this regard, consistent with the existing case law concerning the very similar Occupational Safety and Health Act.

(B) The ability of the agency to accurately measure diesel particulate matter (dpm) in underground metal and nonmetal mine environments. As MSHA noted in the preamble to the proposed rule, there are a number of methods which can measure dpm concentrations with reasonable accuracy when it is at high concentrations and when the purpose is exposure assessment. Measurements for the purpose of compliance determinations must be more accurate, especially if they are to measure compliance with a dpm concentration of 200_{DPM} µg/m^3 or lower. Accordingly, MSHA noted that it needed to address a number of questions as to whether such any existing method could produce accurate, reliable and reproducible results in the full variety of underground mines, and whether the infrastructure (samplers and laboratories) existed to support such determinations. (See 63 FR 58127 *et seq.*).

MSHA concluded that there was no method suitable for such compliance measurements in underground coal mines, due to the inability of the available methods to distinguish between dpm and coal dust. Accordingly, the agency developed a rule for the coal mining sector that does not depend upon ambient dpm measurements.

By contrast, the agency tentatively concluded that by using a sampler developed by the Bureau of Mines, and an analytical method developed by the National Institute for Occupational Safety and Health (NIOSH) to detect the total amount of carbon in a sample, MSHA could accurately measure dpm levels at the required concentrations in underground metal and nonmetal mines. While not requiring operators to use this method for their own sampling, MSHA did commit itself through provisions of the proposed rule to use this approach (or a method subsequently determined by NIOSH to provide equal or improved accuracy) for its own sampling. Moreover the agency proposed that MSHA sampling be the sole basis upon which determinations would be made of compliance by metal and nonmetal mine operators with applicable compliance limits, and that a single sample would be adequate for such purposes. Specifically, proposed § 57.5061 provided as follows:

§ 57.5061 Compliance Determinations

(a) A single sample collected and analyzed by the Secretary in accordance with the procedure set forth in paragraph (b) of this section shall be an adequate basis for a determination of noncompliance with an applicable limit on the concentration of diesel particulate matter pursuant to § 57.5060.

(b) The Secretary will collect and analyze samples of diesel particulate matter by using the method described in NIOSH Analytical Method 5040 and determining the amount of total carbon, or by using any method subsequently determined by NIOSH to provide equal or improved accuracy in mines subject to this part.

This part of MSHA's proposed rule received considerable comment. Some commenters challenged the accuracy, precision and sensitivity of NIOSH Analytical Method 5040. Some challenged whether the amount of total carbon determined by the method is a reliable way to determine the amount of dpm. Others questioned whether the sampler developed by the Bureau of Mines would provide an accurate sample to be analyzed, and whether such samplers and analytical procedures would be commercially available. Commenters also questioned the use of a single sample as the basis for a compliance determination, and the use of area sampling in compliance determinations. These comments are addressed elsewhere in this preamble (section 3 of Part II, and in connection with section 5061 in Part IV).

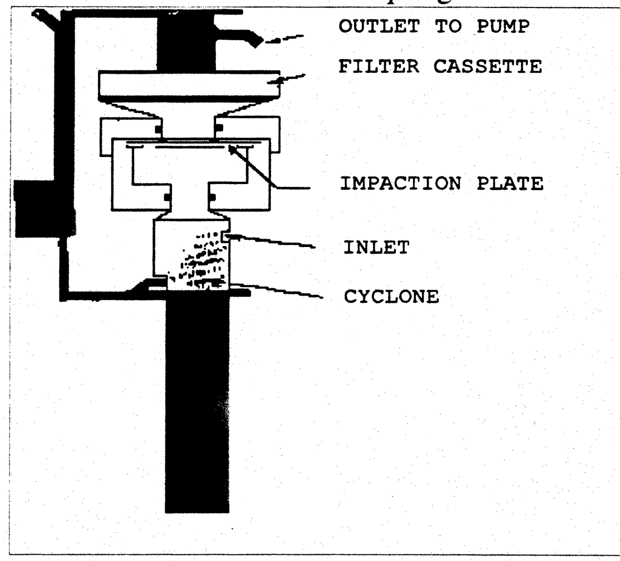
Here, MSHA summarizes its views on the most common assertion made by commenters: that the sampling and analytical methods the agency proposed to use are not able to distinguish between dpm and various other substances in the atmosphere of underground metal and nonmetal mines—carbonates and carbonaceous minerals, graphitic materials, oil mists and organic vapors, and cigarette smoke.

Interferences: what MSHA said in preamble to proposed rule. In the preamble to the proposed rule, MSHA recognized that there might be some interferences from other common organic carbon sources in underground metal and nonmetal mines: specifically, oil mists and cigarette smoke. The agency noted it had no data on oil mists, but had not encountered the problem in its own sampling. With respect to cigarette smoke, the agency noted that: ''Cigarette smoke is under the control of operators, during sampling times in particular, and hence should not be a consideration.'' (63FR 58129)

The agency also discussed the potential advantages and disadvantages of using a special device on the sampler—a submicron impactor—to eliminate certain other possible interferences (See Figure I–1). The submicron impactor stops particles larger than a micron from being collected by the sampler, while allowing the smaller dpm to be collected. Thus, an advantage of using the impactor would be to ensure that the sampler was not inadvertently collecting materials other than dpm. However MSHA pointed out that while samples in underground metal and nonmetal mines could be taken with a submicrometer impactor, this could lead to underestimating the total amount of dpm present (63FR 58129). This is because the fraction of dpm particles greater than 1 micron in size in the environment of noncoal mines can be as great as 20% (Vuk, Jones, and Johnson, 1976).

BILLING CODE 4510–43–P

Figure II- 3
Personal Sampler For Submicrometer Particulate Sampling



BILLING CODE 4510–43–C

Interferences: comments and MSHA efforts to verify. Many commenters asserted that no matter how it is performed in underground metal and nonmetal mines, the sampling and analysis proposed by MSHA to determine the amount of diesel particulate present would suffer from one or more of the aforementioned interferences. A number asserted that their own measurements using this approach provided clear evidence of such interferences. Although MSHA repeatedly asked for actual data and information about the procedures used to verify these assertions, very little was provided. Nevertheless, rather than conclude that these assertions were baseless, MSHA decided to attempt to verify these assertions itself. Accordingly, appropriate field and laboratory measurements were conducted toward this end, the results written up in appropriate fashion, and added to the record of this rulemaking. The agency has taken those results into account in ascertaining what weight to give to the assertions made by commenters and how to deal with those assertions supported by its measurements.

As described in detail in section 3 of Part II, MSHA's verifications demonstrate that the submicron impactor can eliminate any interferences from carbonates, carbonaceous minerals, and graphitic ores. Accordingly, although use of the impactor will result in an undercount of dpm, the final rule provides that MSHA will always use the submicron impactor in compliance sampling.

MSHA's verifications also demonstrated that oil mists as well as cigarette smoke, can in fact, under certain circumstances, create interferences even with the use of the impactor. MSHA presumes the same would happen with organic vapors. The verifications demonstrated that the problems occur in the immediate vicinity of the interferent (*e.g.,* close to a drill or smoker). However, the verifications also demonstrated that the interference dissipates when the sampling device is located a certain distance away from the interferent.

Accordingly, as detailed in the discussion of section 5061 in Part IV of this preamble, MSHA's sampling strategy for dpm will take these problems into account. For example, if a miner works in an enclosed cab all day and smokes, MSHA will not place a sampler in that cab or on that miner. If a miner works part of a day drilling, MSHA will not place a sampler on that miner. But MSHA can, for example, take an area sample in an area of a mine where drilling is being performed without concern about interferences from oil mists if it locates the sampler far enough away from the drill. MSHA's compliance manual will provide specific instructions to inspectors on how to avoid interferences.

The organic interferences (diesel mist, smoking) could be avoided by only analyzing a sample for elemental carbon, pursuant to the NIOSH method. As it indicated in the preamble to the proposed rule, however, MSHA does not at this time know the ratio between the amount of elemental carbon and the amount of dpm. Accordingly, rather than deal with the uncertainties in all samples which this approach would present, MSHA is going to use a method (i.e., sampling and analyzing for both organic carbon and elemental carbon) that, if properly applied, provides accurate results.

(C) The feasibility of the requirements for this sector of the mining industry. The Mine Act generally requires MSHA to set the standard that is most protective of miner health while still being technologically and economically feasible. In addition, consistent with the Regulatory Flexibility Act, the agency pays particular attention to the impact of any standard on small mining operations.

(1) Technological feasibility of the rule. It has been clear since the beginning of this rulemaking that if technological feasibility was an issue, it would be in the context of requiring all underground metal and nonmetal mines to meet a particular limit. While the Mine Act does not require that each mine be able to meet a standard for it to be considered technologically feasible—only that the standard be feasible for the industry as a whole—the extent to which various mines might have a problem complying is the evidence upon which this conclusion must be based.

Accordingly, MSHA evaluated the technological feasibility of the concentration limit in the underground metal and nonmetal sector by evaluating whether it was possible, using a combination of existing control approaches, to reach the concentration limit even in situations in which the Agency's engineers determined that compliance might be the most difficult. In this regard, the Agency examined how emissions generated by the actual equipment in four different underground mining operations could be controlled. The mines were very diverse—an underground limestone mine, an underground (and underwater) salt mine, and an underground gold mine. Yet in each case, the analysis revealed that there are available combinations of controls that can bring dpm concentrations down to well below the final limit—even when the controls that needed to be purchased were not as extensive as those which the Agency is assuming will be needed in determining the costs of the final rule. (The results of these analyses are discussed in Part V of the preamble, together with the methodology used in modeling the results—just as they were discussed in the preamble accompanying the proposed rule.) As a result of these studies, the Agency has concluded that there are engineering and work practice controls available to bring dpm concentrations in all underground metal and nonmetal mines down to the required levels.

The best actions for an individual operator to take to come into compliance with the interim and final concentration limits will depend upon an analysis of the unique conditions at the mine. The final rule provides 18 months after it is promulgated for MSHA to provide technical assistance to individual mine operators. It also gives all mine operators in this sector an additional three and a half years to bring dpm concentrations down to the proposed final concentration limit—using an interim concentration limit during this time which the Agency is confident every mine in this sector can timely meet. And the rule provides an opportunity for a special extension for an additional two years for mines that have unique technological problems meeting the final concentration limit.

As noted during 1995 workshops co-sponsored by MSHA on methods for controlling diesel particulate, many underground metal and nonmetal mine operators have already successfully determined how to reduce diesel particulate concentrations in their mines. MSHA has disseminated the ideas discussed at these workshops to the entire mining community in a publication, ''Practical Ways to Control Exposure to Diesel Exhaust in Mining—a Toolbox''. The control methods are divided into eight categories: use of low emission engines; use of low sulfur fuel; use of aftertreatment devices; use of ventilation; use of enclosed cabs; diesel engine maintenance; work practices and training; fleet management; and respiratory protective equipment. Moreover, MSHA designed a model in the form of a computer spreadsheet that can be used to simulate the effects of various controls on dpm concentrations. (This model is discussed in Part V of the preamble.) This makes it possible for individual underground mine operators to evaluate the impact on diesel particulate levels of various combinations of control methods, prior to making any investments, so each can select the most feasible approach for his or her mine.

(2) Economic Feasability of the Rule. The underground metal and nonmetal industry uses a lot of diesel-powered equipment, and it is widely distributed. Accordingly, MSHA recognizes that the costs of bringing mines into compliance with this rule will be widely felt in this sector (although, unlike underground coal mines, this sector did not have to comply with MSHA's 1996 diesel equipment rule).

In summary, the costs per year to the underground metal and nonmetal industry are about $25.1 million. The cost for an average underground metal and nonmetal mine is expected to be about $128,000 annually.

The Agency's initial cost estimates of $19.2 million a year were challenged during the rulemaking proceeding. As a result, the Agency reconsidered the costs.

In its initial estimate of the costs for the industry to comply with the concentration limit, MSHA assumed that a variety of engineering controls, such as low emission engines, ceramic filters, oxidation catalytic converters, and cabs would be needed on diesel powered equipment. Most of the engineering controls would be needed on diesel equipment used for production, while a small amount of diesel equipment that is used for support purposes would need engineering controls. In addition to these controls, MSHA assumed that some underground metal and nonmetal mines would need to make ventilation changes in order to meet the proposed concentration limits.

Specifically, in the PREA, MSHA assumed that: (1) the interim standard would be met by replacing engines, installing oxidation catalytic converters, and improving ventilation; and (2) the final standard would be met by adding cabs and filters. Comments on the PREA and data collected by the Agency since publication of the proposed rule indicate that engine replacement is more expensive than originally thought and filters are more effective relative to engine replacement. The revised compliance strategy, upon which MSHA bases its revised estimates of compliance costs, reverses the two most widely used measures. MSHA now anticipates that: (1) the interim standard will be met with filters, cabs, and ventilation; and (2) the final standard will be met with more filters, ventilation, and such turnover in equipment and engines as will have occurred in the baseline. This new approach uses the same toolbox and optimization strategy that was used in the PREA. Since relative costs are different, however, the tools used and cost estimated are different.

(3) Impact on small mines. As required by the Regulatory Flexibility Act, MSHA has performed a review of the effects of the proposed rule on ''small entities''.

The Small Business Administration generally considers a small mining entity to be one with less than 500 employees. MSHA has traditionally defined a small mine to be one with less than 20 miners, and has focused special attention on the problems experienced by such mines in implementing safety and health rules. Accordingly, MSHA has separately analyzed the impact of the rule on three categories of mines: large mines (more than 500 employees), middle size mines (20–500 employees), and small mines (those with less than 20 miners).

As required by law, MSHA has also developed a preliminary and final regulatory flexibility analysis. The Agency published its preliminary Regulatory Flexibility Analysis with its proposed rule and specifically requested comments thereon; the agency's final Regulatory Flexibility Analysis is included in the Agency's REA. In addition to a succinct statement of the objectives of the rule and other information required by the Regulatory Flexibility Act, the analysis reviews alternatives considered by the Agency with an eye toward the nature of small business entities.

In promulgating standards, MSHA is required to protect the health and safety of all the Nation's miners and may not include provisions that provide less protection for miners in small mines than for those in larger mines. But MSHA does consider the impact of its standards on even the smallest mines when it evaluates the feasibility of various alternatives. For example, a major reason why MSHA concluded it needed to stagger the effective dates of some of the requirements in the rule is to ensure that it would be feasible for the smallest mines to have adequate time to come into compliance.

MSHA recognizes that smaller mines may need particular assistance from the agency in coming into compliance with this standard. Before the dpm concentration goes into effect in 18 months, the Agency plans to provide extensive compliance assistance to the mining community. The metal and nonmetal community will also have an additional three and a half years to comply with the final concentration limit, which in many cases means these mines may have a full five years of technical assistance before any engineering controls are required. MSHA intends to focus its efforts on smaller operators in particular—training them in measuring dpm concentrations, and providing technical assistance on available controls. The Agency will also issue a compliance guide, and continue its current efforts to disseminate educational materials and software.

(4) Benefits of the final rule Benefits of the rule include reductions in lung cancer. In the long run, as the mining population turns over, MSHA estimates that a minimum of 8.5 lung cancer deaths will be avoided per year.[2]

Benefits of the rule will also include reductions in the risk of death from cardiovascular, cardiopulmonary, or respiratory causes and in sensory irritation and respiratory symptoms. MSHA does not believe that the available data can support reliable or precise quantitative estimates of these benefits. Nevertheless, the expected reductions in the risk of death from cardiovascular, cardiopulmonary, or respiratory causes appear to be significant, and the expected reductions in sensory irritation and respiratory symptoms appear to be rather large.

II. General Information

This part provides the context for this preamble. The nine topics covered are:

(1) The role of diesel-powered equipment in underground metal and nonmetal mining in the United States;

(2) The composition of diesel exhaust and diesel particulate matter (dpm);

(3) The sampling and analytical techniques for measuring ambient dpm in underground metal and nonmetal mines;

(4) Limiting the public's exposure to diesel and other final particulates—ambient air quality standards;

(5) The effects of existing standards—MSHA standards on diesel exhaust gases (CO, CO_2, NO, NO_2, and SO_2), and EPA diesel engine emission standards—on the concentration of dpm in underground metal and nonmetal mines;

(6) Methods for controlling dpm concentrations in underground metal and nonmetal mines;

(7) MSHA's approach to diesel safety and health in underground coal mines and its effect on dpm;

(8) Information on how certain states are restricting occupational exposure to dpm; and

(9) A history of this rulemaking.

Material on these subjects which was available to MSHA at the time of the proposed rulemaking was included in Part II of the preamble that accompanied the proposed rule. (63 FR 58123 et seq). Portions of that material relevant to underground metal and nonmetal mines is reiterated here (although somewhat reorganized), and the material is amended and supplemented where appropriate as a result of comments and additional information added to the record since the proposal was published.

(1) The Role of Diesel-Powered Equipment in Underground Metal and Nonmetal Mining in the United States

Diesel engines, first developed about a century ago, now power a full range of mining equipment in underground metal and nonmetal mines, and are used extensively in this sector. This sector's reliance upon diesel engines to power equipment in underground metal and nonmetal mines appears likely to continue for some time.

Historical Overview of Diesel Power Use in Mining. As discussed in the notice of proposed rulemaking, the diesel engine was developed in 1892 by the German engineer Rudolph Diesel. It was originally intended to burn coal dust with high thermodynamic efficiency. Later, the diesel engine was modified to burn middle distillate petroleum (diesel fuel). In diesel engines, liquid fuel droplets are injected into a prechamber or directly into the cylinder of the engine. Due to compression of air in the cylinder the temperature rises high enough in the cylinder to ignite the fuel.

The first diesel engines were not suited for many tasks because they were too large and heavy (weighing 450 lbs. per horsepower). It was not until the 1920's that the diesel engine became an efficient lightweight power unit. Since diesel engines were built ruggedly and had few operational failures, they were used in the military, railway, farm, construction, trucking, and busing industries. The U.S. mining industry was slow, however, to begin using these engines. Thus, when in 1935 the former U.S. Bureau of Mines published a comprehensive overview on metal mine ventilation (McElroy, 1935), it did not even mention ventilation requirements for diesel-powered equipment. By contrast, the European mining community began using these engines in significant numbers, and various reports on the subject were published during the 1930's. According to a 1936 summary of these reports (Rice, 1936), the diesel engine had been introduced into German mines by 1927. By 1936, diesel engines were used extensively in coal mines in Germany, France, Belgium and Great Britain. Diesel engines were also used in potash, iron and other mines in Europe. Their primary use was in locomotives for hauling material.

It was not until 1939 that the first diesel engine was used in the United States mining industry, when a diesel haulage truck was used in a limestone mine in Pennsylvania, and not until 1946 was a diesel engine used in a coal mine. Today, however, diesel engines are used to power a wide variety of equipment in all sectors of U.S. mining. Production equipment includes vehicles such as haultrucks and shuttle cars, front-end loaders, hydraulic shovels, load-haul-dump units, face drills, and explosives trucks. Diesel engines are also used in support equipment including generators and air compressors, ambulances, fire trucks, crane trucks, ditch diggers, forklifts, graders, locomotives, lube units, personnel carriers, hydraulic power units, longwall component carriers, scalers, bull dozers, pumps (fixed, mobile and portable), roof drills, elevating work platforms, tractors, utility trucks, water spray units and welders.

Current Patterns of Diesel Power Use in Underground Metal and Nonmetal Mining. Table II–1 provides information on the current utilization of diesel equipment in underground metal and nonmetal mines.

[2] This lower bound figure could significantly underestimate the magnitude of the health benefits. For example the estimate based on the mean value of all the studies examined is 49 lung cancer deaths avoided per year.

TABLE II–1.—DIESEL EQUIPMENT IN UNDERGROUND METAL AND NONMETAL MINES

Mine size	Number of underground mines [A]	Number of mines with diesels [B]	Number of Engines [B]
Small [C]	134	77	584
Large	130	119	3,414
All	264	196	3,998

(A) Number of underground mines is based on those reporting operations for FY1999 (preliminary data).
(B) Number of mines using diesels are based on January 1998 count, by MSHA inspectors, of underground metal and nonmetal mines that used diesel powered equipment, and the number of engines (the latter rounded to the nearest 25) was determined in the same count with reference to equipment normally in use.
(C) A ‘‘small’’ mine is one with less than 20 miners.

As noted in Table II–1, a majority of underground metal and nonmetal mines use diesel-powered equipment.

Diesel engines in metal and nonmetal underground mines, and in surface coal mines, range up to 750 HP or greater, although equipment size, and thus the size of the engine, can be limited by production requirements, the dimensions of mine openings, and other factors. By contrast, in underground coal mines, the average engine size is less than 150 HP. The reason for this disparity is the nature of the equipment powered by diesel engines. In underground metal and nonmetal mines, and surface mines, diesel engines are widely used in all types of equipment—both the equipment used under the heavy stresses of production and the equipment used for support. In underground metal and nonmetal mines, of the approximate 4,000 pieces of diesel equipment normally in use, about 1,800 units are used for loading and hauling. By contrast, the great majority of the diesel usage in underground coal mines is in support equipment.

This fact is significant for dpm control in underground metal and nonmetal mines. As the horsepower size of the engine increases, the mass of dpm emissions produced per hour increases. (A smaller engine may produce the same or higher levels of particulate emissions per volume of exhaust as a large engine, but the mass of particulate matter increases with the engine size). Accordingly, as engine size increases, control of emissions may require additional efforts.

Another factor relevant to control of dpm emissions in this sector is that fewer than 15 underground metal and nonmetal mines are required to use Part 36 permissible equipment because of the possibility of the presence of explosive mixtures of methane and air. The surface temperature of diesel powered equipment in underground metal and nonmetal mines classified as gassy must be controlled to less than 400°F. Such mines must use equipment approved as permissible under Part 36 if the equipment is utilized in areas where permissible equipment is required. These gassy metal and nonmetal mines have been using the same permissible engines and power packages as those approved for underground coal mines. (MSHA has not certified a diesel engine exclusively for a Part 36 permissible machine for the metal and nonmetal sector since 1985 and has certified only one permissible power package; however, that engine model has been retired and is no longer available as a new purchase to the industry). As a result, engine size (and thus dpm production of each engine) is more limited in these mines, and, as explained in section 6 of this part, the exhaust from these engines is cool enough to add a paper type of filtration device directly to the equipment.

By contrast, since in nongassy underground metal and nonmetal mines mine operators can use conventional construction equipment in their production sections without the need for modifications to the machines, they tend to do so. Two examples are haulage vehicles and front-end loaders. As a result, these mines can and do use engines with larger horsepower and hot exhaust. As explained in section 6 of this part, the exhaust from such engines must be cooled by a wet or dry device before a paper filter can be used, or high temperature filters (*e.g.,* ceramics) must be used.

At this time, diesel power faces little competition from other power sources in underground metal and nonmetal mines. As can be seen from the chart, there are some small metal and nonmetal mines (less than 20 employees) which do not use diesel-powered equipment; most of these used compressed air for drilling and battery-powered rail equipment for haulage.

It is unclear at this time, how quickly new ways to generate energy to run mobile vehicles will be available for use in a wide range of underground metal and nonmetal mining activities. New hybrid electric automobiles are being introduced this year by two manufacturers (Honda and Toyota); such vehicles combine traditional internal combustion power sources (in this case gasoline) with electric storage and generating devices that can take over during part of the operating period. By reducing the time the vehicle is directly powered by combustion, such vehicles reduce emissions. Further developments in electric storage devices (batteries), and chemical systems that generate electricity (fuel cells) are being encouraged by government-private sector partnerships. For further information on recent developments, see the Department of Energy alternative fuels web site at http://www.afdc.doe.gov/altfuels.html, and ‘‘The Future of Fuel Cells’’ in the July 1999 issue of *Scientific American.* Until such new technologies mature, are available for use in large equipment, and are reviewed for safe use underground, however, MSHA assumes that the underground metal and nonmetal mining community's significant reliance upon the use of diesel-power will continue.

(2) The Composition of Diesel Exhaust and Diesel Particulate Matter (DPM)

The emissions from diesel engines are actually a complex mixture of compounds, containing gaseous and particulate fractions. The specific composition of the diesel exhaust in a mine will vary with the type of engines being used and how they are used. Factors such as type of fuel, load cycle, engine maintenance, tuning, and exhaust treatment will affect the composition of both the gaseous and particulate fractions of the exhaust. This complexity is compounded by the multitude of environmental settings in which diesel-powered equipment is operated. Nevertheless, there are a few 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 aromatic hydrocarbons (*e.g.,* phenanthrene, fluoranthene). The oxides of nitrogen (NO_X) are worth particular mention because in the atmosphere they can precipitate into particulate matter. Thus, controlling the emissions of NO_X is one way that engine manufacturers can control particulate production indirectly. (See section 5 of this part).

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 sub-micron range of 100nm.

The main particulate fraction of diesel exhaust is made up of very small individual particles. These particles have a solid core mainly consisting of elemental carbon. They also have 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. There can be up to 1,800 different organic compounds adsorbed onto the elemental carbon core. A portion of this hydrocarbon material is the result of incomplete combustion of fuel; however, the majority is derived from the engine lube oil. In addition, the diesel particles contain a fraction of non-organic adsorbed materials. Figure II–1 illustrates the composition of dpm.

Diesel particles released to the atmosphere can be in the form of individual particles or chain aggregates (Vuk, Jones, and Johnson, 1976). In underground coal mines, more than 90% of these particles and chain aggregates are submicrometer in size (i.e., less than 1 micrometer (1 micron) in diameter). Dust generated by mining and crushing of material—*e.g.,* silica dust, coal dust, rock dust—is generally not submicrometer in size. Figure II–2 shows a typical size distribution of the particles found in the environment of a mine that uses equipment powered by diesel engines (Cantrell and Rubow, 1992). The vertical axis represents relative concentration, and the horizontal axis the particle diameter. As can be seen, the distribution is bimodal, with dpm generally being well less than 1 μm in size and dust generated by the mining process being well greater than 1 μm.

BILLING CODE 4510–43–P

Figure II-1
DPM components

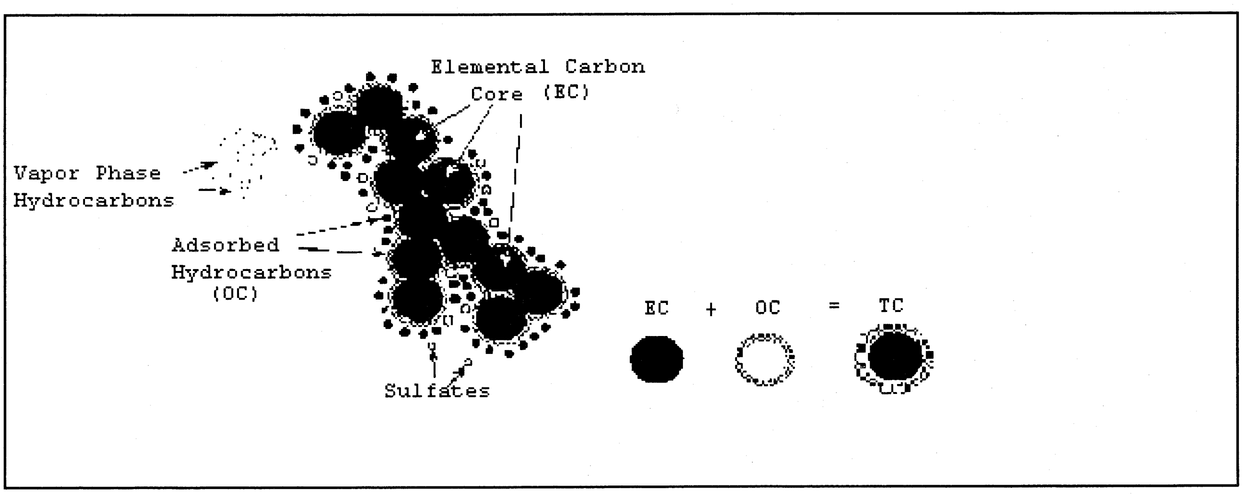


Figure II-2 -Typical distribution of dpm relative to distribution of other mining particulates.

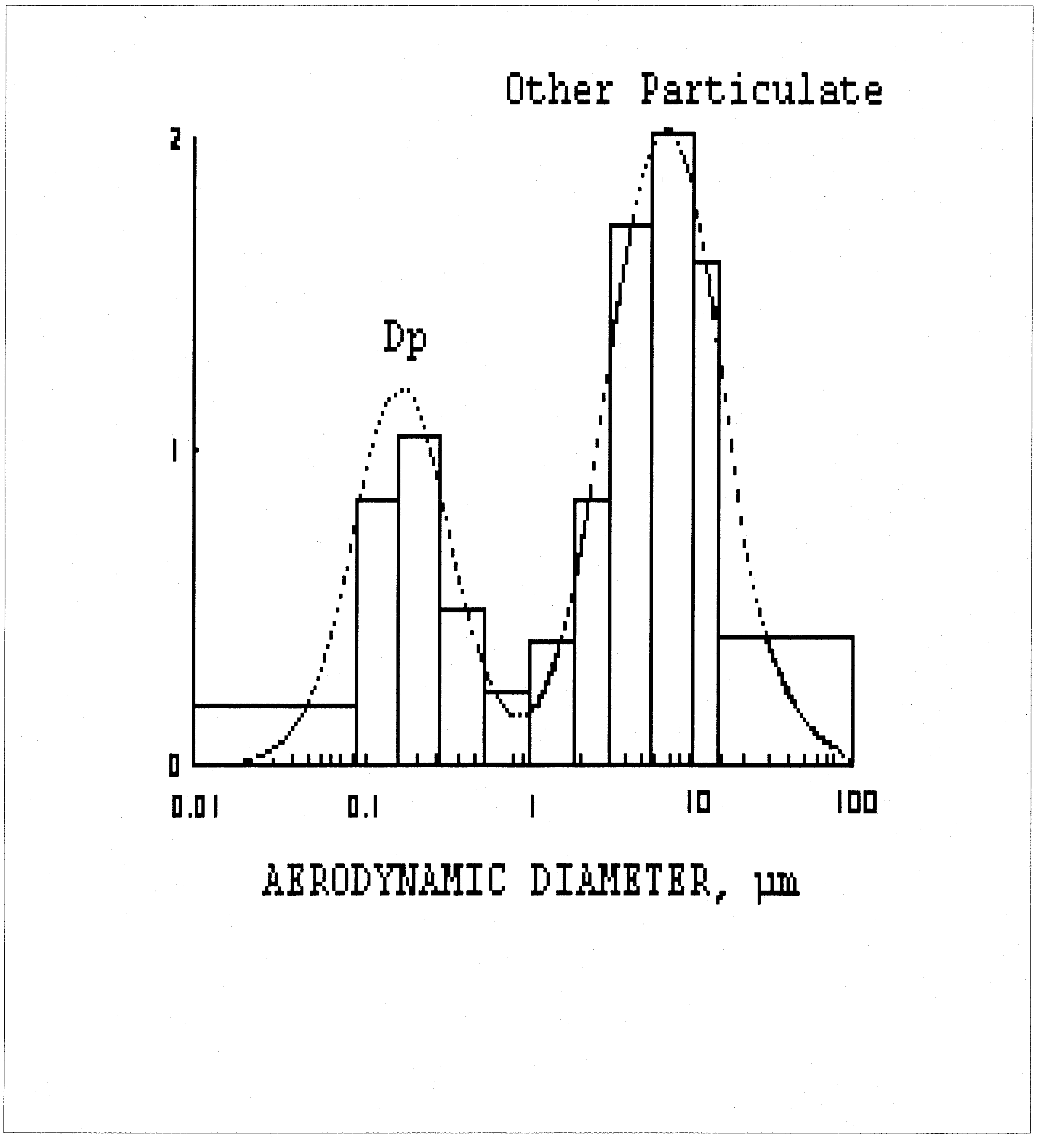
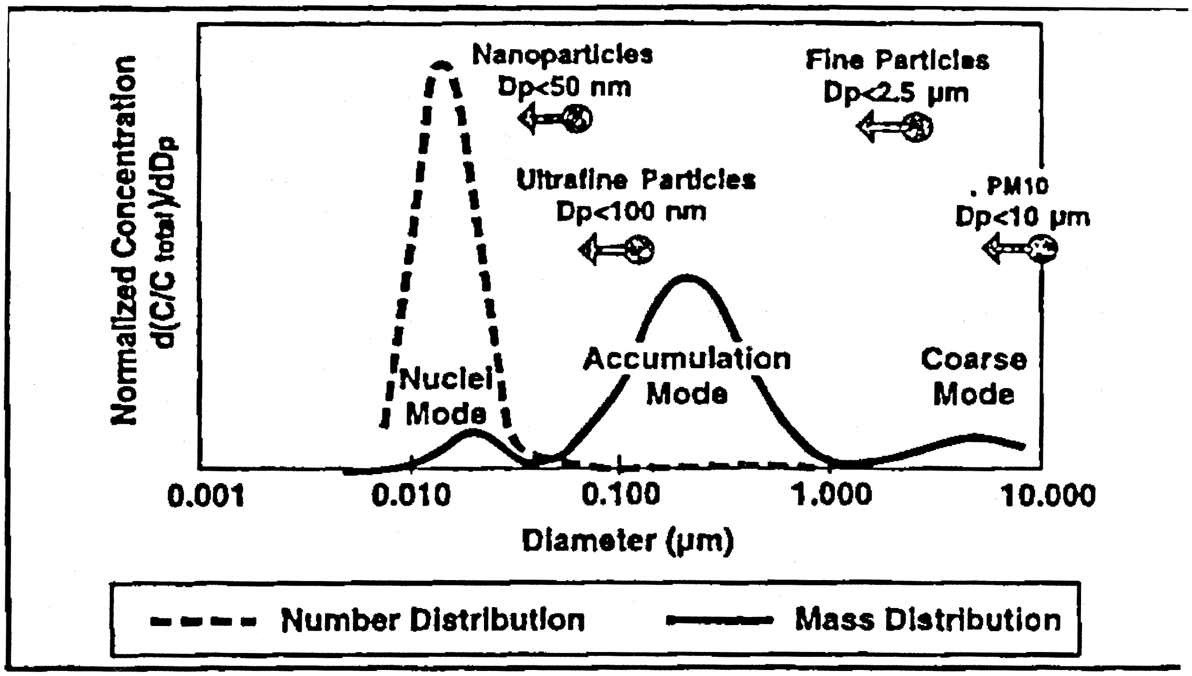


Figure II-3



Diesel particulate size distribution.

BILLING CODE 4510–43–C

As shown on Figure II–3 (Majewski, W. Addy, Diesel Progress June, 1998) diesel particulates have a bimodal size distribution which includes small nuclei mode particles and larger accumulation mode particles. As further shown, most of diesel particle mass is contained in the accumulation mode but most of the particle number can be found in the nuclei mode.

The particles in the nuclei mode, also known as nanoparticles, are being investigated as to their health hazard relevance. The interest in these particles has been sparked by the finding that newer "low polluting engines emit higher numbers of small particles than the old technology engines. Although the exact composition of diesel nanoparticles is not known, it was found that they may be composed of condensates (hydrocarbons, water, sulfuric acid). The amount of these condensates and the number of nanoparticles depends very significantly on the particulate sampling conditions, such as dilution ratios, which were applied during the measurement.

Both the maximum particle concentration and the position of the nuclei and accumulation mode peaks, however, depend on which representation is chosen. In mass distributions, the majority of the particulates (*i.e.,* the particulate mass) is found in the accumulation mode. The nuclei mode, depending on the engine technology and particle sampling technique, may be as low as a few percent, sometimes even less than 1%. A different picture is presented when the number distribution representation is used. Generally, the number of particles in the nuclei mode contributes to more than 50% of the total particle count. However, sometimes the nuclei mode particles represent as much as 99% of the total particulate number. The topic of nanoparticles is discussed further in section 5 of this Part.

(3) The Sampling and Analytical Techniques for Measuring Ambient dpm in Underground Metal and Nonmetal Mines

As MSHA noted in the preamble to the proposed rule, there are a number of methods which can measure dpm concentrations with reasonable accuracy when it is at high concentrations and when the purpose is exposure assessment. Measurements for the purpose of compliance determinations must be more accurate, especially if they are to measure compliance with a dpm concentration as low as 200 $\mu g/m^3$ or lower. Accordingly, MSHA noted that it needed to address a number of questions as to whether any existing method could produce accurate, reliable and reproducible results in the full variety of underground mines, and whether the samplers and laboratories existed to support such determinations. (See 63 FR 58127 *et.seq*).

MSHA concluded that there was no method suitable for such compliance measurements in underground coal mines, due to the inability of the available methods to distinguish between dpm and coal dust. Accordingly, the agency developed a rule for the coal mining sector that does not depend upon ambient dpm measurements.

By contrast, the agency concluded that by using a sampler developed by the former Bureau of Mines, and an analytical method developed by the National Institute for Occupational Safety and Health (NIOSH), MSHA could accurately measure dpm levels at the required concentrations in underground metal and nonmetal mines. While not requiring operators to use this method for their own sampling, MSHA did commit itself to use this approach (or a method subsequently determined by NIOSH to provide equal or improved accuracy) for its own sampling. Moreover the agency proposed that MSHA sampling be the sole basis for determining compliance by metal and nonmetal mine operators with applicable compliance limits, and that a single sample would be adequate for such purposes. Specifically, proposed § 57.5061 would have provided:

Section 57.5061 Compliance determinations.

(a) A single sample collected and analyzed by the Secretary in accordance with the procedure set forth in paragraph (b) of this section shall be an adequate basis for a determination of noncompliance with an applicable limit on the concentration of diesel particulate matter pursuant to § 57.5060.

(b) The Secretary will collect and analyze samples of diesel particulate matter by using the method described in NIOSH Analytical Method 5040 and determining the amount of total carbon, or by using any method subsequently determined by NIOSH to provide equal or improved accuracy in mines subject to this part.

This part of MSHA's proposed rule received considerable comment. Some commenters challenged the accuracy, precision and sensitivity of NIOSH Analytical Method 5040. Some challenged whether the amount of total carbon determined by the method is a reliable way to determine the amount of dpm. Others questioned whether the sampler developed by the former Bureau of Mines would provide an accurate sample to be analyzed. Many commenters asserted that the analytical method would not be able to distinguish between dpm and various other substances in the atmosphere of underground metal and nonmetal mines—carbonates and carbonaceous minerals, graphitic materials, oil mists and organic vapors, and cigarette smoke. (It should be noted that commenters also questioned the use of a single sample as the basis for a compliance determination, and the use of area sampling in compliance determinations; these comments are reviewed and responded to in Part IV of this preamble in connection with the discussion of § 57.5061.)

The agency has carefully reviewed the information and data submitted by commenters. Where necessary to verify the validity of comments, MSHA collected additional information which it has placed in the record, and which in turn were the subject of an additional round of comments.

Background. As discussed in section 2 of this part, diesel particulate consists of a core of elemental carbon (EC), adsorbed organic carbon (OC) compounds, sulfates, vapor phase hydrocarbons and traces of other compounds. The method developed by NIOSH provides for the collection of a sample on a quartz fiber filter. As originally conceived, the filter is mounted in an open face filter holder that allows for the sample to be uniformly deposited on the filter surface. After sampling, a section of the filter is analyzed using a thermal-optical technique (Birch and Cary, 1996). This technique allows the EC and OC species to be separately identified and quantified. Adding the EC and OC species together provides a measure of the total carbon concentration in the environment.

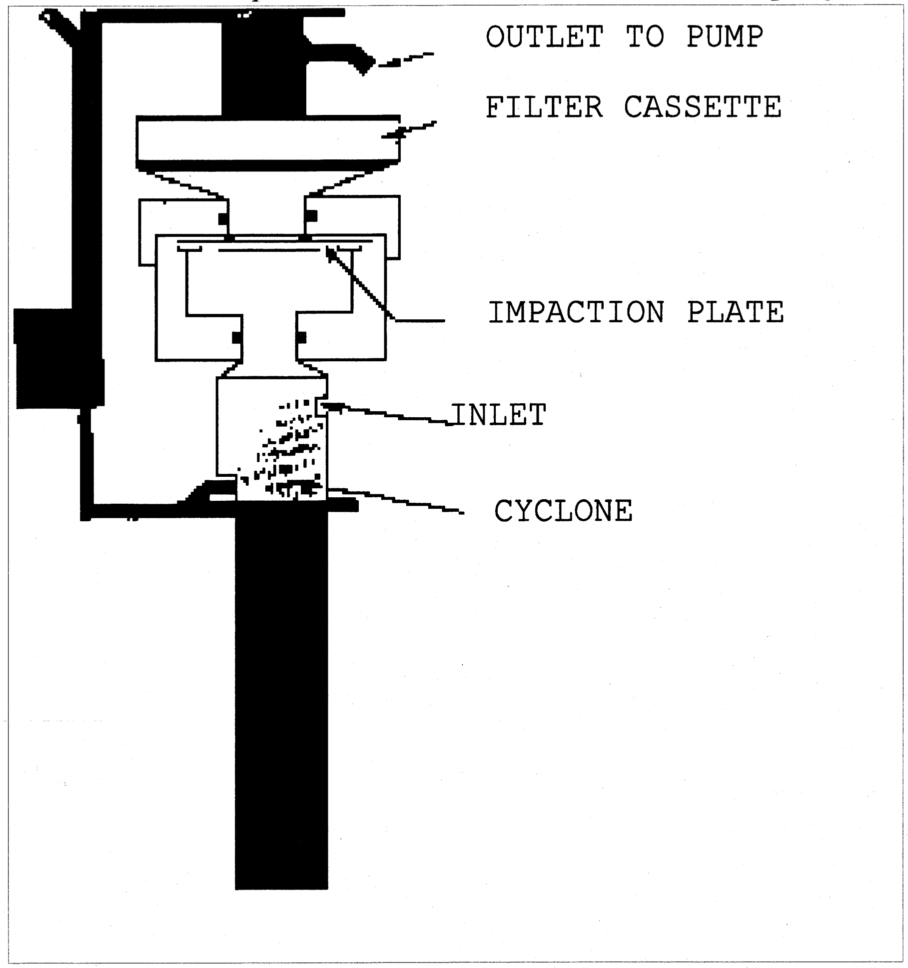
Studies have shown that the sum of the carbon (C) components (EC + OC) associated with dpm accounts for 80–85% of the total dpm concentration when low sulfur fuel is used (Birch and Cary, 1996). Therefore, in the preamble to the proposed rule, MSHA asserted that since the TC:DPM relationship is consistent, it provides a method for determining the amount of dpm. MSHA noted that the method can detect as little as 1 $\mu g/m^3$ of TC. Moreover, NIOSH has investigated the method and found it to meet NIOSH's accuracy criterion (NIOSH, 1995)—i.e., that measurements come within 25 percent of the true TC concentration at least 95 percent of the time.

In the preamble to the proposed rule, MSHA recognized that there might be some interferences from other common organic carbon sources in underground metal and nonmetal mines: specifically, oil mists and cigarette smoke. The agency noted it had no data on oil mists, but had not encountered the problem in its own sampling. With respect to cigarette smoke, the agency noted that: ''Cigarette smoke is under the control of operators, during sampling times in particular, and hence should not be a consideration.'' (63 FR 58129).

The agency also discussed the potential advantages and disadvantages of using a special device on the sampler to eliminate certain other possible interferences. NIOSH had recommended the use of a submicron impactor when taking samples in coal mines to filter out particles more than one micron in size. See Figure III–3. The idea is to ensure that a sample taken in a coal mine does not include significant amounts of coal dust, since the analytical method would capture the organic carbon in the coal dust just like the carbon in dpm. Coal dust is generally larger than one micron, while dpm is generally smaller than one micron. However, MSHA pointed out that while samples in underground metal and nonmetal mines could be taken with a submicrometer impactor, this could lead to underestimating the total amount of dpm present. This is because the fraction of dpm particles greater than 1 micron in size in the environment of noncoal mines can be as great as 20%.

BILLING CODE 4510–43–P

Figure II- 3
Personal Sampler For Submicrometer Particulate Sampling



BILLING CODE 4510–43–C

MSHA also noted that while NIOSH Method 5040 requires no specialized equipment for collecting a dpm sample, the sample would most probably require analysis by a commercial laboratory. The agency noted it did not foresee the availability of qualified testing facilities as a problem. The agency likewise discussed the availability of the sampling device, and noted steps that were underway to develop a disposable sampler. (63 FR 58130)

Sample Collection Methods. Some commenters raised questions about how dpm samples should be taken: using open face sampling, respirable sampling and submicron sampling. All three are discussed in NIOSH Analytical Method 5040. Because diesel particulate matter is primarily submicron in size any of the three sampling methods could be used.

The choice of sample collection method considers the cost and potential interferences that the method can contribute. Regardless of the sampling method, the sampling media (filter) must be one that does not interfere with the analysis. For this reason a pre-fired quartz fiber filter has been chosen. The quartz fiber filter is capable of withstanding the temperatures from the analytical procedure. The filter is pre-fired to remove residual carbon, attached to the filter during manufacturing.

Total Dust Sampling. Total dust sampling is the least expensive method to collect an airborne dust sample. It is commonly used to collect a sample that is representative of all the dust in the environment; i.e., the particles are not preclassified during the collection process. Total dust sampling can be performed using a filter cassette that allows the whole face of the filter to be exposed during collection of the sample (open face) or using a filter cassette with a small inlet opening (referred to as a closed face filter cassette). The latter method is used by MSHA for compliance sampling for total dust in the metal and nonmetal sector. Because the sample collected is representative of all the particulate matter in the environment, there is the potential for interference from mineral contaminants when sampling for diesel particulate matter. While in many cases the analytical results can be corrected for these interferences, in some instances the interferences may be so large that they can not be quantified with the analytical procedure, thus preventing the analytical result to be corrected for the interference.

Additionally, MSHA has noted that in some cases when using the total dust sampler with the small inlet hole, distribution of the collected sample on the filter is not uniform. The distribution of sample is concentrated in the center of the filter. This can result in the effect of an interference being magnified. As a result, MSHA considers that total dust sampling is not an appropriate sampling method for the mining industry to use when sampling diesel particulate matter.

Respirable Dust Sample Collection. Respirable dust sampling is commonly used when a size selective criteria for dust is required. The mining industry is familiar with size selective sampling for the collection of coal mine dust samples in coal mines and for collecting respirable silica samples in metal and nonmetal mines. For respirable dust sampling MSHA uses a 10 millimeter, Dorr Oliver nylon cyclone as a particle classifier to separate the respirable fraction of the aerosol from the total aerosol sampled. The use of this particle classifier would be suitable when sampling diesel particulate, provided significant amounts of interfering minerals are not present. This is because 90 percent of the diesel particulate is typically less than 1 micrometer in size. Particles less than 1 micrometer in size pass through the cyclone and are deposited on the filter. While in many cases, these interferences could be removed during the analytical procedures, the analytical procedures alone can not be assured to remove the interferences when large amounts of mineral dust are present.

Additionally, MSHA has observed that in some sampling equipment the cyclone outlet hole has been reduced when interfacing it with the filter capsule. MSHA has further observed that where this has occurred, the distribution of sample on the collection filter may not be uniform. In this circumstance the sample is also concentrated in the center of the filter which can result in the effect of a mineral interference being magnified. As a result, MSHA considers that respirable dust sampling is not a universally applicable sampling method for the mining industry to use for sampling diesel particulate matter.

Submicron Dust Sample Collection. Since only a small fraction of a mineral dust aerosol is less than 1 micrometer in size, a submicrometer impactor (Cantrell and Rubow, 1992) was developed to permit the sampling of diesel particulate without sampling potential mineral interferences. The submicrometer impactor was initially developed to remove the interference from coal mine dust when sampling diesel particulate in coal mines. It was designed to remove the carbon coal particles, that are greater than 0.8 micrometer in size, when sampling for diesel particulate matter at a pump flowrate of 2.0 liters per minute. As a result the submicrometer impactor cleans potentially interfering mineral dust from the sample.

As noted in the preamble to the proposed rule, use of this method to measure dpm does result in the exclusion of that portion of dpm that is not submicron in size, and this can be significant. On the other hand, this method avoids problems associated with the other methods described above. Moreover, as discussed in more detail below under the topic of ''interferences'', the submicron impactor can eliminate certain substances that in metal and nonmetal mines would otherwise make it difficult for the analytical method to be used for compliance purposes.

Accuracy of Analytical Method, NIOSH Method 5040. Commenters challenged the accuracy, precision and sensitivity of the analytical method (NIOSH Method 5040) used for the diesel particulate analysis. MSHA has carefully reviewed these concerns, and has concluded that provided a submicron impactor is used with the sampling device in underground metal and nonmetal mines, NIOSH Method 5040 does provide the accuracy, precision and sensitivity necessary to use in compliance sampling for dpm in such mines.

As noted above, NIOSH Method 5040 is an analytical method that is used to determine elemental and organic carbon content from an airborne sample. It is more versatile than other carbon analytical methods in that it differentiates the carbon into its organic and elemental carbon components. The method accomplishes this through a thermal optical process. An airborne sample is collected on a quartz fiber filter. A portion of the filter, (approximately 2 square centimeters in area) is placed into an oven. The temperature of the oven is increased in increments. At certain oven temperature and atmospheric conditions (helium, helium-oxygen), carbon on the filter is oxidized into carbon dioxide. The carbon dioxide gas is then passed over a catalyst and reduced to methane. The methane concentration is measured and carbon content is determined. Separation of different types of organic carbon is accomplished through temperature and atmospheric control. The instrument is programmed to increase temperature in steps over time. This step by step increase in temperature allows for differentiation between various types of organic carbon.

A laser is used to differentiate the organic carbon from the elemental carbon. The laser penetrates the filter and when the laser transmittance reaches its initial value this determines when elemental carbon begins to evolve. The computer software supplied with the instrumentation indicates this separation by a vertical line. The separation point can be adjusted by the analyst. As a result, there may be small differences in the determination of organic and elemental carbon between analysts, but the total carbon (sum of elemental and organic carbon) does not change. The software also allows the analyst to identify and quantify the different types of organic carbon using identifiable individual peaks. This permits the mathematical subtraction of a particular carbon peak. This feature is particularly useful in removing contributions from carbonates or other carbonaceous minerals. In other total carbon methods, samples have to be acidified to remove carbonate interference. A thermogram is produced with each analysis that shows the temperature ramps, oven atmospheric conditions and the amount of carbon evolved during each step.

A range of five separate sucrose standards between 10–100 $\mu g/cm^2$ carbon are initially analyzed to check the linearity of the internal calibration determined using a constant methane concentration. This constant methane concentration is injected at the end of each analysis. To monitor this methane constant, sucrose standards are analyzed several times during a run to determine that this constant does not deviate by more than 5–10%.

The method has the sensitivity to analyze environmental samples containing 1 to 10 $\mu g/m^3$ of elemental carbon. The method will be used in mining applications to determination total carbon contamination where the diesel particulate concentration will be limited to 400 $\mu g/m^3{}_{TC}$ and 160 $\mu g/m^3{}_{TC}$. NIOSH has reported that the lower limit of detection for the method is 0.1 $\mu g/cm^2$ elemental carbon for an oven pre-fired filter portion and 0.5 $\mu g/cm^2$ organic carbon for an oven pre-fired filter portion. For a full shift sample, this detection limit represents approximately 1 and 5 $\mu g/m^3$ of elemental and organic carbon, respectively. Additionally, NIOSH has conducted a round robin program to assess interlaboratory variability of the method. This study indicated a relative standard deviation for total carbon, of less than 15 percent.

A typical diesel particulate thermogram is shown in Figure II–4. The thermogram generally contains five or six carbon peaks, one for each temperature ramp on the analyzer. The first four peaks (occurring during a helium atmosphere ranging from a temperature of 210C to 870C) are associated with organic carbon determination and the fifth and/or sixth peak (occurring during a helium/oxygen atmosphere ranging in temperature from 610C to 890C) is the elemental carbon determination.

The fourth peak (temperature ~750C) is also where carbonate and other carbonaceous minerals are evolved in the analysis. For a diesel particulate sample without interferences present, this fourth peak is usually minimal as it is attributed to heavy distillant organics not normally associated with diesel operations in underground mining applications. If this peak is due to carbonate, the carbonate interference can be verified by analyzing a second portion of the sample after acidification as described in the NIOSH 5040 method. If the fourth peak is caused by some other carbonaceous mineral, the acidification process may not completely remove the interference and may, on occasion cause a positive bias to elemental carbon.

As explained below in the discussion of interferences, these analytical interferences from carbonaceous materials can be corrected by using the submicron impactor preceded by a cyclone (respirable classifier) to collect diesel particulate matter samples, since nearly all the particles of these minerals are greater than 1 micrometer in size. Accordingly, MSHA has determined it should utilize a submicron impactor in taking any samples in underground metal and nonmetal mines, and has included this requirement in the rule. Specifically, 57.5061(b) now provides:

(b) The Secretary will collect samples of diesel particulate matter by using a respirable dust sampler equipped with a submicrometer impactor and analyze the samples for the amount of total carbon using the method described in NIOSH Analytical Method 5040, except that the Secretary may also use any methods of collection and analysis subsequently determined by NIOSH to provide equal or improved accuracy for the measurement of diesel particulate matter in mines subject to this part.

BILLING CODE 4510–43–P

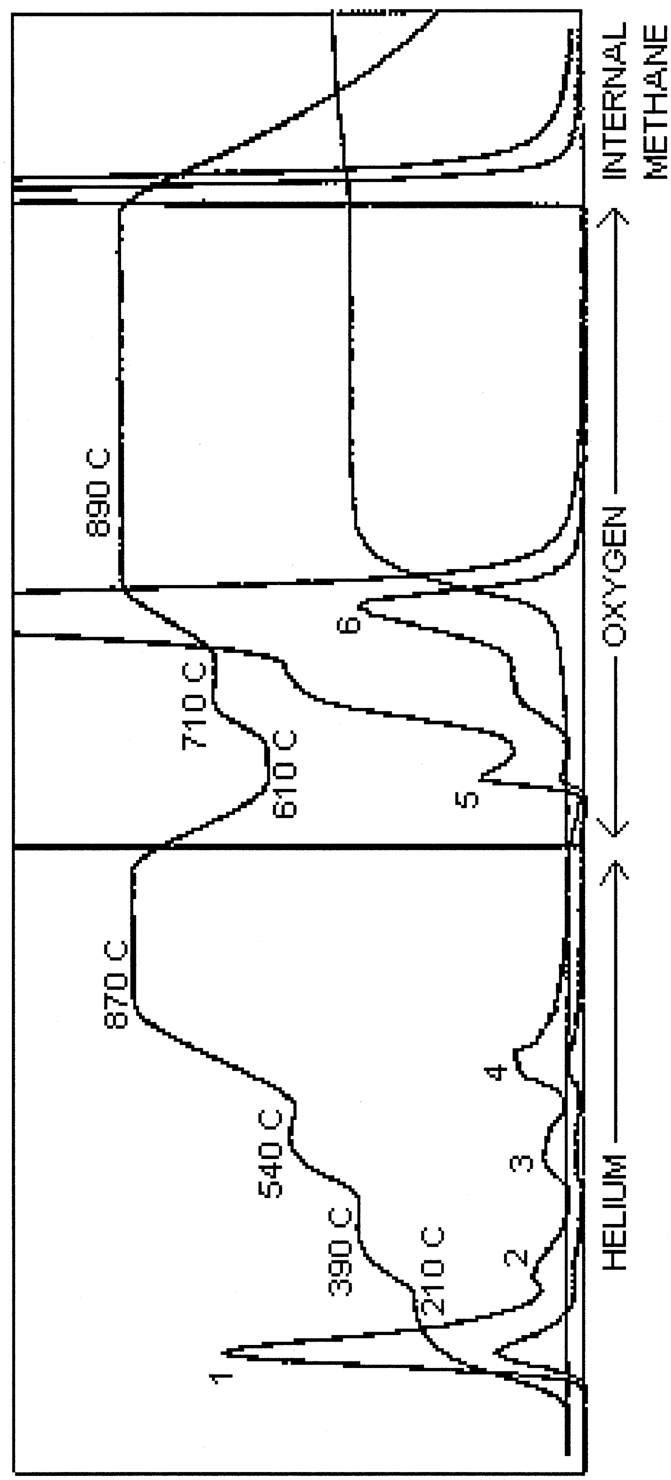


Figure II-4 Thermogram from analysis of a respirable dust sample.

BILLING CODE 4510–43–C

In keeping with established metal and nonmetal sampling protocol, the samplers will be operated at a flow rate of 1.7 LPM. At a flow rate of 1.7 LPM, the cut point for the impactor is 0.9 micrometers.

Any organic carbon detected at the fourth peak will be subtracted from the organic carbon portion of the sample analysis using the software supplied with the analytical program. The only samples that MSHA anticipates that will be acidified are those collected in trona mines. These samples contain a bicarbonate which evolves in several of the organic peaks but can be removed by acidification. Use of the submicron impactor will also insure a uniform distribution of diesel particulate and mineral dust on the filter.

Some Commenters indicated that a uniform deposit of mineral dust was sometimes not obtained with certain respirable dust sampler configurations. For some commodities such as salt and potash, where carbonate may not be an interference, it is probably not necessary to sample with the submicron impactor. However, in order to be consistent, MSHA will sample all commodities using a respirable dust sampler equipped with a submicrom impactor, and has so noted in the rule.

Proper use of sample blanks. Each set of samples collected to measure the diesel particulate concentration of a mine environment, must be accompanied by a field blank (a filter cassette that is treated and handled in the same manner as filters used to collect the samples) when submitted for analysis. The amount of total carbon determined from the analysis of the blank sample must be applied to (subtracted from) the carbon analysis of each individual sample. The field blank correction is applied to account for non-sampled carbon that attaches to the filter media. The blank correction is applied to the organic fraction as, typically, no elemental carbon is found on the blank filters.

Failure to adjust for the blanks can lead to incorrect results, as was the case with samples collected by some commenters. While field blanks were submitted and analyzed with their samples, the field blank analytical results were not used to correct the individual samples for nonsampled carbon content. Typically the carbon content on the reviewed field blanks ranged from 2 to 3 µg/square centimeter of filter area. For a one-hour sample, not using a blank correction of this magnitude, could result in an overestimate of 250 µg/m³ of dpm (3×8.55×1000/(1.7 * 60)=250). For an eight-hour sample, not using a blank correction, could result in an overestimate of 30 µg/m³ of dpm (3×8.55×1000/(1.7* 480)=30).

Variability of Sample Blanks

In response to the July 1, 2000, reopening of the record, one commenter submitted summary data from a study that examined diesel exposures in seven underground facilities where trona, salt, limestone, and potash were mined. The purpose of this study was to determine the precision and accuracy of the NIOSH 5040 method in these environments. According to the commenter, the study data ''provide strong evidence that the NIOSH 5040 Method * * * is not feasible as a measure of DPM exposure.'' The commenter's conclusion was based on five ''difficulties'' that, according to the commenter, were documented when sampling for DPM using organic carbon or total carbon as a surrogate. These difficulties were:

(1) High and variable blank values from filters;

(2) High variability from duplicate punches from the same sampling filter;

(3) Consistently positive interference when open-faced monitors were sampled side-by-side with cyclones;

(4) Poor correlation of organic carbon to total carbon levels; and

(5) Interference from limestone that could not be adequately corrected with acid-washing.

As discussed elsewhere in this preamble, difficulties #3 and #5 will be resolved by the use of a submicrometer impactor sampler. Difficulty #4, the lack of a strong correlation between organic carbon and total carbon, has long been recognized by MSHA. That is one of the reasons MSHA chose total carbon (TC=EC+OC) as the best surrogate to use for assessing DPM levels in underground metal and nonmetal mines. MSHA has never proposed using organic carbon as a surrogate measure of DPM.

The summary data that the commenter submitted do not appear to demonstrate the first two items of ''difficulties'' with respect to TC measurements. Because MSHA has not experienced the difficulties of (1) high and variable blank values and (2) high variability between duplicate punches from the same sampling filter, MSHA also performed its own analysis of the data submitted by the commenter. MSHA's examination of the data included:

- Estimating the mean, within-mine standard deviation, and relative standard deviation (RSD) for blank TC values, based on the ''Summary of Blank Sample Results'' submitted; and
- Estimating the variability (expressed as RSD) associated with the TC analysis of duplicate punches from the same filter, based on individual sample data submitted earlier by the same commenter for five of the mines.

Based on the summary data, the overall average mean TC content per blank filter, weighted by the number of blank samples in each mine, was 16.9 µg TC. This represents the average value that would be subtracted from the TC measurement from an exposed sample before making a noncompliance determination. At a TC concentration of 160 µg/m³ (the final limit established by this rule), the TC accumulated on a filter after an 8-hour sampling period would be approximately 130 µg. Therefore, these data show that the mean TC value for a blank is less than 13 percent of TC accumulated at the concentration limit, and an even lower percentage of total TC accumulated at concentrations exceeding the limit. MSHA considers this to be acceptable for samples used to make noncompliance determinations. Based on the same summary data presented for TC measurements on blank samples, the weighted average of within-mine standard deviations is 6.4 µg. Compared to TC values greater than or equal to 130 µg, this corresponds to an RSD no greater than 6.4/130 = 4.9 percent. MSHA also regards this degree of variability in blank TC values to be acceptable for purposes of noncompliance determination.

To estimate the measurement variability associated with analytical errors in the TC measurements, MSHA examined the individual TC results from duplicate punches on the same filter. These data were submitted earlier by the same commenter for five mines. As shown, by the commenter's summary table, data obtained from the first mine were invalid, leaving data from four mines (2–5) for MSHA's data analysis. Data were provided on a total of 73 filters obtained from these four mines, yielding 73 pairs of duplicate TC measurements, using the initial and first repeated measurement provided for both elemental and organic carbon. MSHA calculated the mean percent difference within these 73 pairs of TC measurements (relative to the average for each pair) to be 8.2 percent (95-percent confidence interval = 5.6 to 10.9 percent). Based on the same data, MSHA calculated an estimated RSD = 10.0 percent for the analytical error in a single determination of TC.[1] Contrary

[1] This estimate was obtained by first calculating the standard deviation of the differences between the natural logarithms of the TC measurements within each pair. Since each of these differences

to the commenter's conclusion, this result supports MSHA's position that TC measurements do not normally exhibit excessive analytical errors.

This estimate of the RSD = 10.0 percent for TC measurements is also consistent with the replicated area sample results submitted by the commenter for the seven mines. In this part of the study, designed to evaluate measurement precision, 69 sets of simultaneous samples were collected at the seven mines. Each set, or ''basket,'' of samples normally consisted of five simultaneous samples taken at essentially the same location. Since the standard deviation of the TC measurements within each basket was based on a maximum of five samples, the standard deviation calculated within baskets is statistically unstable and does not provide a statistically reliable basis for estimating the RSD within individual baskets. However, as shown in the summary table submitted by the commenter, the mean RSD across all 69 baskets was 10.6 percent. This RSD, which includes the effects of normal analytical variability, variability in the volume of air pumped, and variability in the physical characteristics of individual sampler units, is not unusually high, in the context of standard industrial hygiene practice.

MSHA also examined data submitted by another commenter to estimate the total variability associated with TC sample analysis by different laboratories. Based on 25 pairs of simultaneous TC samples (using a cyclone) analyzed by different laboratories, this analysis showed a total RSD of approximately 20.6 percent. If the most extreme of three statistical outliers in these data is excluded, the result based on 24 pairs is an estimated RSD of 11.7 percent. Like the first commenter's estimate of RSD = 10.6 percent, based on simultaneous samples analyzed at the same laboratory, these RSD's include not only normal analytical variability in a TC determination, but also variability in the volume of air pumped and variability in the physical characteristics of individual sampler units. The higher estimates, however, also cover uncertainty in a TC measurement attributable to differences between laboratories.

Based on these analyses, MSHA has concluded that the data submitted to the record by commenters support the Agency's position that NIOSH Method 5040 is a feasible method for measuring DPM concentrations in underground M/NM mines.

Availability of analysis and samplers. One of the concerns expressed by commenters was the limited number of commercial laboratories available to analyze diesel particulate samples, and the availability of required samplers. While MSHA will be doing all compliance sampling itself, and running the analyses in its AIHA accredited laboratory in Pittsburgh, pursuant to § 57.5071 of the rule, operators in underground metal and nonmetal mines will be required to do environmental monitoring; and although they will not be required to use the same methods as MSHA to determine dpm concentrations, MSHA presumes that many will wish to do so. Moreover, there are certain situations (*e.g.,* verification that a dpm control plan is working) where the rule requires operators to use this method (§ 57.5062(c)).

Currently there are four commercial labs that have the capability to analyze for dpm using the NIOSH 5040 Method. These labs are: Sunset Laboratory, Forest Grove, Oregon and Chapel Hill, North Carolina; Data Chem, Salt Lake City, Utah; and Clayton Group Services, Detroit, MI. All of these labs, as well as including the NIOSH Laboratories in Cincinnati and Pittsburgh and the MSHA laboratory in Pittsburgh participate in a round robin analytical test to verify the accuracy and precision of the analytical method being used by each. As MSHA indicated in the preamble to its proposed rule, it believes that once there is a commercial demand for these tests, additional laboratories will offer such services.

The cost of the analysis from the commercial labs is approximately $30 to $50 for a single punch analysis and a report. This is about the same amount as a respirable silica analysis. The labs charge another $75 to acidify and analyze a second punch from the same filter and to prepare an analytical report. The labs report both organic and elemental carbon. By using the submicron impactor, operators can significantly reduce the number of situations where acidification is required, and thus reduce the cost of sample analysis.

The availability of samplers has been the subject of many comments—not so much because of concern about availability once the rule is in effect, but because of assertions that they are not available now. In particular, it has been alleged by some commenters that they have been unable to conduct their own ''independent evaluation'' of the NIOSH method because the agency has kept from them the samplers needed to properly conduct such testing. Some commenters even accused the agency of deliberately withholding the needed samplers.

As indicated in MSHA's toolbox and the preamble to the proposed rule, the former Bureau of Mines (BOM) submitted information on the development of a prototype dichotomous impactor sampling device that separates and collects the submicron respirable particulate from the respirable dust sampled. Information on this sampling device has been available to the industry since 1992. A picture of the sampler is shown above as Figure II–3. The impactor plate is made out of brass and the nozzles are drilled. The former BOM made available to all interested parties detailed design drawings that permitted construction of the dichotomous impactor sampler by any local machine shop. NIOSH and MSHA had hundreds of these sampling devices made for use in their programs to measure dpm concentrations. Anyone could have had impactor samplers built by a local machine shop at a cost ranging from $50 to $100.

In 1998, MSHA provided NIOSH with research funds for the development of a disposable sampling device that would have the same sampling characteristics as the BOM sampler, and including an impactor with the same sampling characteristics as the metal one. NIOSH awarded SKC the contract for the development of the disposable sampler. MSHA estimates the cost of the disposable sampler will be less than $50. The sampler is designed to interface with the standard 10 millimeter Dorr Oliver cyclone particle classifier and to fit in a standard MSHA respirable dust breast plate assembly. The quartz fiber filter used for the collection of diesel particulate in accordance with NIOSH Method 5040 has been encapsulated in an aluminum foil to make handling during the analytical procedure easier. To reduce manufacturing expense (and therefore, sampler cost), the nozzle plate in the SKC sampler is made of plastic instead of brass. In order to ensure that the nozzles in the impaction plate would hold their tolerances during manufacturing, the plastic nozzle plate for the SKC sampler is fitted with synthetic sapphire nozzles. This nozzle plate and nozzle assembly have the same performance as the BOM-designed sampler.

---

contains two TC determinations, and two corresponding analytical errors, this standard deviation was divided by the square root of 2. Using standard propagation of error formulas, the result provides a reasonably good estimate of the RSD over the range of TC values reported. MSHA used the same technique to estimate the RSD for the 25 pairs of TC samples analyzed at different laboratories, as described below.

As of the time MSHA conducted its verification sampling for interferences, SKC had developed several prototypes of the disposable unit. However, testing of the devices by NIOSH indicated that a minor design modification was needed to better secure the impaction plate and nozzle plate to the sampler housing for a production unit. In its verification sampling, MSHA used both BOM designed and SKC prototype samplers. Prior to its verification tests, MSHA replaced the brass nozzle plates in the BOM design impactors with plastic nozzle-plates fitted with sapphire nozzles, as used in the SKC prototype sampler. However, because there was no change in nozzle geometry, this change in the BOM impactors did not affect their performance. During MSHA's verifications testing, no problems were experienced with dislodgement of the impaction plates or nozzle plates. The impactors used by MSHA in its verification sampling were not defective in any way, as suggested by several Commenters.

Under the Mine Act, MSHA has no obligation to make devices available to the mining community to conduct its own test sampling or to verify MSHA's results, nor does the mining industry have any explicit authority under the Mine Act to ''independently evaluate'' MSHA's results. The responsibility for determining the accuracy of the device and method for sampling rests with the agency, not the mining community. Accordingly, although some commenters requested that MSHA remove its interference studies from the record, the agency declines to do so. These studies are discussed in more detail below; additional questions raised about the sampling devices used in the studies, and the procedures for that sampling, are discussed in that context.

Some commenters initially asserted that their inability to conduct their own testing would prevent them from making comments of MSHA's verification studies. Based on the detailed comments subsequently provided, this initial concern appears to have been overstated.

It appears from some of the comments on MSHA's studies that members of the mining community may have understood MSHA to say that use of an impactor sampler would remove all interferences. MSHA can find no such statement. As noted in more detail below, use of the impactor will remove most of the interferences (albeit at the cost of eliminating some dpm as well).

Choice of Total Carbon as Measurement of Diesel Particulate Matter. MSHA asserted that the amount of total carbon (determined by the sampling and analytical methods discussed above) would provided the agency with an accurate representation of the amount of dpm present in an underground metal and nonmetal mine atmosphere at the concentration levels which will have to be maintained under the new standard. Some commenters questioned MSHA's statements concerning the consistency of the ratio between total carbon and diesel particulate, and the amount of that ratio. Other commenters suggested that elemental carbon may be a better indicator of diesel particulate because it is not subject to the interference that could effect a total carbon measurement.

Under the approach incorporated into the final rule, the concentration of organic and elemental carbon (in μg per square centimeter) are separately determined from the sample analysis and added together to determine the amount of total carbon. The interference from carbonate or mineral dust quantified by the fourth organic carbon peak is subtracted from the organic carbon results. The field blank correction is then subtracted from the organic analysis (the blank does not typically contain elemental carbon). Concentrations (time weighted average) of carbon are calculated from the following formula:

$$\frac{C\left(\mu g/cm^2\right) * A\left(cm^2\right) * 1{,}000\ L/m^3}{1.7\ LPM * time\ (min)}$$

Where:

C=The Organic Carbon (OC) or Elemental Carbon (EC) concentration, in μg/m³, measured in the thermal/optical carbon analyzer (corrected for carbonate and field blank).

A=The surface area of the filter media used. The surface areas of the filters are as follows: quartz fiber filter without aluminum cover is 8.55 cm²; quartz fiber filter with aluminum cover is 8.04 cm².

The 80 percent factor MSHA used to establish the total carbon level equivalents of the 500 μg/m³ and 200 μg/m³ dpm concentration limits being set by the rule was based on information obtained from laboratory measurements conducted on diesel engines (Birch and Cary, 1996). Since the publishing of the proposed rule, this value has been confirmed by measurements collected in underground mines in Canada (Watts, 1999)

MSHA agrees that the total carbon measurement is more subject to interferences than the elemental carbon measurement. However, because the ratio of elemental carbon to total carbon in underground mines is dependent on the duty cycle at which the diesel engine is operated (found to vary between 0.2 and 0.7), MSHA believes that total carbon is the best indicator of diesel particulate for underground mines. Additionally, MSHA has observed that some controls, such as filtration systems on cabs can alter the ratio of elemental to total carbon. The ratio can be different inside and outside a cab on a piece of diesel equipment. MSHA notes that NIOSH has asserted that the ratio of elemental carbon to dpm is consistent enough to provide the basis for a standard based on elemental carbon (''* * * the literature and the MSHA laboratory tests support the assertion that DPM, on average, is approximately 60 to 80% elemental carbon, firmly establishing EC as a valid surrogate for DPM''). However, while an average value for elemental carbon percent may be a useful measure for research purposes, data submitted by commenters show that elemental carbon can range from 8 percent to 81 percent of total carbon.

MSHA does not believe elemental carbon is a valid surrogate for dpm in the context of a compliance determination that, like all other metal and nonmetal health standards, can be based on a single sample. By contrast, as noted above, studies have shown that there is a consistent ratio between total carbon and dpm (from 80 to 85%). Moreover, although the ratio of the elemental carbon to organic carbon components obtained using the NIOSH Method 5040 may vary, total carbon determinations obtained with this method are very consistent, and agree with other carbon methods (Birch, 1999). Accordingly, while total carbon sampling does necessitate sampling protocols to avoid interferences, of the sort discussed below, MSHA has concluded that it would not be suitable at this time to use elemental carbon as a surrogate for dpm.

Potential Sample Interferences/ Contributions. As noted in the introduction to this section, many commenters asserted that the analytical method would not be able to distinguish between dpm and various other substances in the atmosphere of underground metal and nonmetal mines—carbonates and carbonaceous minerals, graphitic materials, oil mists and organic vapors, and cigarette smoke. The agency carefully reviewed the information submitted by commenters, both during the hearings and in writing, and found that it was in general insufficient to establish that such interferences would be a problem. Limitations in the data submitted by the commenters included, for example, failure to utilize blanks, failure to blank correct sample results, open face and respirable samples that were collected in the presence of high levels of carbonate interference, the amount of carbonate interference was not quantified, dpm was not uniformly deposited on filters and sample punches were taken where the deposit was heaviest, failure to adjust sample results due to short sampling times, failure to consider the impact of interferences such as carbonate, oil mist, and cigarette smoke on dpm exposure.

Rather than dismiss these assertions, however, the agency decided to conduct some investigations to verify the validity of the comments. As a result of these tests, the agency has determined that certain interferences can exist, within certain parameters; and was also able to demonstrate how these interferences can be minimized or avoided. The material which follows reviews the information MSHA has on this topic, including representative comments MSHA received on these verification studies. Part IV of this preamble reviews in some detail the adjustments MSHA has made to the proposed rule, and the practices MSHA will follow in compliance sampling, to avoid these interferences.

General discussion of interference studies. As noted above, MSHA conducted the verifications to determine if the alleged interferences were in fact measurable in underground mining environments. At the same time, the studies gave MSHA an opportunity to identify sampling techniques that would minimize or eliminate the interferences, evaluate analytical techniques to minimize or eliminate the interferences from the samples, and develop a sampling and analytical strategy to assure reliable dpm measurements in underground mines.

A total of six studies were conducted. One field study was conducted at Homestake Mine, a gold mine in Lead, South Dakota, three field studies were conducted at gold mines near Carlin, Nevada. These included Newmont, South Area Carlin Mine and Barrick Goldstrike. One study was conducted in the NIOSH Research Laboratory's experimental mine in Pittsburgh, Pennsylvania and one study conducted in a laboratory dust chamber at the NIOSH Pittsburgh Research Laboratory. For example the studies conducted at Carlin and Homestake were to evaluate interference from oil mist and the studies conducted at Homestake, Newmont and Barrick were to assess interference from carbonaceous dust. These locations were carefully selected in light of the assertions about interferences which had been made by commenters.

Despite the care that went into designing where to conduct the verification samples, there were a number of comments asserting the samples were not representative. For example, it was asserted that MSHA did not sample a representative particle size distribution and sampled the wrong material (i.e., ores with the highest carbon content). On the contrary the samples that MSHA collected were representative of the respirable and submicron fractions of the dust in the environment as well as the total dust in the environment. Therefore, MSHA believes that the particle size distribution of the samples collected were representative. Also, MSHA obtained a bulk sample of the various ores tested. While the samples collected at the crushers were low carbon content (0–10.3%), the carbon content (30.3%) of the ore collected at the underground mining area sampled at Carlin was similar to the high carbon content (31.4%) ores obtained at Barrick. The sampling therefore included a cross section of the ores in question.

Some commenters objected to the fact that no personal samples were collected in these studies. Packages of samplers were placed in areas that were close to the breathing zone of the workers. Upwind and downwind samples were used to determine the extent of the interference. The regulation recognizes the validity of area samples. As a result these samples provided valid information on interferences that are likely to be encountered during sampling by MSHA inspectors.

More generally, commenters asserted that MSHA lacked enough studies for statistical analysis. MSHA notes again that the studies were conducted to verify specific industry assertions, and were properly designed to try and verify those assertions. However, the same studies which confirmed that such interferences could be measured in certain conditions were also able to determine that these interferences could not be measured, or were not significant in scope, if some of the conditions were changed. Part IV of this preamble discusses what actions the agency plans to take as a result of its current information on this matter.

Some commenters asserted that MSHA made certain incorrect technical assumptions in its verification sampling: about the sampling method used to conclude that overall dust levels would meet MSHA's standards; about the concentration of EC in submicrometer dust; and about the variability of carbonaceous ores. With respect to the first point, the final sampling strategy adopted by MSHA for dpm allows for either personal or area sampling using a submicrometer sampler preceded by a respirable cyclone. Because of the sampling and analytic procedures, the only potential mineral interferent would be the graphitic contribution (elemental carbon). The carbonate and carbonaceous contribution would be eliminated or reduced by the use of the impactor sampler and using the software integration procedure described in Method 5040.

With respect to the second point, the concentration of EC in the submicrometer dust, for personal and most area samples, the allowable silica exposure would limit the amount of submicrometer mineral dust sampled. This has been demonstrated for samples collected in coal mines where the coal dust contains high levels of elemental carbon, but the interference for EC from submicrometer samples has been less that 4 μg/m^3.

With respect to the last point which addresses the geology of the ore, MSHA acknowledges that there would be variation in the carbon content of the ore. However, it would be unlikely that the carbon content would exceed that of coal mine dust where the elemental carbon interference has been found to be negligible.

The sampling was performed with the BOM designed or SKC prototype samplers as described in the prior section. All samplers used the more precise sapphire nozzles. Samples were collected using standard procedures developed by MSHA for assessing particulate concentrations in mine environments. Samples were analyzed for total carbon using NIOSH Method 5040. The analyses was performed by MSHA at the Pittsburgh Safety and Health Technology Center's Dust Division laboratory. For some samples a second analysis was performed using an acidification procedure.

Commenters alleged a number of technical problems with how the sampling was performed. Some asserted that defective devices were used for the sampling, or that MSHA did not properly calibrate its equipment. MSHA did not experience any problems with the samplers, and did calibrate its equipment according to standard procedures. Some pointed out that MSHA conducted the verifications with samplers different from those required by the rule. MSHA presumes this comment reflects the fact that the proposed rule did not require an impactor to be used; this is, however, the case with the final rule.

Some commenters noted that MSHA voided some sample results and that, lacking further explanation, it might be assumed the agency simply eliminated those samples which gave results that did not agree with the conclusions it sought. The only samples that were voided were chamber samples. Some voided samples were higher than, and some void samples were lower than, the sample used. These were duplicate samples collected for short time periods. Samples were voided because they were inconsistent with other samples in the set of six samples collected. These inconsistencies as-well-as variability between other duplicate samples were attributed to short sample times. Voided sample results are shown for Homestake (1 of 12 impactors). No impactor samples were voided at Barrick nor at the Newmont crusher. In the Jackleg drill tests conducted at Carlin Mine, there were 2 of 6 impactor samples voided.

Others asserted that MSHA failed to validate the design of the box which held the sampling equipment. In fact, all of the issues mentioned relative to the sampling box (i.e., pressure build up, leakage of chamber, impaction of particles, pump calibration) had been carefully examined by MSHA prior to the tests and found not to be a problem. Also, this sample chamber has been used extensively in other field tests where duplicate samples or a variety of samplers have been used and has worked extremely well.

One commenter stated that these studies confirm that measurement interference cannot be eliminated by blank correction and longer sample times, and that the proposed single sample enforcement policy would not be representative of typical mine conditions. MSHA disagrees with this conclusion from the verification tests. The MSHA tests demonstrated that blank correction does eliminate a source of interference. The residual organic carbon indicated in several of the samples collected at crushers were attributed to short sample time and normal variation in the range of blank values. The verification tests did not address sample time. However, when converting the mass collected to a concentration, the mass is divided by the sample time. Dividing by a longer time will always reduce an interference caused by a positive bias.

Other commenters alleged that there were problems with the MSHA personnel performing the studies. Some asserted these personnel failed to listen to suggestions made by representatives of mine companies who accompanied MSHA in their facilities during in-mine testing, suggestions which they assert would have corrected asserted problems in the testing procedure. Others simply assert that the MSHA personnel were biased, manipulated the data, and tried to conform the study results to those they wanted to find. It was also asserted that any potential for bias should have been removed through independent peer review of the results, or performance or confirmation of the studies by independent personnel or laboratories.

The tests were designed and conducted by personnel from MSHA's Pittsburgh Safety and Heath Technology's Dust Division. This laboratory at this facility is AIHA accreditated, and its personnel are among the foremost experts in particulate sampling analysis in the mining industry. They are widely published and are accustomed to performing work that must survive legal and scientific scrutiny. Moreover, the personnel designing and performing these studies have more experience than anybody else with dust sampling in general, and with this particular measurement application. While the agency welcomes scrutiny of its work, and repetition by others, it also recognizes that such efforts take time. In this case, the agency elected to conduct tests to address specific concerns, given its obligation to respond to the risks to miners reviewed in Part III of this preamble. It did so using a sound study design and expert personnel, and has made the detailed results of its studies a matter of public record.

In this regard, a number of commenters made reference to a study currently being conducted by NIOSH of possible interferences with the 5040 method. Some of these commenters provided MSHA with a copy of what is apparently the final protocol for the study, asserted that it would provide better information than the verification studies conducted by MSHA, and urged the agency to wait for completion of this study.

MSHA welcomes the NIOSH study, and will carefully consider its results—and the results of any other studies of this matter—in refining the compliance practices outlined in part IV of this preamble. But given the agency's obligation to respond to the risks to miners reviewed in Part III of this preamble, and the recommendations of NIOSH to take action in light of that risk, it would be inappropriate to await the results of another study.

Carbonates and Carbonaceous Minerals. As noted in the discussion of the analytical method (NIOSH Method 5040), carbonates have been known to cause an interference when determining the total carbon content of a diesel particulate sample. Carbonates are generally in two forms—carbonates such as limestone and dolomite and bicarbonate which is associated with trona (soda ash). As further noted, the amount of carbonate and bicarbonate collected on a sample can be significantly reduced or eliminated through the use of a submicrometer impactor. If the total carbon analysis of a sample indicates that a carbonate interference exists after the use of a submicrometer impactor, any remaining interfering effect may be removed or diminished using the acidification process described in NIOSH Method 5040.

Carbonate interference can also be removed during the analytical process by mathematically subtracting the organic carbon quantified by the fourth peak in the thermogram. Because bicarbonate is evolved over several temperature ranges, subtraction of only one peak does not remove all of the interference from bicarbonate. As a result, the sample needs to be acidified to remove all of the bicarbonate interference.

Commenters correctly pointed out that other carbonaceous minerals are not removed by the acidification process and in fact in some cases, the acidification process may cause a positive bias to the elemental carbon measurement. However, MSHA has verified that through the use of the submicrometer impactor, which reduces the mineral dust collected, combined with the subtraction of organic carbon quantified by the fourth organic carbon peak, this source of interference can be eliminated (PS&HTC–DD–505, PS&HTC–DD–509, PS&HTC–DD–510 and PS&HTC–DD–00–523).

MSHA has verified the use of a submicron impactor to remove carbonate interference through field and laboratory measurements. In the field measurements, simultaneous respirable and submicron dust samples were collected near crushing operations where there was no diesel equipment operating. In the laboratory measurements, a aerosol containing carbonate dust was introduced into a dust chamber and simultaneous submicron, respirable and total dust samples were collected. For both the field and laboratory measurements, the samples were analyzed for carbon using NIOSH Method 5040. Results of analysis of these samples showed that for respirable dust samples, acidification of the sample removed the carbonate.

Carbonate was evolved in the fourth peak of the organic portion of the analysis. The carbon evolved by the analysis was approximately 10 percent of the carbonate collected on the gravimetric sample, roughly equating to 12 percent carbon contained in calcium carbonate tested (limestone). Sampling with the submicron impactor removed the carbonate and carbonaceous component from the sample. A commenter noted that in the dust chamber tests, organic carbon was reported, even though the carbonate was removed by sampling, acidification or software integration. This organic carbon was attributed to oil vapors leaking from the compressor that delivered the dust to the chamber. This oil leak was reported to MSHA after the tests were completed.

Sample results further indicated that the total carbon mass determined for the respirable diesel particulate samples was approximately 95 percent of the diesel particulate mass determined gravimetrically and the total carbon mass determined from the impactor diesel particulate samples was approximately 82 percent of the respirable value. Use of the impactor reduced the amounts of carbonate collected on the sample by 90 percent.

The difference between the respirable total carbon determinations and the gravimetric diesel particulate can be attributed to sulfates or other noncarbonaceous minerals in the diesel particulate. The difference between the submicron total carbon and the respirable total carbon determinations is attributed to the removal of diesel particulate particles that are greater than 0.9 micrometers in size. The difference between the carbonate measured by NIOSH Analytical Method 5040 and the gravimetric carbonate is attributed to impurities in the material. The expected ratio of evolved carbon from the carbonate to carbonate (C/CaCo3) would be 0.12 (12/(40 + 12 + 48)).

Graphitic Minerals. Commenters reported that several ores, primarily associated with gold mines, contain graphitic carbon, and that this carbon shows up as elemental carbon in an airborne dust sample. MSHA has collected samples of this ore and has found that in fact this is true (PS&HTC-DD–505, PS&HTC-DD–509, PS&HTC-DD–510). MSHA has verified the use of a submicron impactor to remove graphitic carbon interference through field measurements.

In the field measurements, simultaneous respirable and submicron dust samples were collected near crushing operations where there was no diesel equipment operating. For both the field and laboratory measurements, the samples were analyzed for carbon using NIOSH Method 5040. Results of analysis of these samples showed that for respirable dust samples, several μg/m^3 of elemental carbon could be present in the sample.

However, MSHA has found this interference is very small, and can be reduced still further through the use of the submicron impactor on the sampler. The highest elemental carbon content of the ores was less than 5 percent. These ores also contain at least 20 percent respirable silica, as determined from samples collected near crushers where diesel particulate was not present. Based on a 20 percent respirable silica content in the dust in the environment, the allowable respirable dust exposure would be limited to 0.45 mg/m^3. Based on a 5 percent elemental carbon content in the sample, this sample could contain 23 μg/m^3 of elemental carbon. Typically 10 percent of mineral dust is less than one micron. By using the submicron impactor, the interference from graphitic carbon in the ore would be less than 3 μg/m^3. Samples collected by MSHA, near crushing operations, using submicron impactors, did not contain elemental carbon.

Accordingly, MSHA plans to sample for diesel particulate matter using submicron impactors to reduce the potential interference from carbonates, carbonaceous minerals and graphitic ores. As noted previously, this requirement is being specifically added to the regulation.

Oil Mist and Organic Vapors. Commenters indicated that diesel particulate sample interference can occur from sampling around drilling operations and from organic solvents.

To verify the existence and extent of any such interference, MSHA collected samples at stoper drilling, jack leg drilling and face drilling operations. The stoper drill and jack leg drill were pneumatic. The face drill was electrohydraulic. Interference from drill oil mist was observed for both the stoper drill and jack leg drill operations (PS&HTC–DD–505, PS&HTC–DD–511). Respirable and submicron samples were collected in the stope, the intake air to the stope and the exhaust air from the stope. Interference from drill oil mist was not found in submicron samples collected on the electrohydraulic face drill (PS&HTC–DD–505). The oil mist interference for the stoper drill was confined to the drill location due to the use of a high viscosity lube grease. The amount of interference in the stope on a submicron sample for the stoper drill was 4.5 μg/m^3 per hour of drilling. The interference from the oil mist on the jack leg operation extended throughout the mining stope area, but it did not extent into the main ventilation heading. The amount of interference in the stope on a submicron sample for the jack leg drill was 9 to 11 μg/m^3 per hour of drilling. MSHA believes that similar interferences could occur when miners are working near organic solvents.

Accordingly, this is an interference that can be addressed by not sampling too close to the source of the interference. As discussed in more detail in Part IV of this preamble, when MSHA collects compliance samples on drilling operations that produce an oil mist, or where organic solvents are used, personal samples will not be collected. Instead, an area sample will be collected, upwind of the driller or organic solvent source.

A commenter suggested that the lack of organic carbon reduction from outside to inside the cab at Homestake Mine indicated additional sources of organic carbon that have not been identified. MSHA believes that the reduction in elemental but not organic carbon from outside to inside the cab at Homestake Mine was attributed to size distribution. The organic carbon is small enough to pass through a filter. The organic carbon in the cab could not have been generated from a source inside the cab or attributed to residual cigarette smoke as the air exchange rate for the cab was one air change per minute. The cab operator did not smoke.

Cigarette Smoke. Cigarette smoke is a form of organic carbon. Commentors indicated that cigarette smoke can interfere with a diesel particulate measurement when total carbon is used as the indicator of dpm. Industry Commenters collected samples in a surface ‘‘smoke room’’ where the airflow and number of cigarettes were not monitored.

To verify the existence and the extent of any such interference, MSHA took samples in an underground mine where controlled smoking took place. Two series of cigarette tests were conducted. A test site was chosen in the NIOSH, PRL, Experimental Mine. The site consisted of approximately 75 feet of straight entry. The entry was approximately 18.5 feet wide and 6.2 feet high (115 square feet area). In the first test, the airflow rate through the test area was 6,000 cfm and 4 cigarettes were smoked over a 120 minute period. In the second test, the airflow was 3,000 cfm and 28 cigarettes were smoked over a 210 minute period. A control filter was used to adjust for organic carbon present on the filter media. MSHA collected samples on the smokers, twenty-five feet upwind of the smokers, twenty-five feet downwind of the smokers and fifty feet downwind of the smokers. Results of the underground test did verify that smoking could be an interference on a dpm measurement.

Analysis of the thermogram from the smoking test showed that cigarette smoke showed up only in the organic portion of the analysis. In this test with the cigarette smoke, a fifth organic peak was observed. This peak contributed approximately 0.5 μg/m² to the analysis. This would be equivalent to an 8 hour full shift concentration of 5 μg/m³. The thermogram otherwise is not distinguishable from the organic portion of a thermogram for a diesel particulate sample. Analysis of the thermogram indicated that 30 percent of the organic carbon appeared in the first organic peak, 15 percent appeared in the second organic peak, 10 percent appeared in the third organic peak, 25 percent of the cigarette smoke appeared in the fourth organic peak, and 20 percent of the cigarette smoke appeared in the fifth organic peak. While the amount of carbon identified by the fourth organic peak can be quantified and mathematically subtracted from the amount of total carbon measured, the remaining three peaks, representing 83 percent of the total carbon associated with smoking, would be an interferrant to the diesel particulate matter measurement.

However, the effect of cigarette smoke was even more localized to the smoker than the oil mist was to the stoper or jack leg drill operator. Twenty five feet upwind of the smoker, no carbon attributed to cigarette smoke was detected. For the smoker, each cigarette smoked would add 5 to 10 μg/m³ to the exposure, depending on the airflow. Smoking 10 cigarettes would add 50 to 100 μg/m³ to a worker's exposure. At both twenty five feet and fifty feet downwind of the smoker, after mixing with the ventilating air, the contribution of carbon attributed to smoking was reduced to 0.3 μg/m³ for each cigarette smoked. Sampling twenty-five to fifty feet down wind of a worker smoking 10 cigarettes per day would add no more than 3 μg/m³ to the worker's exposure (PS&HTC–DD–518). The air velocities in this test (30 to 60 feet per minute) were relatively low compared to typical mine air velocities. The interference would be even less at the higher air velocities normally found in mines.

Accordingly, as discussed in more detail in Part IV of this preamble, when MSHA collects compliance samples, miners will be requested not to smoke. If a miner does want to smoke while being sampled, and is not prohibited from doing so by the mine operator, the inspector will collect an area sample a minimum of twenty-five feet upwind or downwind of the smoker. Smokers working inside cabs will not be sampled.

Summary of Conclusions from Verification Studies. In summary, MSHA was able to draw the following conclusions from these studies:

• As specified in NIOSH Method 5040, it is essential to use a blank to correct organic carbon measurements.

• Contamination (interference) from carbonate and carbonaceous minerals is evolved in the fourth organic peak of the thermogram.

• Interference from graphitic minerals may appear in the elemental carbon portion of the analysis.

• Interference from cigarette smoke and oil mist from pneumatic drills appears in several peaks of the organic analysis.

• Use of the submicron impactor removes the mineral interference from carbonate, carbonaceous minerals and graphitic minerals.

• Acidification is required to remove the interference from bicarbonate which maybe evolved in several of the organic peaks.

• Subtraction of the fourth organic peak by software integration can be used to correct for interference from carbonaceous minerals.

• Interference from cigarette smoke and oil mist from pneumatic drills is localized. It can be avoided by sampling upwind or downwind of the interfering source.

• Total carbon from cigarettes smoke and oil mist are small compared to emissions from a diesel engine.

• Sampling can be conducted down wind of the interfering source after the contaminated air current has been diluted with another air current.

The magnitude of interferences measured during the verifications were small compared to the levels of total carbon measured in underground mines (as reported in Part III of this preamble). The discussion of section 5061 in Part IV of this preamble provides further information on how MSHA will take this information about interferences into account in compliance sampling; in addition, MSHA will provide specific guidance to inspectors as to how to avoid interferences when taking compliance samples.

(4) Limiting the Public's Exposure to Diesel and Other Fine Particulates—Ambient Air Quality Standards.

Pursuant to the Clean Air Act, the Federal Environmental Protection Agency (EPA) is responsible for setting air pollution standards to protect the public from toxic air contaminants. These include standards to limit exposure to particulate matter. The pressures to comply with these limits have an impact upon the mining industry, which limits various types of particulate matter into the environment during mining operations, and a special impact on the coal mining industry whose product is used extensively in particulate emission generating power facilities. But those standards hold interest for the mining community in other ways as well, for underlying some of them is a large body of evidence on the harmful effects of airborne particulate matter on human health. Increasingly, that evidence has pointed toward the risks of the smallest particulates—including the particles generated by diesel engines.

This section provides an overview of EPA's rulemaking efforts to limit the ambient air concentration of particulate matter, including its recent particular focus on diesel and other fine particulates. Additional and up-to-date information about the most current rulemaking in this regard is available on EPA's Web site, http://www.epa.gov/ttn/oarpg/naaqsfin/.

EPA is also engaged in other work of interest to the mining community. Together with some state environmental agencies, EPA has actually established limits on the amount of particulate matter that can be emitted by diesel engines. This topic is discussed in the next section of this Part (section 5). Environmental regulations also establish the maximum sulfur content permitted in diesel fuel, and such sulfur content can be an important factor in dpm generation. This topic is discussed in section 6 of this Part. In addition, EPA and some state environmental agencies have also been exploring whether diesel particulate matter is a carcinogen or a toxic material at the concentrations in which it appears in the ambient atmosphere. Discussion of these studies can be found in Part III of this preamble.

Background. Air quality standards involve a two-step process: standard setting by EPA, and implementation by each State.

Under the law, EPA is specifically responsible for reviewing the scientific literature concerning air pollutants, and establishing and revising National Ambient Air Quality Standards (NAAQS) to minimize the risks to health and the environment associated with such pollutants. This review is to be conducted every five years. Feasibility of compliance by pollution sources is not supposed to be a factor in establishing NAAQS. Rather, EPA is required to set the level that provides ''an adequate margin of safety'' in protecting the health of the public.

Implementation of each national standard is the responsibility of the states. Each must develop a state implementation plan that ensures air quality in the state consistent with the ambient air quality standard. Thus, each state has a great deal of flexibility in targeting particular modes of emission (*e.g.,* mobile or stationary, specific industry or all, public sources of emissions vs. private-sector sources), and in what requirements to impose on polluters. However, EPA must approve the state plans pursuant to criteria it establishes, and then take pollution measurements to determine whether all counties within the state are meeting each ambient air quality standard. An area not meeting an NAAQS is known as a ''nonattainment area''.

TSP. Particulate matter originates from all types of stationary, mobile and natural sources, and can also be created from the transformation of a variety of gaseous emissions from such sources. In the context of a global atmosphere, all these particles are mixed together, and both people and the environment are exposed to a ''particulate soup'' the chemical and physical properties of which vary greatly with time, region, meteorology, and source category.

The first ambient air quality standards dealing with particulate matter did not distinguish among these particles. Rather, the EPA established a single NAAQS for ''total suspended particulates'', known as ''TSP.'' Under this approach, the states could come into compliance with the ambient air requirement by controlling any type or size of TSP. As long as the total TSP was under the NAAQS—which was established based on the science available in the 1970s—the state met the requirement.

PM_{10}. When the EPA completed a new review of the scientific evidence in the mid-eighties, its conclusions led it to revise the particulate NAAQS to focus more narrowly on those particulates less than 10 microns in diameter, or PM_{10}. The standard issued in 1987 contained two components: an annual average limit of 50 $\mu g/m^3$, and a 24-hour limit of 150 $\mu g/m^3$. This new standard required the states to reevaluate their situations and, if they had areas that exceeded the new PM_{10} limit, to refocus their compliance plans on reducing those particulates smaller than 10 microns in size. Sources of PM_{10} include power plants, iron and steel production, chemical and wood products manufacturing, wind-blown and roadway fugitive dust, secondary aerosols and many natural sources.

Some state implementation plans required surface mines to take actions to help the state meet the PM_{10} standard. In particular, some surface mines in Western states were required to control the coarser particles—*e.g.,* by spraying water on roadways to limit dust. The mining industry has objected to such controls, arguing that the coarser particles do not adversely impact health, and has sought to have them excluded from the EPA ambient air standards.

$PM_{2.5}$. The next scientific review was completed in 1996, following suit by the American Lung Association and others. A proposed rule was published in November of 1996, and, after public hearings and review by the Office Management and Budget, a final rule was promulgated on July 18, 1997. (62 FR 38651).

The new rule further modifies the standard for particulate matter. Under the new rule, the existing national ambient air quality standard for PM_{10} remains basically the same—an annual average limit of 50 $\mu g/m^3$ (with some adjustment as to how this is measured for compliance purposes), and a 24-hour ceiling of 150 $\mu g/m^3$. In addition, however, a new NAAQS has now been established for ''fine particulate matter'' that is less than 2.5 microns in size. The $PM_{2.5}$ annual limit is set at 15 $\mu g/m^3$, with a 24-hour ceiling of 65 $\mu g/m^3$.

The basis for the $PM_{2.5}$ NAAQS is a large body of scientific data suggesting that particles in this size range are the ones responsible for the most serious health effects associated with particulate matter. The evidence was thoroughly reviewed by a number of scientific panels through an extended process. The proposed rule resulted in considerable press attention, and hearings by Congress, in which this scientific evidence was further discussed. Moreover, challenges to EPA's determination that this size category warranted rulemaking were rejected by a three judge panel of the DC Circuit Court. (American Trucking Association vs. EPA, 275 F.3d 1027).

Second, the majority of the panel agreed with challenges to the EPA's determination to keep the existing requirements on PM10 as a surrogate for the coarser particulates in this category (those particulates between 2.5 and 10 microns in diameter); instead, the panel ordered EPA to develop a new standard for this size category. (Op.Cit., *23.)

Implications for the Mining Community. As noted earlier in this part, diesel particulate matter is mostly less than 1.0 micron in size. It is, therefore, a fine particulate; indeed, in some regions of the country, diesel particulate generated by highway and off-road vehicles constitutes a significant portion of the ambient fine particulate (June 16, 1997, PM–2.5 Composition and Sources, Office of Air Quality Planning and Standards, EPA). Moreover, as noted in Part III of this preamble, some of the scientific studies of health risk from fine particulates used to support the EPA rulemaking were conducted in areas where the major fine particulate was from diesel emissions. Accordingly, MSHA has concluded that it must consider the body of evidence of human health risk from environmental exposure to fine particulates in assessing the risk of harm to miners of occupational exposure to diesel particulate. Comments on the appropriateness of the conclusion by MSHA, and whether MSHA should be working on a fine particulate standard rater than just one focused on diesel particulate are reviewed in Part III.

(5) The Effects of Existing Standards—MSHA Standards on Diesel Exhaust Gases (CO, CO_2, NO, NO_2, and SO_2), and EPA Diesel Engine Emission Standards—on the Concentration of dpm in Underground Metal and Nonmetal Mines

With the exception of diesel engines used in certain classifications of gassy mines, MSHA does not require that the emissions from diesel engines used in underground metal and nonmetal mines, as measured at the tailpipe, meet certain minimum standards of cleanliness. (Some states may require engines used in underground metal and nonmetal mines to be MSHA Approved.) This is in contrast to underground coal mines, where only engines which meet certain standards with respect to gaseous emissions are ''approved'' for use in underground coal mines. Indeed, as discussed in section 7 of this part, the whole underground coal mine fleet must now consist of approved engines, and the engines must be maintained in approved condition. While such restrictions do not directly control dpm emissions of underground coal equipment, they do have some indirect impact on them.

MSHA does have some requirements for underground metal and nonmetal mines that limit the exposure of miners to certain gases emitted by diesel engines. Accordingly, those requirements are discussed here.

Engine emissions of dpm in underground metal and nonmetal mines are gradually being impacted by Federal environmental regulations, supplemented in some cases by State restrictions. Over time, these regulations have required, and are continuing to require, that new diesel engines meet tighter and tighter standards on dpm emissions. As these cleaner engines replace or supplement older engines in underground metal and nonmetal mines, they can significantly reduce the amount of dpm emitted by the underground fleet. Much of this section reviews developments in this area. Although this subject was discussed in the preamble of the proposed dpm rule (63 FR 58130 *et seq.*), the review here updates the relevant information.

MSHA Limitations on Diesel Gases. MSHA limits on the exposure of miners to certain gases in underground mines are listed in Table II–2, for both coal mines and metal/nonmetal mines, together with information about the recommendations in this regard of other organizations. As indicated in the table, MSHA requires mine operators to comply with gas specific threshold limit values (TLV®s) recommended by the American Conference of Governmental Industrial Hygienists (ACGIH) in 1972 (for coal mines) and in 1973 (for metal and nonmetal mines).

BILLING CODE 4510–43–P

TABLE II-2 GASEOUS EXPOSURE LIMITS (PPM)

Pollutant	Range of Limits Recommended		MSHA Limits	
			$Coal_A$	M/NM_B
HCHO (formaldehyde)	0.016_C	0.3_D	2	2
CO	25_D	50	50	50
CO_2	$5,000_C$	5,000	5,000	5,000
NO	$25_{C,D,E}$	25	25	25
NO_2	1_F	3_D	5	5
SO_2	$2_{C,D}$	5_E	2	5

Table Notes:
A) ACGIH, 1972
B) ACGIH, 1973
C) NIOSH recommended exposure limit (REL), based on a 10-hour, time-weighted average
D) ACGIH, 1996
E) OSHA permissible exposure limit (PEL)
F) NIOSH recommends only a 1-ppm, 15-minutes, short-term exposure limit (STEL)

BILLING CODE 4510–43–C

To change an exposure limit at this point in time requires a regulatory action; the rule does not provide for their automatic updating. In 1989, MSHA proposed changing some of these gas limits in the context of a proposed rule on air quality standards. (54 FR 35760). Following opportunity for comment and hearings, a portion of that proposed rule, concerning control of drill dust and abrasive blasting, has been promulgated, but the other components are still under review.

One commenter expressed concern that MSHA would attempt to regulate dpm together with diesel exhaust gases based on their additive or combined effects. As discussed in greater detail in Part IV of this preamble, MSHA does not, at this time, have sufficient information upon which to enforcement limits for dpm and diesel exhaust gases on the basis of their additive or combined effects, if any.

Authority for Environmental Engine Emission Standards. The Clean Air Act authorizes the Federal Environmental Protection Agency (EPA) to establish nationwide standards for mobile vehicles, including those powered by diesel engines (often referred to in environmental regulations as ''compression ignition'' or ''CI'' engines). These standards are designed to reduce the amount of certain harmful atmospheric pollutants emanating from mobile sources: the mass of particulate matter, nitrogen oxides (which as previously noted, can result in the generation of particulates in the atmosphere), hydrocarbons and carbon monoxide.

California has its own engine emission standards. New engines destined for use in California must meet standards under the law of that State. The standards are issued and administered by the California Air Resources Board (CARB). In many cases, the California standards are the same as the national standards; as noted herein, the EPA and CARB have worked on certain agreements with the industry toward that end. In other situations, the California standards may be more stringent.

Regulatory responsibility for implementation of the Clean Air Act is vested in the Office of Transportation and Air Quality (formerly the Office of Mobile Sources), part of the Office of Air and Radiation of the EPA. Some of the discussion which follows was derived from materials which can be accessed from the agency's home page on the World Wide Web at (http://www.epa.gov/omswww/omshome.htm). Information about the California standards may be found at the CARB home page at (http://www.arb.ca.gov/homepage.htm).

Diesel engines are generally divided into three broad categories for purposes of engine emissions standards, in accordance with the primary use for which the type of engine is designed: (1) light duty vehicles and light duty trucks (i.e., those engines designed primarily to power passenger transport or transportation of property); (2) heavy duty highway engines (i.e., those designed primarily to power over-the-road truck hauling); and (3) nonroad vehicles (i.e., those engines designed primarily to power small equipment, construction equipment, locomotives and other non-highway uses).

The exact emission standards which a new diesel engine must meet varies with engine category and the date of manufacture. Through a series of regulatory actions, EPA has developed a detailed implementation schedule for each of the three engine categories noted. The schedule generally forces technology while taking into account certain technological realities.

Detailed information about each of the three engine categories is provided below; a summary table of particulate matter emission limits is included at the end of the discussion.

EPA Emission Standards for Light-Duty Vehicles and Light Duty Trucks.[2] Current light-duty vehicles generally comply with the Tier 1 and National LEV emission standards. Particulate matter emission limits are found in 40 CFR Part 86. In 1999, EPA issued new Tier 2 standards that will be applicable to light-duty cars and trucks beginning in 2004. With respect to pm, the new rules phase in tighter emissions limits to parts of production runs for various subcategories of these engines over several years; by 2008, all light duty trucks must limit pm emissions to a maximum of 0.02 g/mi. (40 CFR 86.1811–04(c)). Engine manufacturers may, of course, produce complying engines before the various dates required.

EPA Emissions Standards for Heavy-Duty Highway Engines. In 1988, a standard limiting particulate matter emitted from the heavy duty highway diesel engines went into effect, limiting dpm emissions to 0.6 g/bhp-hr. The Clean Air Act Amendments of 1990 and associated regulations provided for phasing in even tighter controls on NO_X and particulate matter through 1998. Thus, engines had to meet ever tighter standards for NO^X in model years 1990, 1991 and 1998; and tighter standards for PM in 1991 (0.25 g/bhp-hr) and 1994 (0.10 g/bhp-hr). The latter remains the standard for PM from these engines for current production runs (40 CFR 86.094–11(a)(1)(iv)(B)). Since any heavy duty highway engine manufactured since 1994 must meet this standard, there is a supply of engines available today which meet this standard. These engines are used in mining in the commercial type pickup trucks.

New standards for this category of engines are gradually being put into place. On October 21, 1997, EPA issued a new rule for certain gaseous emissions from heavy duty highway engines that will take effect for engine model years starting in 2004 (62 FR 54693). The rule establishes a combined requirement for NO_X and Non-methane Hydrocarbon (NMHC). The combined standard is set at 2.5 g/bhp-hr, which includes a cap of 0.5 g/bhp-hr for NMHC. EPA promulgated a rulemaking on December 22, 2000 (65 FR 80776) to adopt the next phase of new standards for these engines. EPA is taking an integrated approach to: (a) Reduce the content of sulfur in diesel fuel; and thereafter, (b) require heavy-duty highway engines to meet tighter emission standards, including standards for PM. The purpose of the diesel fuel component of the rulemaking is to make it technologically feasible for engine manufacturers and emissions control device makers to produce engines in which dpm emissions are limited to desired levels in this and other engine categories. The EPA's rule will reduce pm emissions from new heavy-duty engines to 0.01 g/bhp-hr, a reduction from the current 0.1 g/bhp-hr. MSHA assumes it will be some time before there is a significant supply of engines that can meet this standard, and the fuel supply to make that possible.

EPA Emissions Standards for Nonroad Engines. Nonroad engines are those designed primarily to power small portable equipment such as compressors and generators, large construction equipment such as haul trucks, loaders and graders, locomotives and other miscellaneous equipment with non-highway uses. Engines of this type are the ones used most frequently in the underground coal mines to power equipment.

Nonroad diesel engines were not subjected to emission controls as early as other diesel engines. The 1990 Clean Air Act Amendments specifically directed EPA to study the contribution of nonroad engines to air pollution, and

[2] The discussion focuses on the particulate matter requirements for light duty trucks, although the current pm requirement for light duty vehicles is the same. The EPA regulations for these categories apply to the unit, rather than just to the engine itself; for heavy-duty highway engines and nonroad engines, the regulations attach to the engines.

regulate them if warranted (Section 213 of the Clean Air Act). In 1991, EPA released a study that documented higher than expected emission levels across a broad spectrum of nonroad engines and equipment (EPA Fact Sheet, EPA420–F–96–009, 1996). In response, EPA initiated several regulatory programs. One of these set Tier 1 emission standards for larger land-based nonroad engines (other than for rail use). Limits were established for engine emissions of hydrocarbons, carbon monoxide, NO_X, and dpm. The limits were phased in with model years from 1996 to 2000. With respect to particulate matter, the rules required that starting in model year 1996, nonroad engines from 175 to 750 hp meet a limit on pm emissions of 0.4 g/bhp-hr, and that starting in model year 2000, nonroad engines over 750 hp meet the same limit.

Particulate matter standards for locomotive engines were set subsequently (63 FR 18978, April, 1998). The standards are different for line-haul duty-cycle engine and switch duty-cycle engines. For model years from 2000–2004, the standards limit pm emissions to 0.45 g/bhp-hr and 0.54 g/bhp-hr respectively for those engines; after model year 2005, the limits drop to 0.20 g/bhp-hr and 0.24 g/bhp-hr respectively.

In October 1998, EPA established additional standards for nonroad engines (63 FR 56968). Among these are gaseous and particulate matter limits for the first time (Tier 1 limits) for nonroad engines under 50 hp. Tier 2 emissions standards for engines between 50 and 175 hp include pm standards for the first time. Moreover, they establish Tier 2 particulate matter limits for all other land-based nonroad engines (other than locomotives which already had Tier 2 standards). Some of the non-particulate emissions limits set by the 1998 rule are subject to a technology review in 2001 to ensure that the levels required to be met are feasible; EPA has indicated that in the context of that review, it intends to consider further limits for particulate matter, including transient emission measurement procedures. Because of the phase-in of these Tier 2 pm standards, and the fact that some manufacturers will produce engines meeting the standard before the requirements go into effect, there are or soon will be some Tier 2 pm engines in some sizes available, but it is likely to be a few years before a full size range of Tier 2 pm nonroad engines is available.

Table II–3, EPA NonRoad Engine PM Requirements, provides a full list of the EPA required particulate matter limitations on nonroad diesel engines. For example, a nonroad engine of 175 hp produced in 2001 must meet a standard of 0.4 g/hp-hr; a similar engine produced in 2003 or thereafter must meet a standard of 0.15 g/hp-hr.

TABLE II–3.—EPA NONROAD ENGINE PM REQUIREMENTS

kW range	Tier	Year first applicable	PM limit (g/kW-hr)
kW<8	1	2000	1.00
	2	2005	0.80
8≤kW<19	1	2000	0.80
19≤kW<37	1	1999	0.80
	2	2004	0.60
37≤kW<75	1	1998	....
	2	2004	0.40
75≤kW<130	1	1997	....
	2	2003	0.30
130≤kW<225	1	1996	0.54
	2	2003	0.20
225≤kW<450	1	1996	0.54
	2	2001	0.20
450≤kW<560	1	1996	0.54
	2	2002	0.20
kW>560	1	2000	0.54
	2	2006	0.20

The Impact of EPA Engine Emission Standards on the Underground Metal and Nonmetal Mining Fleet. In the mining industry, engines and equipment are often purchased in used condition. Thus, many of the diesel engines in an underground mine's fleet may only meet older environmental emission standards, or no environmental standards at all.

By requiring that underground coal mine engines be approved, MSHA regulations have led to a less polluting fleet in that sector than would otherwise be the case. Many highly polluting engines have been barred or phased out as a result. As noted in Part IV of this preamble, such a requirement for the underground metal and nonmetal sector is being added by this rulemaking; however, it will be some time before its effects are felt. Moreover, although the environmental tailpipe requirements will bring about gradual reduction in the overall contribution of diesel pollution to the atmosphere, the beneficial effects on mining atmospheres may require a long timeframe absent actions that accelerate the turnover of mining fleets to engines that emit less dpm.

The Question of Nanoparticles. Comments received from several commenters on the proposed rule for diesel particulate matter exposure of underground coal miners raised questions relative to ''nanoparticles'; i.e., particles found in the exhaust of diesel engines that are characterized by diameters less than 50 nanometers (nm). As the topic may be of interest to this sector as well, MSHA's discussion on the topic is being repeated in this preamble for informational purposes.

One commenter was concerned about recent indications that nanoparticles may pose more of a health risk than the larger particles that are emitted from a diesel engine. This commenter submitted information demonstrating that nanoparticles emitted from the engine could be effectively removed from the exhaust using aftertreatment devices such as ceramic traps. Another commenter was concerned that MSHA's proposed rule for underground coal mines is based on removing 95% of the particulate by mass. His concern was focused on the fact that this reduction in mass was attributed to those particles greater than 0.1µm but less than 1µm and did not address the recent scientific hypothesis that it may be the very small nanopaticles that are responsible for adverse health effects. Based on the recent specific information on the potential health effects resulting from exposure to nanoparticles, this commenter did not believe that the risk to cancer would be reduced if exposure levels to nanoparticles increased. He indicated that studies suggest that the increase in nanoparticles will exceed 6 times their current levels.

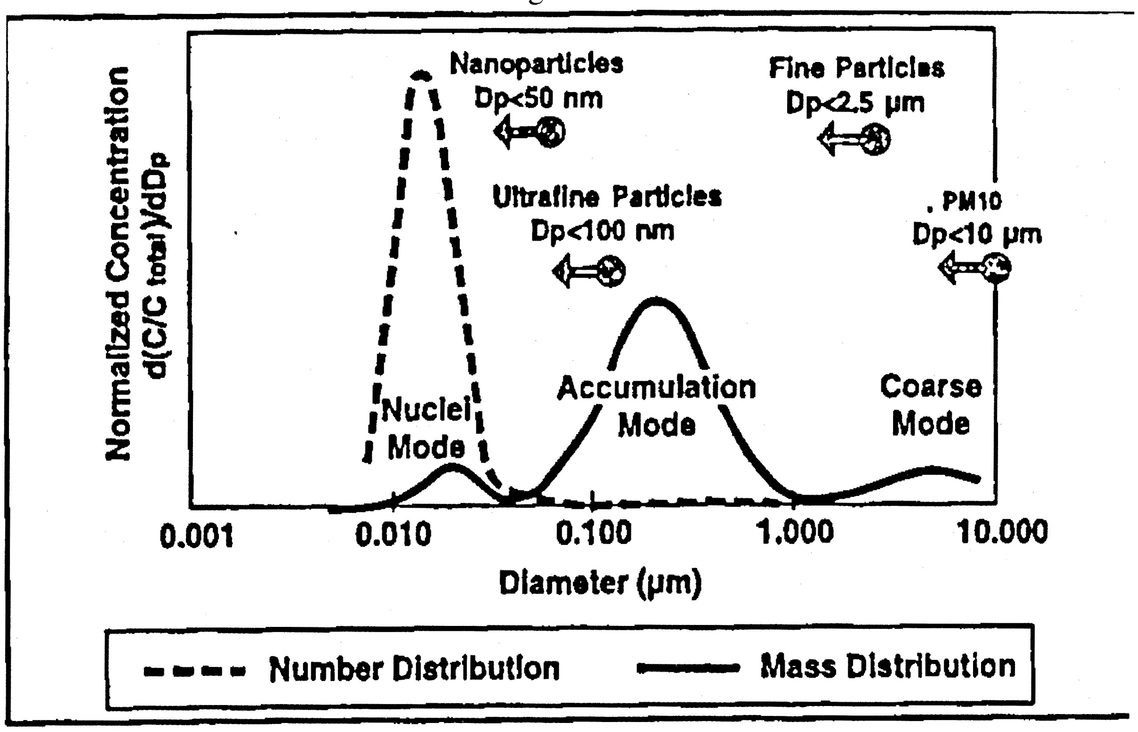
Current environmental emission standards established by EPA and CARB, and the particulate index calculated by MSHA, focus on the total mass of diesel particulate matter emitted by an engine—for example, the number of grams per some unit of measure (i.e., grams/brake-horsepower). Thus, the technology being developed by the engine industry to meet the standards accordingly focuses on reducing the mass of dpm being emitted from the engine.

There is some evidence, however, that some aspects of this new technology, particularly fuel injection, is resulting in an increase in the number of nanoparticles being emitted from the engine.

BILLING CODE 4510–43–P

Figure II-3, repeated here from section 2 of this Part, illustrates this situation (Majewski, W. Addy, Diesel Progress, June, 1998).

Figure II-3



Diesel particulate size distribution.

BILLING CODE 4510–43–C

The formation of particulates starts with particle nucleation followed by subsequent agglomeration of the nuclei particles into an accumulation mode. Thus, as illustrated in Figure II–3, the majority of the mass of dpm is found in the accumulation mode, where the particles are generally between 0.1 and 1 micron in diameter. However, when considering the number of particles emitted from the engine, more than half and sometimes almost all of the particles (by number) are in the nuclei mode.

Various studies have demonstrated that the size of the particles emitted from the new low emission diesel engines, has shifted toward the generation of nuclei mode particles. One study compared a comparable 1991 engine to its 1988 counterpart. The total PM mass in the newer engine was reduced by about 80%; but the new engine generated thousands of times more particles than the older engine (3000 times as much at 75 percent load and about 14,000 times as much at 25 percent load). One hypothesis offered for this phenomenon is that the cleaner engines produce less soot particles on which particulates can condense and accumulate, and hence they remain in nuclei mode. The accumulation particles act as a ''sponge'' for the condensation and/or adsorption of volatile materials. In the absence of that sponge, gas species which are to become liquid or solid will nucleate to form large numbers of small particles (diesel.net technology guide). Mayer, while pointing out that nanoparticle production was a problem with older engines as well, concurs that the technology being used to clean up pollution in newer engines is not having any positive impact on nanoparticle production. While there is scientific evidence that the newer engines, designed to reduce the mass of pollutants emitted from the diesel engine, emit more particles in the nuclei mode, quantifying the magnitude of these particles has been difficult because as dpm is released into the atmosphere the diesel particulate undergoes very complex changes. In addition, current testing procedures can produce spurious increases in the number of nanoparticles that would not necessarily occur under more realistic atmospheric conditions.

Experimental work conducted at WVU (Bukarski) indicate that nanoparticles are not generated during the combustion process, but rather during various physical and chemical processes which the exhaust undergoes in after treatment systems.

While current medical research findings indicate that small particulates, particularly those below 2µm in size, may be more harmful to humans than the larger ones, much more medical research and diesel emission studies are needed to fully characterize diesel nanoparticles emissions and their impact on human health. If nanoparticles are found to have an adverse health impact by virtue of size and number, it could require significant adjustments in environmental engine emission regulation and technology. It could also have implications for the type of controls utilized, with some asserting that aftertreatment filters are the only effective way to limit the emission of nanoparticles and others asserting that aftertreatment filters may under certain circumstances limit the number of nanoparticles.

Research on nanoparticles and their health effects is currently a topic of investigation. (Bagley et al., 1996, EPA Grant). Based on the comments received and a review of the literature currently available on the nanoparticle issue, MSHA believes that, at this time, promulgation of the final rules for underground coal and metal and nonmetal mines is necessary to protect miners. The nanoparticle issues discussed above will not be resolved for some time because of the extensive research required to address the questions raised.

(6) Methods for controlling dpm concentrations in underground metal and nonmetal mines

As discussed in the last section, the introduction of new engines underground will certainly play a significant role in reducing the concentration of dpm in underground metal/nonmetal mines. There are, however, many other approaches to reducing dpm concentrations and occupational exposures to dpm in underground metal/nonmetal mines. Among these are: aftertreatment devices to eliminate particulates emitted by an engine; altering fuel composition to minimize engine particulate emission; maintenance practices and diagnostic systems to ensure that fuel, engine and aftertreatment technologies work as intended to minimize emissions; enhancing ventilation to reduce particulate concentrations in a work area; enclosing workers in cabs or other filtered areas to protect them from exposure; and work and fleet practices that reduce miner exposures to emissions.

As noted in section 9 of this Part, information about these approaches was solicited from the mining community in a series of workshops in 1995, and highlights were published by MSHA as an appendix to the proposed rule on dpm ''Practical Ways to Control Exposure to Diesel Exhaust in Mining—a Toolbox.'' During the hearings and in written comments on this rulemaking, mention was made of all these control methods.

This section provides updated information on two methods for controlling dpm emissions: aftertreatment devices and diesel fuel content. There was considerable comment on aftertreatment devices because MSHA's proposed rule would require high-efficiency particulate filters be installed on a certain percentage of the fleet in order to meet both the interim and final dpm concentration; and the current and potential efficiency of such devices remains an important issue in determining the technological and economic feasibility of the final rule. Moreover, some commenters strongly favored the use of oxidation catalytic converters, a type of aftertreatment device used to reduce gaseous emission but which can also impact dpm levels. Accordingly, information about such devices is reviewed here. With respect to diesel fuel composition, a recent rulemaking initiative by EPA, and actions taken by other countries in this regard, are discussed here because of the implications of such developments for the mining community.

Emissions aftertreatment devices. One of the most discussed approaches to controlling dpm emissions involves the use of devices placed on the end of the tailpipe to physically trap diesel particulate emissions and thus limit their discharge into the mine atmosphere. These aftertreatment devices are often referred to as ''particle traps'' or ''soot traps'', but the term filter is often used. The two primary categories of particulate traps are those composed of ceramic materials (and thus capable of handling uncooled exhaust), and those composed of paper materials (which require the exhaust to first be cooled). Typically, the latter are designed for conventional permissible equipment mainly used in coal mining which have water scrubbers installed which cool the exhaust. However, another alternative that is now utilized in coal is the ''dry system technology'' which cools the diesel exhaust with a heat exchanger and then uses a paper filter. The dry system was first developed for oil shale mining applications where permissibility was required. However, when development of the oil shale industry faltered, manufacturers looked to coal mining for application of the dry system technology. However, dry systems could be used as an alternative to the wet scrubbers for the relatively small number of permissible machines used in the metal/nonmetal industry. In addition, ''oxidation catalytic converters,'' devices used to limit the emission of diesel gases, and ''water scrubbers'', devices used to cool the exhaust gases, are discussed here as well, because they also can have a significant effect on limiting particle emission.

Water Scrubbers. Water scrubbers are devices added to the exhaust system of certain diesel equipment. Water scrubbers are essentially metal boxes containing water through which the diesel exhaust gas is passed. The exhaust gas is cooled, generally to below 170 degrees F. A small fraction of the unburned hydrocarbons are condensed and remain in the water along with a portion of the dpm. Tests conducted by the former Bureau of Mines and others indicate that no more than 20 to 30 percent of the dpm is removed. This information was presented in the Toolbox publication. The water scrubber does not remove any of the carbon monoxide, the oxides of nitrogen, or any other gaseous emission that remains a gas at room temperature so their effectiveness as aftertreatment devices is questionable.

The water scrubber does serve as an effective spark and flame arrester and as a means to cool the exhaust gas when permissibility is required. Consequently, it is used in the majority of the permissible diesel equipment in mining as part of the safety components needed to gain MSHA approval.

The water scrubber has several operating characteristics which keep it from being a candidate for use as an aftertreatment device on nonpermissible equipment. The space required on the vehicle to store sufficient water for an 8 hour shift is not available on some equipment. Furthermore, the exhaust contains a great deal of water vapor which condenses under some mining conditions creating a fog which can adversely effect visibility. Also, operation of the equipment on slopes can cause the water level in the scrubber to change resulting in water being blown out the exhaust pipe. Control devices are sometimes placed within the scrubber to maintain the appropriate water level. Because these devices are in contact with the water through which the exhaust gas has passed, they need frequent maintenance to insure that they are operating properly and have not been corroded by the acidic water created by the exhaust gas. The water scrubber must be flushed frequently to remove the acidic water and the dpm and other exhaust residue which forms a sludge that adversely effects the operation of the unit. These problems, coupled with the relatively low dpm removal efficiency, have prevented widespread use of water scrubbers as a dpm control device on nonpermissible equipment.

Oxidation Catalytic Converters. Oxidation catalytic converters (OCCs) were among the first devices added to diesel engines in mines to reduce the concentration of harmful gaseous emissions discharged into the mine environment. OCCs began to be used in underground mines in the 1960's to control carbon monoxide, hydrocarbons and odor. That use has been widespread. It has been estimated that more than 10,000 OCCs have been put into the mining industry over the years.

Several of the harmful emissions in diesel exhaust are produced as a result of incomplete combustion of the diesel fuel in the combustion chamber of the engine. These include carbon monoxide and unburned hydrocarbons including harmful aldehydes. Catalytic converters, when operating properly, remove significant percentages of the carbon monoxide and unburned hydrocarbons. Higher operating temperatures, achieved by hotter exhaust gas, improve the conversion efficiency.

Oxidation catalytic converters operate by, in effect, continuing the combustion process outside the combustion chamber. This is accomplished by utilizing the oxygen in the exhaust gas to oxidize the contaminants. A very small amount of material with catalytic properties, usually platinum or some combination of the noble metals, is deposited on the surfaces of the catalytic converter over which the exhaust gas passes. This catalyst allows the chemical oxidation reaction to occur at a lower temperature than would normally be required.

For the catalytic converter to work effectively, the exhaust gas temperature must be above 370 degrees Fahrenheit for carbon monoxide and 500 degrees Fahrenheit for hydrocarbons. Most converters are installed as close to the exhaust manifold as possible to minimize the heat loss from the exhaust gas through the walls of the exhaust pipe. Insulating the segment of the exhaust pipe between the exhaust manifold and the catalytic converter extends the portion of the vehicle duty cycle in which the converter works effectively.

The earliest catalytic converters for mining use consisted of alumina pellets coated with the catalytic material and enclosed in a container. The exhaust gas flowed through the pellet bed and the exhaust gas came into contact with the catalyst. Designs have evolved, and the most common design is a metallic substrate, formed to resemble a honeycomb, housed in a metal shell. The catalyst is deposited on the surfaces of the honeycomb. The exhaust gas flows through the honeycomb and comes into contact with the catalyst.

Soon after catalytic converters were introduced, it became apparent that there was a problem brought about by the sulfur found in diesel fuels in use at that time. Most diesel fuels in the United States contained anywhere from 0.25 to 0.50 percent sulfur or more on a mass basis. In the combustion chamber, this sulfur was converted to SO_2, SO_3, or SO_4 in various concentrations, depending on the engine operating conditions. In general, most of the sulfur was converted to gaseous SO_2. When exhaust containing the gaseous sulfur dioxide passed through the catalytic converter, a large proportion of the SO_2 was converted to solid sulphates which are in fact, diesel particulate. Sulfates can ''poison'' the catalyst, severely reducing its life.

Recently, as described elsewhere in this preamble, the EPA required that diesel fuel used for over the road trucks contain no more than 500 ppm sulfur. This action made low sulfur fuel available throughout the United States. MSHA, in its recently promulgated regulations for the use of diesel powered equipment in underground coal mines requires that this low sulfur fuel be used. MSHA is now extending this requirement for low sulfur fuel (<500ppm) to underground metal/nonmetal mines in this final rule. When the low sulfur fuel is burned in an engine and passed through a converter with a moderately active catalyst, only small amounts of SO_2 and additional sulfate based particulate are created. However, when a very active catalyst is used, to lower the operating temperature of the converter or to enhance the CO removal efficiency, even the low sulfur fuel has sufficient sulfur present to create an SO_2 and sulfate based particulate problem. Consequently, as discussed later in this section, the EPA has notified the public of its intentions to promulgate regulations that would limit the sulfur content of future diesel fuel to 15 ppm for on-highway use in 2006.

The particulate reduction capabilities of some OCCs are significant in gravimetric terms. In 1995, the EPA implemented standards requiring older buses in urban areas to reduce the dpm emissions from rebuilt bus engines. (40

CFR 85.1403). Aftertreatment manufacturers developed catalytic converter systems capable of reducing dpm by 25%. Such systems are available for larger diesel engines common in the underground metal and nonmetal sector. However, as has been pointed out by Mayer, the portion of particulate mass that seems to be impacted by OCCs is the soluble component, and this is a smaller percentage of particulate mass in utility vehicle engines than in automotive engines. Moreover, some measurements indicate that more than 40% of NO is converted to more toxic NO_2, and that particulate mass actually increases using an OCC at full load due to the formation of sulfates. In summation, Mayer concluded that the OCCs do not reduce the combustion particulates, produce sulfate particulates, have unfavorable gaseous phase reactions increasing toxicity, and that the positive effects are irrelevant for construction site diesel engines. Indeed, he indicates the negative effects outweigh the benefits. (Mayer, 1998. The Phase 1 interim data report of the Diesel Emission Control-Sulfur Effects (DECSE) Program (a joint government-industry program to explore lower sulfur content that is discussed in more detail later in this section) similarly indicates that using OCCs under certain operating conditions can increase dpm emissions due to an increase in the sulfate fraction (DECSE Program Summary, Dec. 1999). Another commenter also notes that oxidation catalytic activity can increase sulfates and submicron particles under certain operating conditions.

Other commenters during the rulemaking strongly supported the use of OCCs as an interim measure to reduce particulate and other diesel emission to address transitory employee effects that were mentioned in the proposed preamble. MSHA views the use of OCCs as one tool that mine operators can use to reduce the dpm emissions from certain vehicles alone or in combination of other aftertreatment controls to meet the interim and final dpm standards. The overall reduction in dpm emissions achieved with the exclusive use of an OCC is low compared to the reductions required to meet the standards. MSHA is aware of the negative effects produced by OCCs. However, with the use of low sulfur fuel and a catalyst that is formulated for low sulfate production, this problem can be resolved. Mine operators must work with aftertreatment manufacturers to come up with the best plan for their fleet for dpm control.

Hot gas filters. Throughout this preamble, MSHA is referring to the particulate traps (filters) that can be used in the undiluted hot exhaust stream from the diesel engine as hot gas filters. Hot gas filters refer to the current commercially available particulate filters, such as ceramic cell, woven fiber filters, sintered metal filters, etc.

Following publication of EPA rules in 1985 limiting diesel particulate emissions from heavy duty diesel engines, aftertreatment devices capable of significant reductions in particulate levels began to be developed for commercial applications.

The wall flow type ceramic honeycomb diesel particulate filter system was initially the most promising approach. These consisted of a ceramic substrate encased in a shock and vibration absorbing material and covered with a protective metal shell. The ceramic substrate is arranged in the shape of a honeycomb with the openings parallel to the centerline. The ends of the openings of the honeycomb cells are plugged alternately. When the exhaust gas flows through the particulate trap, it is forced by the plugged end to flow through the ceramic wall to the adjacent passage and then out into the mine atmosphere. The ceramic material is engineered with pores in the ceramic material sufficiently large to allow the gas to pass through without adding excessive back pressure on the engine, but small enough to trap the particulate on the wall of the ceramic material. Consequently, these units are called wall flow traps.

Work with ceramic filters in the last few years has led to the development of the ceramic fiber wound filter cartridge (SAE, SP–1073, 1995). The ceramic fiber has been reported by the manufacturer to have dpm reduction efficiencies up to 80 percent. This system has been used on vehicles to comply with German requirements that all diesel engines used in confined areas be filtered. Other manufacturers have made the wall flow type ceramic honeycomb dpm filter system commercially available to meet the German standard.

The development of these devices has proceeded in response to international and national efforts to regulate dpm emissions. However, due to the extensive work performed by the engine manufacturers on new technological designs of the diesel engine's combustion system, and the use of low sulfur fuel, particulate traps turned out to be unnecessary to comply with the EPA standards of the time for vehicle engines.

These devices proved to be very effective at removing particulate achieving particulate removal efficiencies of greater than 90 percent.

It was quickly recognized that this technology, while not immediately required for most vehicles, might be particularly useful in mining applications. The former Bureau of Mines investigated the use of catalyzed diesel particulate filters in underground mines in the United States (BOM, RI–9478, 1993). The investigation demonstrated that filters could work, but that there were problems associated with their use on individual unit installations, and the Bureau made recommendations for installation of ceramic filters on mining vehicles.

Canadian mines also began to experiment with ceramic traps in the 1980's with similar results (BOM, IC 9324, 1992). Work in Canada today continues under the auspices of the Diesel Emission Evaluation Program (DEEP), established by the Canadian Centre for Mineral and Energy Technology in 1996 (DEEP Plenary Proceedings, November 1996). The goals of DEEP are to: (1) Evaluate aerosol sampling and analytical methods for dpm; and (2) evaluate the in-mine performance and costs of various diesel exhaust control strategies.

Perhaps because experience is still limited, the general perception within the mining industry of the state of this technology in recent years is that it remains limited in certain respects; as expressed by one commenter at one of the MSHA workshops in 1995, ''while ceramic filters give good results early in their life cycle, they have a relatively short life, are very expensive and unreliable.''

One commenter reported unsuccessful experiments with ceramic filters in 1991 due to their inability to regenerate at low temperatures, lack of reliability, high cost of purchase and installation, and short life.

In response to the proposed rule, MSHA received a variety of information and claims about the current efficiency of such technologies. Commenters stated that in terms of technical feasibility to meet the standards, the appropriate aftertreament controls are not readily available on the market for the types and sizes of equipment used in underground mines. Another commenter stated that MSHA has not identified a technology capable of meeting the proposed standards at their mine and they were not aware of any technology currently available or on the horizon that would be capable of attaining the standards. Yet another commenter stated that both ceramic and paper filters are not technically feasible at their mine because of the high operating temperatures needed to regenerate filters or the difficulties presented by periodic removal of the filters for regeneration. Periodic removal of fragile ceramic filters subjects them to chipping and cracking and requires a large inventory of surplus filters. Commenter also stated that paper filters require exhaust gas cooling so that the paper filter does not burn. Commenter stated that they have been working with a manufacturer on installing one of these on a piece of equipment, but it is experimental and this installation was the first time a paper filter would be used on equipment of this size and type.

In response to the paper filter comment, dry system technology as described above was first tested on a large haul truck used in oil shale mining and then later applied to coal mining equipment. Paper filter systems have also been successfully installed on coal mining equipment that is identical to LHD machines used in metal/nonmetal mines. Therefore this technology has been applied to engine of the type and size used in metal/nonmetal mines. Commenters have stated that filters are not feasible at this time from the above comments. However, MSHA believes that the technology needed to reduce dpm emissions to both the interim and final standards is feasible. Much work has occurred in the development of aftertreatment controls, especially OCCs and hot gas filters. Aftertreatment control manufacturers have been improving both OCCs and ceramic type filters to provide better performance and reliability. New materials are currently available commercially and new filter systems are being developed especially in light of the recent requirements in Europe and the new proposals from the EPA. Consequently, MSHA does not agree with the commenter concerning chipping of the traps when removed. As stated, manufacturers have designed systems to either be removed easily or even regenerated on the vehicle by simply plugging the unit in without removing the filter.

Two groups in particular have been doing some research comparing the efficiency of recent ceramic models: West Virginia University, as part of that State's efforts to develop rules on the use of diesel-powered equipment underground; and VERT (Verminderung der Emissionen von Realmaschinen in Tunnelbau), a consortium of several European agencies conducting such research in connection with major planned tunneling projects in Austria, Switzerland and Germany to protect occupational health and subsequent legislation in each of the three countries restricting diesel emissions in tunneling.

The State of West Virginia legislature enacted the West Virginia Diesel Act, thereby creating the West Virginia Diesel Commission and setting forth an administrative vehicle to allow and regulate the use of diesel equipment in underground coal mines in West Virginia. West Virginia University was appropriated funds to test diesel exhaust controls, as well as an array of diesel particulate filters. The University was asked to provide technical support and data necessary for the Commission to make decisions on standards for emission controls. Even though the studies were intended for the Commission's work for underground coal, the control technologies tested are relevant to metal/nonmetal mines.

The University reported data on four different engines and an assortment of configurations of available control devices, both hot gas filters and the DST® system, a system which first cools the exhaust and then runs it through a paper filter. The range of collection efficiencies reported for the ceramic filters and oxidation catalysts combined fell between 65% and 78%. The highest collection efficiency obtained using the ISO 8 mode test cycle (test cycle described in rule) was 81% on the DST® system (intended for coal use). The University did report problems with this system that would account for the lower than expected efficiency for a paper filter type system.

VERT's studies of particulate traps are detailed in two articles published in 1999 which have been widely disseminated to the diesel community here through www.DieselNet.com. The March article focuses on the efficiency of the traps; the April article compares the efficiency of other approaches (OCCs, fuel reformulation, engine modifications to reduce ultra-fine particulates) with that of the traps. Here we focus only on the information about particulate traps.

The authors of the March article report that 29 particulate trap systems were tested using various ceramic, metal and fiber filter media and several regeneration systems. The authors of the March article summarize their conclusions as follows:

> The results of the 4-year investigations of construction site engines on test rigs and in the field are clear: particulate trap technology is the only acceptable choice among all available measures. Traps proved to be an extremely efficient method to curtail the finest particles. Several systems demonstrated a filtration rate of more than 99% for ultra-fine particulates. Specific development may further improve the filtration rate.
>
> A two-year field test, with subsequent trap inspection, confirmed the results pertaining to filtration characteristics of ultra-fine particles. No curtailment of the ultra-fine particles is obtained with any of the following: reformulated fuel, new lubricants, oxidation catalytic converters, and optimization of the engine combustion.
>
> Particulate traps represent the best available technology (BAT). Traps must therefore be employed to curtail the particulate emissions that the law demands are minimized. This technology was implemented in occupational health programs in Germany, Switzerland and Austria.

On the bench tests, it appears that the traps reduce the overall particulate matter by between 70 and 80%, with better results for solid ultrafine particulates; under hot gas conditions, it appears the non-solid components of particulate matter cannot be dependably retained by these traps. Consistent with this finding, it was found that polycyclic aromatic hydrocarbons (PAHs) decreased proportionately to the gravimetric decrease of carbon mass. The tests also explored the impact of additives on trap efficiency, and the impact of back pressure.

The field tests confirmed that the traps were easy to mount and retained their reliability over time, although regeneration was required when low exhaust temperatures failed to do this automatically. Electronic monitoring of back pressure was recommended. In general, the tests confirmed that a whole series of trap systems have a high filtration rate and stable long time properties and are capable of performing under difficult construction site conditions. Again, the field tests indicated a very high reduction (97–99%) of particulates by count, but a lower rate of reduction in terms of mass.

Subsequently, VERT has evaluated additional commercially available filter systems. The filtration efficiency, expressed on a gravimetric basis is shown in the column headed ''PMAG—without additive''. The filtration efficiencies determined by VERT for these 6 filter systems range from 80.7% to 94.5%. The average efficiency of these filters is 87%. MSHA will be updating the list of VERT's evaluated systems as they become available.

VERT has also published information on the extent of dpm filter usage in Europe as evidence that the filter technology has attained wide spread acceptance. This information is included in the record of the coal dpm rulemaking where it has particular significance; it is noted here for informational purposes. The information isn't critical in this case because operators have a choice of controls. MSHA didn't explicitly add the latest VERT data to the Metal/

Nonmetal record during the latest reopening of the record. MSHA believes this information is relevant to metal/nonmetal mining because the tunneling equipment on which these filters are installed is similar to metal/nonmetal equipment. VERT stated that over 4,500 filter systems have been deployed in England, Scandinavia, and Germany. Deutz Corporation has deployed 400 systems (Deutz's design) with full flow burners for regeneration of filters installed on engines between 50–600kw. The company Oberland-Mangold has approximately 1,000 systems in the field which have accumulated an average of 8,400 operating hours in forklift trucks, 10,600 operating hours in construction site engines, and 19,200 operating hours in stationary equipment. The company Unikat has introduced in Switzerland over 250 traps since 1989 and 3,000 worldwide with some operating more than 20,000 hours. German industry annually installs approximately 1,500 traps in forklifts.

BILLING CODE 4510–43–P

Table II-4

Efficiency of Diesel Particulate Traps VERT-Certification Test

Average 4 operation points, ISO 8187

Trap	Date	PMAG		PZAG		ECAG	
		without Additive	with Additive	without Additive	with Additive	without Additive	with Additive
3M	VERT-Certification Test Part 1 (new)	80.7	-	98.6	99.6	-	-
Oberland		90.5	-	98.4	99.4	-	-
JMC		94.5	-	99.3	-	-	-
IBIDEN		87.2	-	99.9	-	-	-
Corning		84.9	-	99.5	99.8	-	-
HJS/CRT		83.8	-	99.4	-	98.2	-
SHW(LIB1)	After VERT Field Test Part 3 (after 2000 hrs)	3.2	22.2	96.3	97.1	-	93.1
SHW(CAT1)		77.5	87.6	97.8	98.8	97.2	96.5
BUCK(LIB2)		76.5	81.0	95.4	97.8	94.0	95.5
BUCK(CAT3)		64.2	76.2	91.0	96.8	(87.0) [2]	95.3
ECS(LIB3)		12.4	43.0	99.9	99.9	99.3	99.0
DEUTZ(LIB4) [1]		(70.5)	(76.1)	(86.6)	(91.6)	(84.2)	
UNIKAT(CAT4)		54.7	76.2	99.0	99.6	98.1	98.4
AVERAGE		66.4		98.3		97.2	

[1] Small melting damage

[2] Uncertain data

[3] Coulometry is optional for VERT certification test

PMAG:Efficiency according to Total Particulate Mass PM

PZAG:Efficiency according to Integrated Particulate Count (20 - 300 nm) PZ

ECAG:Efficiency according to Elementary Carbon EC (2 state Coulometry)

$$PMAG = \frac{PM_{before\ trap} - PM_{after\ trapF}}{PM_{before\ trapF}} = \frac{PM_{Ref} - PM_{after\ trap}}{PM_{Ref}} \quad (X\ 100\%)$$

$$PZAG = \frac{PZ_{before\ trap} - PZ_{after\ trap}}{PZ_{before\ trap}} = \frac{PZ_{Ref} - PZ_{after\ trap}}{PZ_{Ref}} \quad (X\ 100\%)$$

$$Penetration = 1 - Efficiency = = \frac{PZ_{after\ PF}}{PZ_{Ref}} \quad (X\ 100\%)$$

≤BILLING CODE 4510–43–C

Some commenters asserted that the VERT work was for relatively small engines and not for large engines, *i.e.,* 600–700 hp, and hence could not be relied upon to demonstrate the availability of filters of such high efficiencies for the larger equipment used in some underground mines. MSHA believes this comment is misplaced. The efficiency of a filter is attributable to the design of the filter and not the size of the engine. VERT is documenting filter efficiencies of commercially available filters. It is customary in the industry, however, for the filter manufacturer to size the filter to fit the size of the engine. The mine operator must work with the filter manufacturer to verify that the filter needed will work for the intended machine. MSHA believes that this is no different for other types of options installed on machines for underground mining use.

More information about the results of the VERT tests on specific filters, and how MSHA intends to use this information to aid the mining industry to comply with the requirements of the standards are discussed in Part IV of this preamble.

The accumulated dpm must be removed from all particulate traps periodically. This is usually done by burning off the accumulated particulate in a controlled manner, called regeneration. If the diesel equipment on which the trap is installed has a duty cycle which creates an exhaust gas temperature greater than about 650 degrees Fahrenheit for more than 25 percent of the operating time, the unit will be self cleaning. That is, the hot exhaust gas will burn off the particulate as it accumulates. Unfortunately, only hard working equipment, such as load-haul-dump and haulage equipment usually satisfies the exhaust gas temperature and duration requirements.

Techniques are available to lower the temperature required to initiate the regeneration. One technique under development is to use a fuel additive. A comparatively small amount of a chemical is added to the diesel fuel and burns along with the fuel in the combustion chamber. The additive is reported to lower the required regeneration temperature significantly. The additive combustion products are retained as a residue in the particulate trap. The trap must be removed from the equipment periodically to flush the residue. Another technique used to lower the regeneration temperature is to apply a catalyst to the surfaces of the trap material. The action of the catalyst has a similar effect as the fuel additive. The catalyst also lowers the concentration of some gaseous emissions in the same manner as the oxidation catalytic converter described earlier.

A very active catalyst applied to the particulate trap surfaces and a very active catalyst in a catalytic converter installed upstream of the trap can create a situation in which the trap performs less efficiently than expected. Burning low sulfur diesel fuel, containing less than 500 ppm sulfur, will result in the creation of significant quantities of sulfates in the exhaust gas. These sulfates will still be in the gaseous state when they reach the ceramic trap and will pass through the trap. These sulfates will condense later forming diesel particulate. Special care must be taken in the selection of the catalyst formulation to ensure that sulfate formation is avoided. This problem is not present on systems which are designed with a catalytic converter upstream of a water scrubber. The gaseous phase sulfates will condense when contacting the water in the scrubber and will not be discharged into the mine atmosphere. Thus far, no permissible diesel packages have been approved which incorporate a catalytic converter upstream of the water scrubber.

One research project conducted by the former Bureau of Mines which attempted this arrangement was unsuccessful. The means selected to maintain a surface temperature less than the 300 degrees Fahrenheit required for permissibility purposes caused the exhaust gas to be cooled to the point that the catalytic converter did not reach the necessary operating temperature. It would appear that a means to isolate the catalytic converter from the exhaust gas water jacket is necessary for the arrangement to function as intended.

If the machine on which the particulate trap is installed does not work hard enough to regenerate the trap with the hot exhaust gas and the option to use a fuel additive or catalyzed trap is not appropriate, the trap can still be regenerated while installed on the machine. Systems are available whereby air is heated by an externally applied heat source and caused to flow through the particle trap with the engine stopped. The heat can be supplied by an electrical resistance element installed in front of the trap. The heat can also be supplied by a burner installed into the exhaust pipe in front of the trap fueled by an auxiliary fuel line. The fuel is ignited creating large quantities of hot gas. With both systems, an air line is also connected to the exhaust pipe to create a flow of hot gases through the particulate trap. Both systems utilize operator panels to control the regeneration process.

Some equipment owners may choose to remove the particle trap from the machine to perform the regeneration. Particle traps are available with quick release devices that allow maintenance personnel to readily remove the unit from the machine. The trap is then placed on a specially designed device that creates a controlled flow of heated air that is passed through the filter burning off the accumulated particulate.

The selection of the most appropriate means to regenerate the trap is dependent on the equipment type, the equipment duty cycle, and the equipment utilization practices at the mine.

A program under the Canadian DEEP project is field testing dpm filter systems in a New Brunswick Mine. The project is testing four filter systems on trucks and scoops. The initial feedback from Canada is very favorable concerning the performance of filters. Operators are very positive and are requesting the vehicles equipped with the filters because of the noticeable improvement in air quality and an absence of smoke even under transient load conditions. One system being tested utilizes an electrical heating element installed in the filter system to provide the heated air for regeneration of the filter. This heating element requires that the filter be connected to an external electrical source at the end of the shift. Initial results have been successful.

Paper filters. In 1990, the former Bureau of Mines conducted a project to develop a means to reduce the amount of dpm emitted from permissible diesel powered equipment using technologies that were available commercially and that could be applied to existing equipment. The project was conducted with the cooperation of an equipment manufacturer, a mine operator, and MSHA. In light of the fact that all permissible diesel powered equipment in coal and metal/nonmetal, at that time, utilized water scrubbers to meet the MSHA approval requirements, the physical characteristics of the exhaust from that type of equipment were the basis for the selection of candidate technologies. The technology selected for development was the pleated media filter or paper filter as it came to be called. The filter selected was an intake air cleaner normally used for over the road trucks. That filter was acceptable for use with permissible diesel equipment because the temperature of the exhaust gas from the water scrubber was less than 170 degrees F which was well below the ignition point of the filter material.

Recognizing that under some operating modes water would be discharged along with the exhaust, a water trap was installed in the exhaust stream before it passed through the filter. After MSHA conducted a thorough permissibility evaluation of the modified system, this filter was installed on a permissible diesel coal haulage vehicle and a series of in mine trials conducted. It was determined, by in mine ambient gravimetric sampling, that the particulate filter reduced dpm emissions by 95 percent compared to that same machine without the filter. The testing determined that the filters would last between one and two shifts, depending on how hard the equipment worked. (BOM, IC 9324).

Following the successful completion of the former Bureau of Mines mine trial, several equipment manufacturers applied for and received MSHA approval to offer the paper filter kits as options on a number of permissible diesel machines. These filter kits were installed on other machines at the mine where the original tests were conducted, and later, on machines at other mines. MSHA is not aware of any paper filters installed on permissible equipment in m/nm to date.

Despite the initial reports on the high efficiency of paper filters, during the coal public hearings and in the coal comments on this rulemaking a number of commenters at the coal public hearings questioned whether in practice paper filters could achieve efficiencies on the order of 95% when used on existing permissible equipment. In order to determine whether it could verify those concerns, MSHA contracted with the Southwest Research Institute to verify the ability of such a filter to reduce the dpm generated by a typical engine used in permissible equipment. The results of this verification effort confirmed that paper filters has a dpm removal efficiency greater than 95%. The information about MSHA's verification effort with respect to paper filters is discussed in detail in connection with the companion rule for the coal sector, where it has particular significance.

Dry systems technology. As mentioned earlier, the most recently developed means of achieving permissibility with diesel powered equipment in the United States is the dry exhaust conditioning system or dry system. This system combines several of the concepts described above as well as new, innovative approaches. The system also solves some of the problems encountered with older technologies.

The dry system in its most basic form consists of a heat exchanger to cool the exhaust gas, a mechanical flame arrestor to prevent the discharge of any flame from within the engine into the mine atmosphere, and a spark arrestor to prevent sparks for being discharged. The surfaces of all of these components and the piping connecting them are maintained below the 300 degrees F required by MSHA approval requirements. A filter, of the type normally used as an intake air filter element, is installed in the exhaust system as the spark arrestor. In terms of this dpm regulation, the most significant feature of the system is the use of this air filter element as a particulate filter. The filter media has an allowable operating temperature rating greater than the 300 degree F exhaust gas temperature allowed by MSHA approval regulations. These filters are reported to last up to sixteen hours, depending on how hard the machine operates.

The dry system can operate on any grade without the problems encountered by water scrubbers. Furthermore, there is no problem with fog created by operation of the water scrubber. Dry systems have been installed and are operating successfully in coal mines on diesel haulage equipment, longwall component carriers, longwall component extraction equipment, and in nonpermissible form, on locomotives.

Although the systems were originally designed for permissible equipment applications, they can also be used directly on nonpermissible equipment (whose emissions are not already cooled), or to replace water scrubbers used to cool most permissible equipment with a system that includes additional aftertreatment.

Reformulated fuels. It has long been known that sulfur content can have a significant effect on dpm emissions. In its diesel equipment rule for underground coal mines, MSHA requires that any fuel used in underground coal mines have less than 0.05% (500 ppm) sulfur. EPA regulations requiring that such low-sulfur fuel (less than 500 ppm) be used in highway engines, in order to limit air pollution, have in practice ensured that this type of diesel fuel is available to mine operators, and they currently use this type of fuel for all engines.

EPA has proposed a rule which would require further reductions in the sulfur content of highway diesel fuel. Such an action was taken for gasoline fuel on December 21, 1999.

On May 13, 1999 (64 FR 26142) EPA published an Advance Notice of Proposed Rulemaking (ANPRM) relative to changes for diesel fuel. In explaining why it was initiating this action, EPA noted that diesel engines ''contribute greatly'' to a number of serious air pollution problems, and that diesel emissions account for a large portion of the country's particulate matter and nitrogen oxides a key precursor to ozone. EPA noted that while these emissions come mostly from heavy-duty truck and nonroad engines, they expected the contribution to dpm emissions of light-duty equipment to grow due to manufacturers' plans to greatly increase the sale of light duty trucks. These vehicles are now subject to Tier 2 emission standards whether powered by gasoline or diesel fuel, and such standards may be difficult to meet without advanced catalyst technologies that in turn would seem to require sulfur reductions in the fuel.

Moreover, planned Tier 3 standards for nonroad vehicles would require similar action (64 FR 26143). The EPA noted that the European Union has adopted new specifications for diesel fuel that would limit it to 50 ppm by 2005, (an interim limit of 350 ppm by this year), that the entire diesel fuel supply in the United Kingdom should soon be at 50 ppm, and that Japan and other nations were working toward the same goal (64 FR 26148). In the ANPRM, the EPA specifically noted that while continuously regenerating ceramic filters have shown considerable promise for limiting dpm emissions even at fairly low exhaust temperatures, the systems are fairly intolerant of fuel sulfur. Accordingly, the agency hopes to gather information on whether or not low sulfur fuel is needed for effective PM control (64 FR 26150). EPA's proposed rule was published in June 2000, (65 FR 35430) and proposed a sulfur limit of 15 ppm for on-highway use in 2006–2009.

A joint government-industry partnership is also investigating the relationship between varying levels of sulfur content and emissions reduction performance on various control technologies, including particulate filters and oxidation catalytic convertors. This program is supported by the Department of Energy's Office of Heavy Vehicles Technologies, two national laboratories, the Engine Manufacturers Association, and the Manufacturers of Emission Controls Association. It is known as the Diesel Emission Control-Sulfur Effects (DECSE) Program; more information is available from its web site, http://www.ott.doe.gov/decse.

MSHA expects that once such cleaner fuel is required for transportation use, it will in practice become the fuel used in mining as well—directly reducing engine particulate emissions, increasing the efficiency of aftertreatment devices, and eventually through the introduction of new generation of cleaner equipment. Mayer states that reducing sulfur content, decreasing aromatic components and increasing the Cetane index of diesel fuel can generally result in a 5% to 15% reduction in total particulate emissions.

Meyer reports the test by VERT of a special synthetic fuel containing neither sulfur nor bound nitrogen nor aromatics, with a very high Cetane index. The fuel performed very well, but produced only abut 10% fewer particulates than low sulfur diesel fuel, nor did it have the slightest improvement in diminishing nonparticulate emissions.

NIOSH provided information on the work that has been done with Biodiesel fuel. Biodiesel fuel is a registered fuel and fuel additive with the EPA and meets clean diesel standards established by the California Air Resources Board. NIOSH stated that the undisputed consensus among the research conducted is that the use of biodiesel will significantly reduce dpm and other harmful emissions in underground mines. MSHA agrees that biodiesel fuel is an option that mine operators can use from the toolbox to meet the dpm standards.

Cabs. A cab is an enclosure around the operator installed on a piece of mobile equipment. It can provide the same type of protection as a booth at a crusher station. While cabs are not available for all mining equipment, they are available for much of the larger equipment that also has application in the construction industry.

Even though cabs are not the type of control device that is bolted onto the exhaust of the diesel engine to reduce emissions, cabs can protect miners from environmental exposures to dpm. Both cabs and control booths are discussed in the context of reducing miners exposures to dpm.

To be effective, a cab should be tightly sealed with windows and doors must be closed. Rubber seals around doors and windows should be in good conditions. Door and window latches should operate properly. In addition to being well sealed, the cab should have an air filtration and space pressurizing system. Air intake should be located away from engine exhaust. The airflow should provide one air change per minute for the cab and should pressurize the cab to 0.20 inches of water. While these are not absolute requirements, they do provide a guideline of how a cab should be designed. If a cab does not have an air filtration and pressurizing system, the diesel particulate concentration inside the cab will be similar to the diesel particulate concentration outside the cab.

MSHA has evaluated the efficiency of cab filters for diesel particulate reduction (Commercial Stone Study, PS&HTC–DD–98–346, Commercial Stone Study, PS&HTC–DD–99–402 and Homestake Mine Study, PS&HTC–DD–00–505.) Several different types of filter media have been tested in underground mines. Depending on the filter media, cabs can reduce diesel particulate exposures by 45 to 90 percent.

(7) MSHA's Diesel Safety Rule for Underground Coal Mines and its Effect on dpm

MSHA's proposed rule to limit the concentration of dpm in underground metal and nonmetal mines included a number of elements which have already proven successful in helping to reduce dpm concentrations in the coal sector. Accordingly, this section provides some background on the substance of the rules that have been in effect in underground coal mines (for more information on the history of rulemaking in the coal sector, please refer to section 9 of this Part). It should be noted, however, that not all of the requirements discussed here are going to be required for underground metal and nonmetal mines; see Part IV of this preamble for details on what is included in the final rule.

Diesel Equipment Rule in Underground Coal Mines. On October 25, 1996, MSHA promulgated standards for the ''Approval, Exhaust Gas Monitoring, and Safety Requirements for the Use of Diesel-Powered Equipment in Underground Coal Mines,'' sometimes referred to as the ''diesel equipment rule'' (61 FR 55412; the history of this rulemaking is briefly discussed in section 9 of this Part). The diesel equipment rule focuses on the safe use of diesels in underground coal mines. Integrated requirements are established for the safe storage, handling, and transport of diesel fuel underground, training of mine personnel, minimum ventilating air quantities for diesel powered equipment, monitoring of gaseous diesel exhaust emissions, maintenance requirements, incorporation of fire suppression systems, and design features for nonpermissible machines.

MSHA Approval Requirements for Engines Used in Underground Coal Mines. MSHA requires that all diesel engines used in underground coal mines be ''approved'' by MSHA for such use, and be maintained by operators in approved condition. Among other things, approval of an engine by MSHA ensures that engines exceeding certain pollutant standards are not used in underground coal mines. MSHA sets the standards for such approval, establishes the testing criteria for the approval process, and administers the tests. The costs to obtain approval of an engine are usually borne by the engine manufacturer or equipment manufacturer. MSHA's 1996 diesel equipment rule made some significant changes to the consequences of approval. The new rule required the whole underground coal fleet to convert to approved engines no later than November 1999.

The new rule also required that during the approval process the agency determine the particulate index (PI) for the engine. The particulate index (or PI), calculated under the provisions of 30 CFR 7.89, indicates the air quantity necessary to dilute the diesel particulate in the engine exhaust to 1 milligram of diesel particulate matter per cubic meter of air.

The PI does not appear on the engine's approval plate. (61 FR 55421). Furthermore, the particulate index of an engine is not, under the diesel equipment rule, used to determine whether or not the engine can be used in an underground coal mine.

At the time the equipment rule was issued, MSHA explicitly deferred the question of whether to require engines used in mining environments to meet a particular PI. (61 FR 55420–21, 55437). While there was some discussion of using it in this fashion during the diesel equipment rulemaking, the approach taken in the final rule was to adopt, instead, the multi-level approach recommended by the Diesel Advisory Committee. This multi-level approach included the requirement to use clean fuel, low emission engines, equipment design, maintenance, and ventilation, all of which appear in the final rule. The requirement for determining the particulate index was included in the diesel equipment rule in order to provide information to the mining community in purchasing equipment—so that mine operators can compare the particulate levels generated by different engines. Mine operators and equipment manufacturers can use the information along with consideration of the type of machine the engines would power and the area of the mine in which it would be used to make decisions concerning the engine's contribution of diesel particulate to the mine's total respirable dust. Equipment manufactures can use the particulate index to design and install exhaust after-treatments. (61 FR 55421). So that the PI for any engine is known to the mining community, MSHA reports the index in the approval letter, posted the PI and ventilating air requirement for all approved engines on its website, and publishes the index with its lists of approved engines.

Gas Monitoring. As discussed in section 5, there are limitations on the exposure of miners to various gases emitted from diesel engines in both underground coal mines and underground metal and nonmetal mines.

The 1996 diesel equipment rule for underground coal mines supplemented these protections in that sector by providing for the monitoring and control of gaseous diesel exhaust emissions. (30 CFR part 70; 61 FR 55413). The rule requires that underground coal mine operators take samples of carbon monoxide and nitrogen dioxide as part of existing onshift workplace examinations. Samples exceeding an action level of 50 percent of the threshold limits set forth in 30 CFR 75.322 trigger corrective action by the mine operator.

Engine Maintenance. The diesel equipment rule also requires that diesel-powered equipment be maintained in safe and approved condition. As explained in the preamble, maintenance requirements were included because of MSHA's recognition that inadequate equipment maintenance can, among other things, result in increased levels of harmful gaseous and particulate components from diesel exhaust.

Among other things, the rule requires the weekly examination of diesel-powered equipment in underground coal mines. To determine if more extensive maintenance is required, the rule further requires that a weekly check of the gaseous CO emission levels on permissible and heavy duty outby machines be made. The CO check requires that the engine be operated at a repeatable loaded condition and the CO measured. The carbon monoxide concentration in the exhaust provides a good indication of engine condition. If the CO measurement increases to a higher concentration than what was normally measured during the past weekly checks, then a maintenance person would know that a problem has developed that requires further investigation. In addition, underground coal mine operators are required to establish programs to ensure that those performing maintenance on diesel equipment are qualified.

Fuel. The diesel equipment rule also requires that underground coal mine operators use diesel fuel with a sulfur content of 0.05% (500 ppm) or less. Some types of exhaust aftertreatment technology designed to lower hazardous diesel emissions work more effectively when the sulfur content of the fuel is low. More effective aftertreatment devices will result in reduced hydrocarbons, carbon monoxide, and particulate levels. Low sulfur fuel also greatly reduces the sulfate production from the catalytic converters currently in use in underground coal mines, thereby decreasing exhaust particulate. To further reduce miners' exposure to diesel exhaust, the final rule prohibits operators from unnecessarily idling diesel-powered equipment.

Ventilation. The diesel equipment rule requires that as part of the approval process, ventilating air quantities necessary to maintain the gaseous emissions of diesel engines within existing required ambient limits be set. The ventilating air quantities are required to appear on the engine's approval plate. The rule also requires that mine operators maintain the approval plate quantity minimum airflow in areas of underground coal mines where diesel-powered equipment is operated. The engine's approval plate air quantity is also used to determine the minimum air quantity in areas where multiple units of diesel powered equipment are being operated. The minimum ventilating air quantity where multiple units of diesel powered equipment are operated on working sections and in areas where mechanized mining equipment is being installed or removed, must be the sum of 100 percent of the approval plate quantities of all of the equipment. As set forth in the preamble of the diesel equipment rule, MSHA believes that effective mine ventilation is a key component in the control of miners' exposure to gasses and particulate emissions generated by diesel equipment.

Impact of the diesel equipment rule on dpm levels in underground coal mines. The diesel equipment rule has many features which, by reducing the emission and concentration of harmful diesel emissions in underground coal mines, will indirectly reduce particulate emissions.

In developing the diesel equipment rule, however, MSHA did not explicitly consider the risks to miners of a working lifetime of dpm exposure at very high levels, nor the actions that could be taken to specifically reduce dpm exposure levels in underground coal mines. It was understood that the agency would be taking a separate look at the health risks of dpm exposure. For example, the agency explicitly deferred discussion of whether to make operators use only equipment that complied with a specific Particulate Index.

(8) Information on How Certain States are Restricting Occupational Exposure to DPM.

As noted earlier in this part, the Federal government has long been involved in efforts to restrict diesel particulate emissions into the environment—both through ambient air quality standards, and through restrictions on diesel engine emissions. While MSHA's actions to limit the concentration of dpm in underground mines are the first effort by the Federal government to deal with the special risks faced by workers exposed to diesel exhaust on the job, several states have already taken actions in this regard with respect to underground coal mines.

This section reviews some of these actions, as they were the subject of considerable discussion and comment during this rulemaking.

Pennsylvania. As indicated in section 1, Pennsylvania essentially had a ban on the use of diesel-powered equipment in underground coal mines for many years. As noted by one commenter, diesel engines were permitted provided the request was approved by the Secretary of the Department of Environmental Protection.

In 1995, one company in the State submitted a plan for approval and started negotiations with its local union representatives. This led to statewide discussions and the adoption of a new law in the State that permits the use of diesel-powered equipment in deep coal mines under certain circumstances specified in the law (Act 182). As further noted by this commenter, the drafters of the law completed their work before the issuance of MSHA's new regulation on the safe use of diesel-powered equipment in underground coal mines. The Pennsylvania law, unlike MSHA's diesel equipment rule, specifically addresses diesel particulate. The State did not set a limit on the exposure of miners to dpm, nor did it establish a limit on the concentration of dpm in deep coal mines. Rather, it approached the issue by imposing controls that will limit dpm emissions at the source.

First, all diesel engines used in underground deep coal mines in Pennsylvania must be MSHA-approved engines with an "exhaust emissions control and conditioning system" that meets certain tests. (Article II-A, Section 203-A, Exhaust Emission Controls). Among these are dpm emissions from each engine no greater than "an average concentration of 0.12 mg/m^3 diluted by fifty percent of the MSHA approval plate ventilation for that diesel engine." In addition, any exhaust emissions control and conditioning system must include a ''Diesel Particulate Matter (DPM) filter capable of an average of ninety-five percent or greater reduction of dpm emissions.'' It also requires the use of an oxidation catalytic converter. Thus, the Pennsylvania statute requires the use of low-emitting engines, and then the use of aftertreatment devices that significantly reduce the particulates emitted from these engines.

The Pennsylvania law also has a number of other requirements for the safe use of diesel-powered equipment in the particularly hazardous environments of underground coal mines. Many of these parallel the requirements in MSHA's diesel equipment rule. Like MSHA's requirements, they too can result in reducing miner exposure to diesel particulate—*e.g.,* regular maintenance of diesel engines by qualified personnel and equipment operator examinations. The requirements in the Pennsylvania law take into account the need to maintain the aftertreatment devices required to control diesel particulate.

While both mine operators and labor supported this approach, it remains controversial. During the hearings on this rulemaking, one commenter indicated that at the time the standards were established, it would have taken a 95% filter to reduce dpm from certain equipment to the 0.12 mg/m^3 emissions standard because 0.25 sulfur fuel was being utilized. This test reported by the commenter was completed prior to MSHA promulgating the diesel equipment rule that required the use of .05% sulfur fuel. Another commenter pointed out that as operators in the state began considering the use of newer, less polluting engines, achieving an efficiency of 95% reduction of the emissions from any such engines would become even more difficult. There was some disagreement among the commenters as to whether existing technology would permit operators to meet the 0.12 mg/m^3 emission standard in many situations. One commenter described efforts to get a small outby unit approved under Pennsylvania law. Accordingly, the industry has indicated that it would seek changes to the Pennsylvania diesel law. Commenters representing miners indicated that they were involved in these discussions.

West Virginia. Until 1997, West Virginia law banned the use of diesel-powered equipment in underground coal mines. In that year, the State created the joint labor-management West Virginia Diesel Equipment Commission (Commission) and charged it with developing regulations to permit and govern diesel engine use in underground coal mines. As explained by several commenters, the Commission, in collaboration with West Virginia University (WVU), developed a protocol for testing diesel engine exhaust controls, and the legislature appropriated more than $150,000 for WVU to test diesel exhaust controls and an array of diesel particulate filters.

There were a number of comments received by MSHA on the test protocols and results. These are discussed in part IV this preamble. One commenter noted that various manufacturers of products have been very interested in how their products compare to those of other manufacturers tested by the WVU. Another asserted that mine operators had been slowing the scheduling of tests by WVA.

Pursuant to the West Virginia law establishing the Commission, the Commission was given only a limited time to determine the applicable rules for the use of diesel engines underground, or the matter was required to be referred to an arbitrator for resolution. One commenter during the hearings noted that the Commission had not been able to reach resolution and that indeed arbitration was the next step. Other commenters described the proposal of the industry members of the Commission—0.5mg/m^3 for all equipment, as configured, before approval is granted. In this regard, the industry members of the West Virginia Commission said:

> ''We urge you to accelerate the finalization of * * * these proposed rules. We believe that will aid our cause, as well as the other states that currently don't use diesel.'' (*Id*)

Virginia. According to one commenter, diesel engine use in underground mining was legalized in Virginia in the mid-1980s. It was originally used on some heavy production equipment, but the haze it created was so thick it led to a drop in production. Thereafter, most diesel equipment has been used outby (805 pieces). The current state regulations consist of requiring that MSHA approved engines be used, and that the ''most up-to-date, approved, available diesel engine exhaust aftertreatment package'' be utilized. There are no distinctions between types of equipment. The commenter noted that more hearings were planned soon. Under a directive from the governor of Virginia, the state is reviewing its regulations and making recommendations for revisions to sections of its law on diesels.

Ohio. The record of this rulemaking contains little specific information on the restrictions on the underground use of diesel-powered equipment in Ohio. MSHA understands, however, that in practice it is not used. According to a communication with the Division of Mines and Reclamation of the Ohio Division of Natural Resources, this outcome stems from a law enacted on October 29, 1995, now codified as section 1567.35 of Ohio Revised Code Title 15, which imposes strict safety restrictions on the use of various fuels underground.

(9) History of this Rulemaking.

As discussed throughout this part, the Federal government has worked closely with the mining community to ascertain whether and how diesel-powered equipment might be used safely and healthfully in this industry. As the evidence began to grow that exposure to diesel exhaust might be harmful to miners, particularly in underground mines, formal agency actions were initiated to investigate this possibility and to determine what, if any, actions might be appropriate. These actions, including a number of non-regulatory initiatives taken by MSHA, are summarized here in chronological sequence.

Activities Prior to Proposed Rulemaking on DPM. In 1984, the National Institute for Occupational Safety and Health (NIOSH) established a standing Mine Health Research Advisory Committee to advise it on matters involving or related to mine health research. In turn, that standing body established the Mine Health Research Advisory Committee Diesel Subgroup to determine if:

> * * * there is a scientific basis for developing a recommendation on the use of diesel equipment in underground mining operations and defining the limits of current knowledge, and recommending areas of research for NIOSH, if any, taking into account other investigators' ongoing and planned research. (49 FR 37174).

In 1985, MSHA established an Interagency Task Group with NIOSH and the former Bureau of Mines (BOM) to assess the health and safety implications of the use of diesel-powered equipment in underground coal mines.

In April 1986, in part as a result of the recommendation of the Task Group, MSHA began drafting proposed regulations on the approval and use of diesel-powered equipment in underground coal mines. Also in 1986, the Mine Health Research Advisory Committee Diesel Subgroup (which, as noted above, was created by a standing NIOSH committee) summarized the evidence available at that time as follows:

> It is our opinion that although there are some data suggesting a small excess risk of adverse health effects associated with exposure to diesel exhaust, these data are not compelling enough to exclude diesels from underground mines. In cases where diesel equipment is used in mines, controls should be employed to minimize exposure to diesel exhaust.

On October 6, 1987, pursuant to Section 102(c) of the Mine Act, 30 U.S.C. 812(c), which authorizes MSHA to appoint advisory committees as he deems appropriate, the agency appointed an advisory committee ''to provide advice on the complex issues concerning the use of diesel-powered equipment in underground coal mines.'' (52 FR 37381). MSHA appointed nine members to this committee, officially known as The Mine Safety and Health Administration Advisory Committee on Standards and Regulations for Diesel-Powered Equipment in Underground Coal Mines (hereafter the MSHA Diesel Advisory Committee). As required by section 101(a)(1) of the Mine Act, MSHA provided the MSHA Diesel Advisory Committee with draft regulations on the approval and use of diesel-powered equipment in underground coal mines. The draft regulations did not include standards setting specific limitations on diesel particulate, nor had MSHA at that time determined that such standards would be promulgated.

In July 1988, the MSHA Diesel Advisory Committee completed its work with the issuance of a report entitled ''Report of the Mine Safety and Health Administration Advisory Committee on Standards and Regulations for Diesel-Powered Equipment in Underground Coal Mines.'' It also recommended that MSHA promulgate standards governing the approval and use of diesel-powered equipment in underground coal mines. The MSHA Diesel Advisory Committee recommended that MSHA promulgate standards limiting underground coal miners' exposure to diesel exhaust.

With respect to diesel particulate, the MSHA Diesel Advisory Committee recommended that MSHA ''set in motion a mechanism whereby a diesel particulate standard can be set.'' (MSHA, 1988). In this regard, the MSHA Diesel Advisory Committee determined that because of inadequacies in the data on the health effects of diesel particulate matter and inadequacies in the technology for monitoring the amount of diesel particulate matter at that time, it could not recommend that MSHA promulgate a standard specifically limiting the level of diesel particulate matter in underground coal mines (*Id.* 64–65). Instead, the MSHA Diesel Advisory Committee recommended that MSHA ask NIOSH and the former Bureau of Mines to prioritize research in the development of sampling methods and devices for diesel particulate.

The MSHA Diesel Advisory Committee also recommended that MSHA request a study on the chronic and acute effects of diesel emissions (*Id*). In addition, the MSHA Diesel Advisory Committee recommended that the control of diesel particulate ''be accomplished through a combination of measures including fuel requirements, equipment design, and in-mine controls such as the ventilation system and equipment maintenance in conjunction with undiluted exhaust measurements.'' The MSHA Diesel Advisory Committee further recommended that particulate emissions ''be evaluated in the equipment approval process and a particulate emission index reported.'' (*Id.* at 9).

In addition, the MSHA Diesel Advisory Committee recommended that ''the total respirable particulate, including diesel particulate, should not exceed the existing two milligrams per cubic meter respirable dust standard.'' (*Id.* at 9.) It should be noted that section 202(b)(2) of the Mine Act requires that coal mine operators maintain the average concentration of respirable dust at their mines at or below two milligrams per cubic meter which effectively prohibits diesel particulate matter in excess of two milligrams per cubic meter (30 U.S.C. 842(b)(2)).

As noted, the MSHA Diesel Advisory Committee issued its report in 1988. During that year, 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 (NIOSH, 1988). 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 ''[g]iven what we currently know, there is an urgent need for efforts to be made to reduce occupational exposures to DEP [dpm] in mines.''

Consistent with the MSHA Diesel Advisory Committee's research recommendations, MSHA, in September 1988, formally requested NIOSH to perform a risk assessment for exposure to diesel particulate. (57 FR 500). MSHA also requested assistance from NIOSH and the former BOM in developing sampling and analytical methodologies for assessing exposure to diesel particulate in mining operations. (*Id.*). In part, as a result of the MSHA Diesel Advisory Committee's recommendation, MSHA also participated in studies on diesel particulate sampling methodologies and determination of underground occupational exposure to diesel particulate.

On October 4, 1989, MSHA published a Notice of Proposed Rulemaking on approval requirements, exposure monitoring, and safety requirements for the use of diesel-powered equipment in underground coal mines. (54 FR 40950). The proposed rule followed the MSHA Diesel Advisory Committee's recommendation that MSHA promulgate regulations requiring the approval of diesel engines.

On January 6, 1992, MSHA published an Advance Notice of Proposed Rulemaking (ANPRM) (57 FR 500). In the ANPRM, MSHA, among other things, sought comment on specific reports on diesel particulate prepared by NIOSH and the former BOM. MSHA also sought comment on reports on diesel particulate which were prepared by or in conjunction with MSHA. The ANPRM also sought comments on the health effects, technological and economic feasibility, and provisions which should be considered for inclusion in a diesel particulate rule. The notice also identified five specific areas where the agency was particularly interested in comments, and about which it asked a number of detailed questions: (1) Exposure limits, including the basis thereof; (2) the validity of the NIOSH risk assessment model and the validity of various types of studies; (3) information about non-cancer risks, non-lung routes of entry, and the confounding effects of tobacco smoking; (4) the availability, accuracy and proper use of sampling and monitoring methods for diesel particulate; and (5) the technological and economic feasibility of various types of controls, including ventilation, diesel fuel, engine design, aftertreatment devices, and maintenance by mechanics with specialized training. The notice also solicited specific information from the mining community on ''the need for a medical surveillance or screening program and on the use of respiratory equipment.'' (57 FR 500). The comment period on the ANPRM closed on July 10, 1992.

While MSHA was completing a ''comprehensive analysis of the comments and any other information received'' in response to the ANPRM (57 FR 501), it took also several actions to encourage the mining community to begin to deal with the problems identified.

In 1995, MSHA sponsored three workshops ''to bring together in a forum format the U.S. organizations who have a stake in limiting the exposure of miners to diesel particulate (including) mine operators, labor unions, trade organizations, engine manufacturers, fuel producers, exhaust aftertreatment manufacturers, and academia.'' (McAteer, 1995). The sessions provided an overview of the literature and of diesel particulate exposures in the mining industry, state-of-the-art technologies available for reducing diesel particulate levels, presentations on engineering technologies toward that end, and identification of possible strategies whereby miners' exposure to diesel particulate matter can be limited both practically and effectively.

The first workshop was held in Beckley, West Virginia on September 12 and 13, and the other two were held on October 6, and October 12 and 13, 1995, in Mt Vernon, Illinois and Salt Lake City, Utah, respectively. A transcript was made. During a speech early the next year, the Deputy Assistant Secretary for MSHA characterized what took place at these workshops:

> The biggest debate at the workshops was whether or not diesel exhaust causes lung cancer and whether MSHA should move to regulate exposures. Despite this debate, what emerged at the workshops was a general recognition and agreement that a health problem seems to exist with the current high levels of diesel exhaust exposure in the mines. One could observe that while all the debate about the studies and the level of risk was going on, something else interesting was happening at the workshops: one by one miners, mining companies, and manufacturers began describing efforts already underway to reduce exposures. Many are actively trying to solve what they clearly recognize is a problem. Some mine operators had switched to low sulfur fuel that reduces particulate levels. Some had increased mine ventilation. One company had tried a soy-based fuel and found it lowered particulate levels. Several were instituting better maintenance techniques for equipment. Another had hired extra diesel mechanics. Several companies had purchased electronically controlled, cleaner, engines. Another was testing a prototype of a new filter system. Yet another was using disposable diesel exhaust filters. These were not all flawless attempts, nor were they all inexpensive. But one presenter after another described examples of serious efforts currently underway to reduce diesel emissions. (Hricko, 1996).

In March of 1997, MSHA issued, in draft form, a publication entitled ''Practical Ways to Control Exposure to Diesel Exhaust in Mining—a Toolbox''. The draft publication was disseminated by MSHA to all underground mines known to use diesel equipment and posted on MSHA's Web site.

As explained in the publication, the Toolbox was designed to disseminate to the mining community information gained through the workshops about methods being used to reduce miner exposures to dpm. MSHA's Toolbox provided specific information about nine types of controls that can reduce dpm exposures: low emission engines; fuels; aftertreatment devices; ventilation; enclosed cabs; engine maintenance; work practices and training; fleet management; and respiratory protective equipment. Some of these approaches reduce emissions from diesel engines; others focus on reducing miner exposure to whatever emissions are present. Quotations from workshop participants were used to illustrate when and how such controls might be helpful.

As it clearly stated in its introductory section entitled ''How to Use This Publication,'' the Toolbox was not designed as a guide to existing or pending regulations. As MSHA noted in that regard:

''While the (regulatory) requirements that will ultimately be implemented, and the schedule of implementation, are of course uncertain at this time, MSHA encourages the mining community not to wait to protect miners' health. MSHA is confident that whatever the final requirements may be, the mining community will find this Toolbox information of significant value.''

On October 25, 1996, MSHA published a final rule addressing approval, exhaust monitoring, and safety requirements for the use of diesel-powered equipment in underground coal mines (61 FR 55412). The final rule addresses, and in large part is consistent with, the specific recommendations made by the MSHA Diesel Advisory Committee for limiting underground coal miners' exposure to diesel exhaust. As noted in section 7 of this part, the diesel safety rule was implemented in steps concluding in late 1999. Aspects of this diesel safety rule had a significant impact on this rulemaking.

In the Fall of 1997, following comment, MSHA's Toolbox was finalized and disseminated to the mining community. At the same time, MSHA made available to the mining community a software modeling tool developed by the Agency to facilitate dpm control. This model enables an operator to evaluate the effect which various alternative combinations of controls would have on the dpm concentration in a particular mine—before making the investment. MSHA refers to this model as ''the Estimator.'' The Estimator is in the form of a template that can be used on standard computer spreadsheet programs. As information about a new combination of controls is entered, the results are promptly displayed.

On April 9, 1998, MSHA published a proposed rule to ''reduce the risks to underground coal miners of serious health hazards that are associated with exposure to high concentrations of diesel particulate matter'' (63 FR 17492). In order to further facilitate participation by the mining community, MSHA developed as an introduction to its preamble explaining the proposed rule, a dozen ''plain language'' questions and answers.

The proposed rule to limit the concentration of dpm in underground coal mines (63 FR 17578) focused on the exclusive use of aftertreatment filters on permissible and heavy duty nonpermissible equipment to limit the concentration of dpm in underground coal mines. In its Questions and Answers, however, and throughout the preamble, MSHA presented considerable information on a number of other approaches that might have merit in limiting the concentration of dpm in underground coal mines, and drew special attention to the fact that the text of the rule being proposed represented only one of the approaches on which the agency was interested in receiving comment. Training of miners in the hazards of dpm was also proposed.

The Proposed Rule to Limit DPM Concentrations in Underground Metal and Nonmetal Mines and Related Actions. On October 29, 1998 (63 FR 58104), MSHA published a proposed rule establishing new health standards for underground metal and nonmetal mines that use equipment powered by diesel engines.

In order to further facilitate participation by the mining community, MSHA developed as an introduction to its preamble explaining the proposed rule, 30 ''plain language'' questions and answers.

The notice of proposed rulemaking reviewed and discussed the comments received in response to the ANPRM, including information on such control approaches as fuel type, fuel additives, and maintenance practices (63 FR 58134). For the convenience of the mining community, a copy of MSHA's Toolbox was also reprinted as an Appendix at the end of the notice of proposed rulemaking (63 FR 58223). A complete description of the Estimator, and several examples, were also presented in the preamble of the proposed rule.

MSHA proposed to adopt (63 FR 58104) a different rule to address dpm exposure in underground metal and nonmetal mines.

MSHA proposed a limit on the concentration of dpm to which underground metal and nonmetal miners would be exposed.

The proposed rule would have limited dpm concentrations in underground metal and nonmetal mines to about 200 micrograms per cubic meter of air. Operators would have been able to select whatever combination of engineering and work practice controls they wanted to keep the dpm concentration in the mine below this limit.

The concentration limit would have been implemented in two stages: an interim limit that would go into effect following 18 months of education and technical assistance by MSHA, and a final limit after 5 years. MSHA sampling would be used to determine compliance.

The proposal would also have required that all underground metal and nonmetal mines using diesel-powered equipment observe a set of ''best practices'' to reduce engine emissions—*e.g.,* to use low-sulfur fuel.

Additionally, the Agency also considered alternatives that would have led to a significantly lower-cost proposal, *e.g.,* establishing a less stringent concentration limit in underground metal and nonmetal mines, or increasing the time for mine operators to come into compliance. However, MSHA concluded at that time that such approaches would not be as protective, and that the approach proposed was both economically and technologically feasible.

MSHA also explored whether to permit the use of administrative controls (*e.g.,* rotation of personnel) and personal protective equipment (*e.g.,* respirators) to reduce the diesel particulate exposure of miners. It is generally accepted industrial hygiene practice, however, to eliminate or minimize hazards at the source before resorting to personal protective equipment. Moreover, such a practice is generally not considered acceptable in the case of carcinogens since it merely places more workers at risk. Accordingly, the proposal explicitly prohibited the use of such approaches, except in those limited cases where MSHA approves, due to technological constraints, a 2-year extension for an underground metal and nonmetal mine on the time to comply with the final concentration limit.

MSHA sought comments from the mining community on the proposed regulatory text as well as throughout the entire preamble.

In addition, the Agency specifically requested comments on the following issues:

(a) *Assessment of Risk/Benefits of the Rule.* The Agency welcomed comments on the significance of the material already in the record, and any information that could supplement the record. For example, information on the health risks associated with exposure to dpm—especially observations by trained observers or studies of acute or chronic effects of exposure to known levels of dpm or fine particles in general, information about pre-existing health conditions in individual miners or miners as a group that might affect their reactions to exposures to dpm or other fine particles; information about how dpm affects human health; information on the costs to miners, their families and their employers of the various health problems linked to dpm exposure, and the assumptions and approach to use in quantifying the benefits to be derived from this rule.

(b) *Proposed rule.* MSHA sought comments on specific alternative approaches discussed in Part V. The options discussed included: adjusting the concentration limit for dpm; adjusting the phase-in time for the concentration limit; and requiring that specific technology be used in lieu of establishing a concentration limit.

The Agency also requested comments on the composition of the diesel fleet, what controls cannot be utilized due to special conditions, and any studies of alternative controls using the computer spreadsheet described in the Appendix to Part V of the proposed rule preamble. The Agency also requested information about the availability and costs of various control technologies being developed (*e.g.,* high-efficiency ceramic filters), experience with the use of available controls, and information that would help the Agency evaluate alternative approaches for underground metal and nonmetal mines. In addition, the Agency requested comments from the underground coal sector on the implementation to date of diesel work practices (like the rule limiting idling, and the training of those who provide maintenance) to help evaluate related proposals for the underground metal and nonmetal sector. The Agency also asked for information about any unusual situations that might warrant the application of special provisions.

(c) *Compliance Guidance.* The Agency solicited comments on any topics on which initial guidance ought to be provided as well as any alternative practices which MSHA should accept for compliance before various provisions of the rule go into effect; and

(d) *Minimizing Adverse Impact of the Proposed Rule.* The Agency set forth assumptions about impacts (*e.g.,* costs, paperwork, and impact on smaller mines in particular) in some detail in the preamble and in the PREA. We sought comments on the methodology, and information on current operator equipment replacement planning cycles, tax, State requirements, or other information that might be relevant to purchasing new engines or control technology. The Agency also welcomed comments on the financial situation of the underground metal and nonmetal sector, including information that may be relevant to only certain commodities.

From this point on, the actions taken on the rulemakings in underground coal mines and underground metal and nonmetal mines began to overlap in chronology. There is considerable overlap between the coal and metal/nonmetal communities, and so their participation in these separate rulemakings was often intertwined.

In November 1998, MSHA held hearings on the proposed rule for underground coal mines in Salt Lake City, Utah and Beckley, West Virginia. In December 1998, hearings were held in Mt. Vernon, Illinois, and Birmingham, Alabama.

Hearings concerning the proposed rule for underground coal mines were well attended, including representatives from both the coal and metal and nonmetal sectors. Testimony was presented by individual miners, representatives of miners, mine operators, mining industry associations, representatives of engine and equipment manufacturers, and one individual manufacturer. Members of the mining community participating had an extensive opportunity to hear and respond to alternative views; some participated in several hearings. They also had an opportunity to exchange in direct dialogues with the members of MSHA's dpm rulemaking committee—responding to questions and asking questions of their own. There was extensive comment not only about the provisions of the proposed rule itself, but also about the need for diesel powered equipment in this sector, the risks associated with its use, the need for regulation in this sector, alternative approaches including those on which MSHA sought comment, and the technological and economic feasibility of various alternatives.

On February 12, 1999, (64 FR 7144) MSHA published a notice in the **Federal Register** announcing: (1) The availability of three additional studies applicable to the proposals; (2) the extension of the post-hearing comment period and close of record on the proposed rule for underground coal mines for 60 additional days, until April 30, 1999; (3) the extension of the comment period on the proposed rule for metal and nonmetal mines for an additional 60 days, until April 30, 1999; and (4) an announcement that the Agency would hold public hearings on the metal and nonmetal proposal.

On March 24, 1999, (64 FR 14200) MSHA published a notice in the **Federal Register** announcing the dates, time, and location of four public hearings for the metal and nonmetal proposed rule.

The notice also announced that the close of the post-hearing comment period would be on July 26, 1999.

On April 27, 1999, (64 FR 22592) in response to requests from the public, MSHA extended the post-hearing comment period and close of record on the proposed rule for underground coal for 90 additional days, until July 26, 1999.

In May 1999, hearings on the metal and nonmetal proposed rule were held in Salt Lake City, Ut; Albuquerque, NM; St. Louis, MO and Knoxville, TN.

Hearings were well attended and testimony was presented by both labor (miners) and industry (mining associations, coal companies) and government (NIOSH). Testimony was presented by individual mining companies, mining industry associations, mining industry consultants and the National Institute of Occupational Safety and Health. The hearings were held for MSHA to obtain specific comments on the proposed rule for diesel particulate matter exposure of metal and nonmetal miners; additional information on existing and projected exposures to diesel particulate matter and to other fine particulates in various mining operations; information on the health risk associated with exposure to diesel particulate matter; information on the cost to miners, their families and their employers of the various health problems linked to diesel particulate matter; and information on additional benefits to be expected from reducing diesel particulate matter exposure.

Members of the mining community participating, had an extensive opportunity to hear and respond to alternative views; some participated in several of the hearings. They also had an opportunity to exchange in direct dialogues with members of MSHA's dpm rulemaking committee—responding to questions and asking questions of their own. There was extensive comment not only about the provisions of the proposed rule itself, but also about potential interferences with the method used to measure dpm, the studies that MSHA used to document the risk associated with exposure to dpm, the cost estimates derived by MSHA for industry implementation, and the technology and economic feasibility of various alternatives (specifically, industry use of a tool box approach without accountability for an exposure limit).

One commenter, at the Knoxville hearing, specifically requested that the credentials and experience (related to the medical field, epidemiology, metal and nonmetal mining, mining engineering, and diesel engineering) of the hearing panelists be made a part of the public record. The commenter was informed by one of the panelists at the hearing that if this information was wanted it should be requested under the Freedom Of Information Act (FOIA). Such a request was submitted to MSHA by the commenter and appropriately responded to by the Agency.

On July 8, 1999, (64 FR 36826) MSHA published a notice in the **Federal Register** correcting technical errors in the preamble discussion on the Diesel Emission Control Estimator formula in the Appendix to Part V of the proposed rulemaking notice, and correcting Figure V–5 of the preamble. Comments on these changes were solicited. (The Estimator model was subsequently published in the literature (Haney, R.A. and Saseen, G.P., ''Estimation of diesel particulate concentrations in underground mines'', Mining Engineering, Volume 52, Number 5, April 2000)).

The rulemaking records of both rules closed on July 26, 1999, nine months after the date the proposed rule on metal and nonmetal mines was published for public notice. The post-hearing comments, like the hearings, reflected extensive participation in this effort by the full range of interests in the mining community and covered a full range of ideas and alternatives.

On June 30, 2000, the rulemaking record was reopened for 30 days in order to obtain public comment on certain additional documents which the agency determined should be placed in the rulemaking record. Those documents were the verification studies concerning NIOSH Method 5040 mentioned in section 3 of this Part. In addition, the notice provided an opportunity for comment on additional documents being placed in the rulemaking record for the related rulemaking for underground coal mines (paper filter verification investigation and recent hot gas filter test results from VERT), and an opportunity to comment on some additional documents on risk being placed in both records. In this regard, the notice reassured the mining community that any comments filed on risk in either rulemaking proceeding would be placed in both records, since the two rulemakings utilize the same risk assessment.

Part III. Risk Assessment

Introduction

MSHA has reviewed the scientific literature to evaluate the potential health effects of occupational dpm exposures at levels encountered in the mining industry. This part of the preamble presents MSHA's review of the currently available information and MSHA's assessment of health risks associated with those exposures. All material submitted during the public comment periods was considered before MSHA drew its final conclusions.

The risk assessment begins, in Section III.1, with a discussion of dpm exposure levels observed by MSHA in the mining industry. This is followed by a review, in Section III.2, of information available to MSHA on health effects that have been studied in association with dpm exposure. Finally, in Section III.3 entitled ''Characterization of Risk,'' the Agency considers three questions that must be addressed for rulemaking under the Mine Act and relates the available information about risks of dpm exposure at current levels to the regulatory requirements.

A risk assessment must be technical enough to present the evidence and describe the main controversies surrounding it. At the same time, an overly technical presentation could cause stakeholders to lose sight of the main points. MSHA is guided by the first principle the National Research Council established for risk characterization, that the approach be:

> [a] decision driven activity, directed toward informing choices and solving problems * * * Oversimplifying the science or skewing the results through selectivity can lead to the inappropriate use of scientific information in risk management decisions, but providing full information, if it does not address key concerns of the intended audience, can undermine that audience's trust in the risk analysis.

Although the final rule covers only one sector, this portion of the preamble was intended to enable MSHA and other interested parties to assess risks throughout the coal and M/NM mining industries. Accordingly, the risk assessment includes information pertaining to all sectors of the mining industry. All public comments on the exposures of miners and the health effects of dpm exposure—whether submitted specifically for the coal rulemaking or for the metal/nonmetal rulemaking—were incorporated into the record for each rulemaking and have been considered for this assessment.

MSHA had an earlier version of this risk assessment independently peer reviewed. The risk assessment as proposed incorporated revisions made in accordance with the reviewers' recommendations, and the final version presented here contains clarifications and other responses to public comments. With regard to the risk assessment as published in the proposed preamble, the reviewers stated that:

> * * * principles for identifying evidence and characterizing risk are thoughtfully set out. The scope of the document is carefully described, addressing potential concerns about the scope of coverage. Reference citations are adequate and up to date. The document is written in a balanced fashion, addressing uncertainties and asking for additional information and comments as appropriate. (Samet and Burke, Nov. 1997).

Some commenters generally agreed with this opinion. Dr. James Weeks, representing the UMWA, found the proposed risk assessment to be ''balanced, thorough, and systematic.'' Dr. Paul Schulte, representing NIOSH, stated that ''MSHA has prepared a thorough review of the health effects associated with exposure to high concentrations of dpm, and NIOSH concurs with the published [proposed] characterization of risks associated with these exposures.'' Dr. Michael Silverstein, representing the Washington State Dept. of Labor and Industries, found MSHA's ''regulatory logic * * * thoroughly persuasive.'' He commented that ''the best available scientific evidence shows that diesel particulate exposure is associated with serious material impairment of health * * * the evidence * * * is particularly strong and certainly provides a sufficient basis for regulatory action.''

Many commenters, however, vigorously criticized various aspects of the proposed assessment and some of the scientific studies on which it was based. MSHA's final assessment, published here, was modified to respond to all of these criticisms. Also, in response to commenters' suggestions, this assessment incorporates some research studies and literature reviews not covered or inadequately discussed in the previous version.

Some commenters expressed the opinion that the proposed risk assessment should have been peer-reviewed by a group representing government, labor, industry, and independent scientists. Since the rulemaking process included a pre-hearing comment period, eight public hearings (four for coal and four for M/NM), and two post-hearing comment periods, these constituencies had ample opportunity to review and comment upon MSHA's proposed risk assessment. The length of the comment period for the Coal Dpm proposal was 15 months. The length of the comment period for the Metal/Nonmetal Dpm proposal was nine months.

1. Exposures of U.S. Miners

Information about U.S. miner exposures comes from published studies and from additional mine investigations conducted by MSHA since 1993.[1] Previously published studies of exposures to dpm among U.S. miners are: Watts (1989, 1992), Cantrell (1992, 1993), Haney (1992), and Tomb and Haney (1995). MSHA has also conducted investigations subsequent to the period covered in Tomb and Haney (1995), and the previously unpublished data through mid-1998 are included here. Both the published and unpublished studies were placed in the record with the proposal, giving MSHA's stakeholders the opportunity to analyze and comment on all of the exposure data considered.

MSHA's field studies involved measuring dpm concentrations at a total of 50 mines: 27 underground metal and nonmetal (M/NM) mines, 12 underground coal mines, and 11 surface mining operations (both coal and M/NM). At all surface mines and all underground coal mines, dpm measurements were made using the size-selective method, based on gravimetric determination of the amount of submicrometer dust collected with an impactor. With few exceptions, dpm measurements at underground M/NM mines were made using the Respirable Combustible Dust (RCD) method (with no impactor). At two of the underground M/NM mines, measurements were made using the total carbon (TC) method, and at one, RCD measurements were made in one year and TC measurements in another. Measurements at the two remaining underground M/NM mines were made using the size-selective method, as in

[1] MSHA has only limited information about miner exposures in other countries. Based on 223 personal and area samples, average exposures at 21 Canadian noncoal mines were reported to range from 170 to 1300 μg/m^3 (respirable combustible dust), with maximum measurements ranging from 1020 to 3100 μg/m^3 (Gangel and Dainty, 1993). Among 622 full shift measurements collected since 1989 in German underground noncoal mines, 91 (15%) exceeded 400 μg/m^3 (total carbon) (Dahmann et al., 1996). As explained elsewhere in this preamble, 400 μg/m^3 (total carbon) corresponds to approximately 500 μg/m^3 dpm.

coal and surface mines.[2] Weighing errors inherent in the gravimetric analysis required for both size-selective and RCD methods become statistically insignificant at the relatively high dpm concentrations observed.

According to MSHA's experience, the dpm samples reflect exposures typical of mines known to use diesel equipment for face haulage in the U.S. However, they do not constitute a random sample of mines, and care was taken in the proposed risk assessment not to characterize results as necessarily representing conditions in all mines. Several commenters objected to MSHA's use of these exposure measurements in making comparisons to exposures reported in other industries and, for M/NM, in estimating the proposed rule's impact. These objections are addressed in Sections III.1.d and III.3.b.ii(3)(c) below. Comments related to the measurement methods used in underground coal and M/NM mines are addressed, respectively, in Sections III.1.b and III.1.c.

Each underground study typically included personal dpm exposure measurements for approximately five production workers. Also, area samples were collected in return airways of underground mines to determine diesel particulate emission rates.[3] Operational information such as the amount and type of equipment, airflow rates, fuel, and maintenance was also recorded. Mines were selected to obtain a wide range of diesel equipment usage and mining methods. Mines with greater than 175 horsepower and less than 175 horsepower production equipment were sampled. Single and multiple level mines were sampled. Mine level heights ranged from eight to one-hundred feet. In general, MSHA's studies focused on face production areas of mines, where the highest concentrations of dpm could be expected; but, since some miners do not spend their time in face areas, samples were collected in other areas as well, to get a more complete picture of miner exposure. Because of potential interferences from tobacco smoke in underground M/NM mines, samples were not collected on or near smokers.

Table III–1 summarizes key results from MSHA's studies. The higher concentrations in underground mines were typically found in the haulageways and face areas where numerous pieces of equipment were operating, or where airflow was low relative to the amount of equipment operating. In production areas and haulageways of underground mines where diesel powered equipment was used, the mean dpm concentration observed was 644 µg/m³ for coal and 808 µg/m³ for M/NM. In travelways of underground mines where diesel powered equipment was used, the mean dpm concentration (based on 112 area samples not included in Table III–1) was 517 µg/m³ for M/NM and 103 µg/m³ for coal. In surface mines, the higher concentrations were generally associated with truck drivers and front-end loader operators. The mean dpm concentration observed was less than 200 µg/m³ at all eleven of the surface mines in which measurements were made. More information about the dpm concentrations observed in each sector is presented in the material that follows.

TABLE III–1.—FULL-SHIFT DIESEL PARTICULATE MATTER CONCENTRATIONS OBSERVED IN PRODUCTION AREAS AND HAULAGEWAYS OF 50 DIESELIZED U.S. MINES

Mine type	Number of mines	Number of samples	Mean exposure (µg/m³)	Standard error of mean (µg/m³)	Exposure range (µg/m³)
Surface	11	45	88	11	9–380
Underground coal	12	226	644	41	0–3,650
Underground metal and nonmetal	27	355	808	39	10–5,570

Note: Intake and return area samples are excluded.

a. Underground Coal Mines

Approximately 145 out of the 910 existing underground coal mines currently utilize diesel powered equipment. Of these 145 mines, 32 mines currently use diesel equipment for face coal haulage. The remaining mines use diesel equipment for transportation, materials handling and other support operations. MSHA focused its efforts in measuring dpm concentrations in coal mines on mines that use diesel powered equipment for face coal haulage. Twelve mines using diesel-powered face haulage were sampled. Mines with diesel powered face haulage were selected because the face is an area with a high concentration of vehicles operating at a heavy duty cycle at the furthest end of the mine's ventilation system.

Diesel particulate levels in underground mines depend on: (1) The amount, size, and workload of diesel equipment; (2) the rate of ventilation; and, (3) the effectiveness of whatever diesel particulate control technology may be in place. In the dieselized mines studied by MSHA, the sections used either two or three diesel coal haulage vehicles. In eastern mines, the haulage vehicles were equipped with a nominal 100 horsepower engine. In western mines, the haulage vehicles were equipped with a nominal 150 horsepower engine. Ventilation rates ranged from the approval plate requirement, based on the 100–75–50 percent rule (Holtz, 1960), to ten times the approval plate requirement. In most cases, the section airflow was approximately twice the approval plate requirement. Other control technology included aftertreatment filters and fuel. Two types of aftertreatment filters were used. These filters included a disposable diesel emission filter (DDEF) and a Wire Mesh Filter (WMF). The DDEF is a commercially available product; the WMF was developed by and only used at one mine. Both low sulfur and high sulfur fuels were used.

Figure III–1 displays the range of exposure measurements obtained by MSHA in the field studies it conducted in underground coal mines. A study normally consisted of collecting samples on the continuous miner operator and coal haulage vehicle

[2] The various methods of measuring dpm are explained in section 3 of Part II of the preamble to the proposed rule. This explanation, along with additional information on these methods, is also provided in section 3 of Part II of the preamble to the final M/NM rule.

[3] Since area samples in return airways do not necessarily represent locations where miners normally work or travel, they were excluded from the present analysis. A number of area samples were included, however, as described in Sections III.1.b and III.1.c. The included area samples were all taken in production areas and haulageways.

operators for two to three shifts, along with area samples in the haulageways. A total of 142 personal samples and 84 area samples were collected, excluding any area samples taken in intake or return airways.

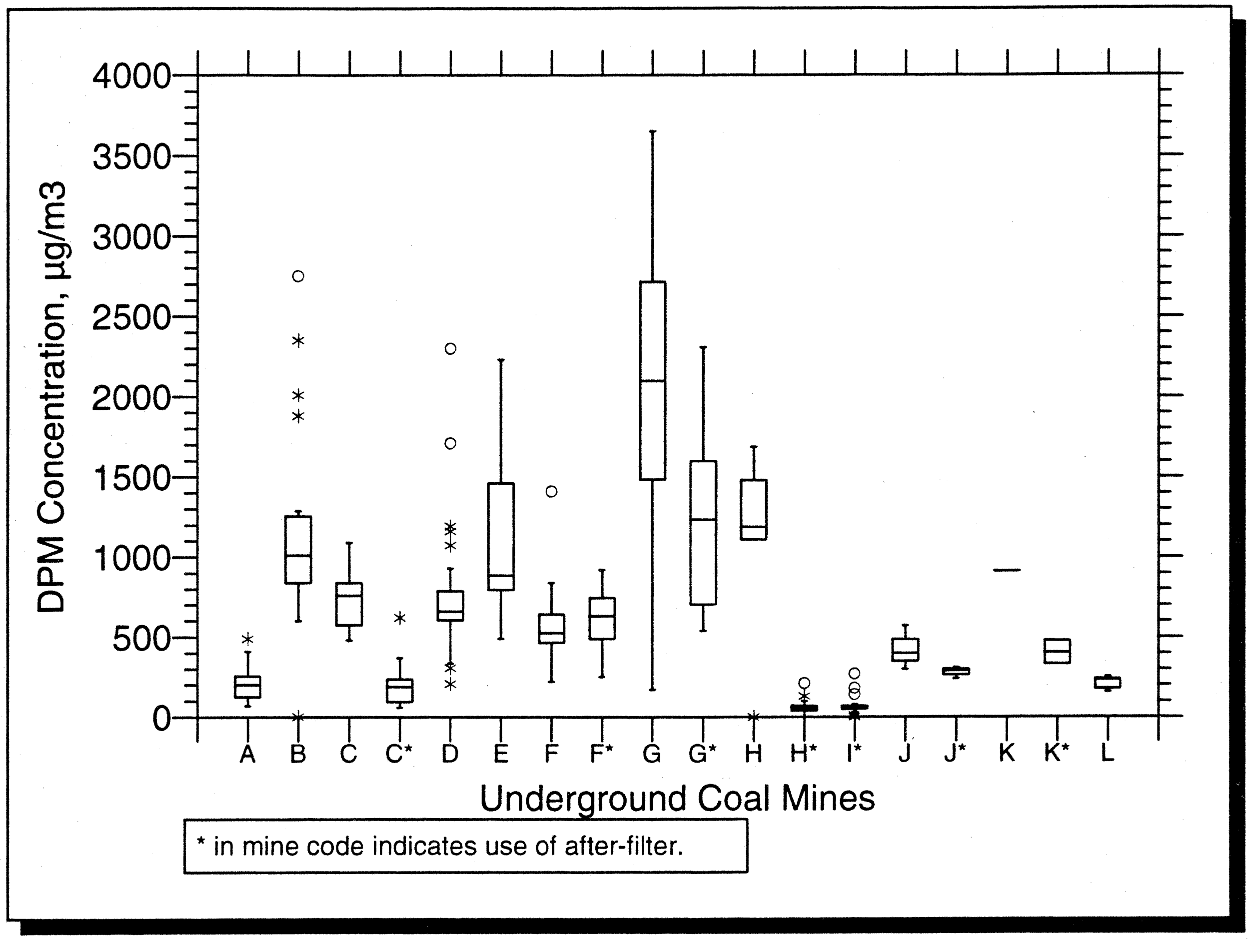


Figure 1Box plots (Tukey, 1977) for dpm concentrations observed at 12 underground coal mines. Top and bottom of each box represent upper and lower quartiles, respectively. "Belt" inside box represents median. Vertical lines span nearly all measurements. Isolated points (either ✳ or ○) are outliers, representing unusually high or low measurements compared to other observations at the same mine. All dpm measurements were made using the size-selective method, based on gravimetric determination of the amount of submicrometer dust collected with an impactor.

As stated in the proposed risk assessment, no statistically significant difference was observed in mean dpm concentration between the personal and area samples.[4] A total of 19 individual measurements exceeded 1500 $\mu g/m^3$, still excluding intake and return area samples. Although the three highest of these were from area samples, nine of the 19 measurements exceeding 1500 $\mu g/m^3$ were from personal samples.

In six mines, measurements were taken both with and without use of disposable after-treatment filters, so that a total of eighteen studies, carried out in twelve mines, are displayed. Without use of after-treatment filters, average observed dpm concentrations exceeded 500 $\mu g/m^3$ in eight of the twelve mines and exceeded 1000 $\mu g/m^3$ in four.[5] At five of the twelve mines, all dpm measurements were 300 $\mu g/m^3$ or greater in the absence of after-treatment filters.

The highest dpm concentrations observed at coal mines were collected at Mine "G." Eight of these samples were collected during employment of WMFs, and eight were collected while filters were not being employed. Without filters, the mean dpm concentration observed at Mine "G" was 2052 $\mu g/m^3$ (median = 2100 $\mu g/m^3$). With employment of WMFs, the mean

[4] One commenter (IMC Global) noted that MSHA had provided no data verifying this statement. For the 142 personal samples, the mean dpm concentration measurement was 608 $\mu g/m^3$, with a standard error of 42.5 $\mu g/m^3$. For the 84 area samples, the mean was 705 $\mu g/m^3$, with a standard error of 82.1 $\mu g/m^3$. The significance level (p-value) of a t-test comparing these means is 0.29 using a separate-variance test or 0.25 using a pooled-variance test. Therefore, a difference in population means cannot be inferred at any confidence level greater than 75%.

Here, and in other sections of this risk assessment, MSHA has employed standard statistical methods described in textbooks on elementary statistical inference.

[5] In coal mine E, the average as expressed by the mean exceeded 1000 $\mu g/m^3$, but the median did not.