The estimated costs of complying with the proposed concentration limits and the other provisions of the proposed rule are about $19.2 million a year.

This option is not the equivalent of what is being proposed for underground coal mines. The underground metal and nonmetal equipment that would be left unfiltered pursuant to this option may in some cases, have larger horsepower engines than the equipment that would be left unfiltered pursuant to the proposed rule for underground coal—and there are more pieces of equipment per mine in the underground metal and nonmetal sector (see Table II–1 in part II of this preamble).

Moreover, under the statute, MSHA must take the approach that provides miners with the greatest protection feasible. This option would be less protective than a concentration limit in this sector. Under the option, the only control in underground metal and nonmetal mines would be filters on heavy-duty equipment; by contrast, the controls MSHA has estimated will be necessary to meet the proposed concentration limit are more stringent—all production equipment will need an oxidation catalytic convertor for example, and 85% of production equipment will also need a new engine.

Moreover, the distribution of equipment and miners in underground metal and nonmetal mine areas means that the protection received under this approach—in which only 46% (i.e., the heavy duty equipment) of the equipment is filtered, and no other controls required—would likely be very uneven. Some miners might be reasonably well protected, but many others would not.

There are two other factors that mitigate against such an approach in underground metal and nonmetal mines.

First, it is not clear this approach is technologically feasible. The only filters that are currently available that can produce 95% efficiency in removing particulates are paper filters. Some of the heavy-duty engines are very large, and it may take some time before commercially available designs for filtration of this efficiency will be available to fit all types and sizes of heavy duty equipment—and work effectively without hampering equipment performance. That is why in determining the role filtration might play in this sector, the Agency assumed that replaceable ceramic filters would be used. At this time, such filters are capable of 60–85% efficiency. It is possible, of course, that once a market develops, the manufacturers of such filters might be able to produce a more efficient filter. MSHA solicits information about any such pending developments.

Second, it would appear that in many cases, a new engine and/or cab might be a more effective solution to a localized dpm concentration in an underground metal and nonmetal mine than a filter—and perhaps less expensive for equipment of this size. One of the advantages of a concentration limit is the flexibility it provides.

MSHA has not yet given detailed consideration to requiring all underground metal and nonmetal operators to utilize an oxidation catalytic converter (OCC)—in combination with a concentration limit—but intends to do so. The studies discussed above, and information from MSHA's workshops, suggests that OCCs are already widely utilized in this sector, and can reduce dpm emissions as much as 20%. MSHA assumes that this is the first control to which most operators would turn if a concentration limit were established. Accordingly, the Agency welcomes comment on whether it would be feasible and appropriate to simply require underground metal and nonmetal mining companies to install and maintain OCCs on all diesel engines.

Feasibility of proposed rule for underground metal and nonmetal mining sector. The Agency has carefully considered both the technological and economic feasibility of the proposed rule for the underground metal and nonmetal mining sector as a whole.

There are two separate issues with respect to technological feasibility—(a) the existence of technology that can accurately and reliably measure dpm concentration levels in all types of underground metal and nonmetal mines; and (b) the existence of control mechanisms that can bring dpm concentrations down to the proposed limit in all types of underground metal and nonmetal mines.

Measurement technology. Part II of this preamble contains a detailed discussion of the measurement method which MSHA is proposing to use in this sector, including the evidence MSHA examined in making its determination that this approach provides an accurate and reliable way to measure dpm concentration levels in all types of underground metal and nonmetal mines. Briefly, the method involves the use of a respirable dust sampler to collect particles on a filter, which is then analyzed using a method to detect total carbon validated by the National Institute for Occupational Safety and Health for that purpose. MSHA has concluded that total carbon, is a valid surrogate for dpm in this sector. In fact, to make the concentration limit on dpm easier to use in practice, MSHA is proposing to express that limit in terms of total carbon so that the measurement results can be directly compared with the standard's requirements.

As further explained in part IV, MSHA recognizes that any measurement system has an inherent level of uncertainty. As is its practice with other compliance determinations based on measurement, MSHA would not issue a citation that an underground metal or nonmetal mine has violated the concentration limit unless the measurement exceeds the limit (interim or final) by an amount adequate to ensure a 95% confidence level. While MSHA has not at this time reached a determination of the amount that it deems appropriate to add to the measured concentration to establish such a confidence level, it could be on the order of 11–20% (see part II discussion of measurement for details).

Control technology. The availability of control technology to enable operators to reduce their existing dpm concentrations to the proposed concentration level was discussed earlier in this part [See (1) *Establish a lower concentration limit for underground metal/nonmetal mines*'']. In fact, these studies suggest it is technologically feasible for operators in this sector to reduce their dpm concentrations to an even lower concentration limit. MSHA's publication ''Practical Ways to Reduce Exposure to Diesel Exhaust in Mining—a Toolbox'' summarizes information about the mining community's experience to date with various controls. A copy of this publication is appended at the end of this document.

Although the agency has reached this conclusion, and moreover knows of no mine that cannot accomplish the required reductions in the permitted time, it has nevertheless proposed that any underground metal or nonmetal mine may have up to an additional two years to install the required controls should it find that there are unforseen technological barriers to timely completion. A detailed discussion of the requirements for obtaining approval for such an extension of time to comply is provided in part IV of the preamble. The Agency would particularly welcome comments illustrating situations which warrant further attention in this regard.

Economic Feasibility. MSHA estimates that the proposed rule would cost the underground metal and nonmetal sector about $19.2 million a year even with the extended phase-in time. The costs per underground dieselized metal or nonmetal mine are estimated to be about $94,600 annually.

As explained in the PREA, most ($19.2 million) of the anticipated yearly costs would be investments in equipment to meet the interim and final concentration limits. While operators have complete flexibility as to what controls to use to meet the concentration limits, the Agency based its cost estimates on the assumption that operators will ultimately need the following to get to the final concentration limit: (a) all production equipment will need an oxidation catalytic converter; (b) about 38% of all equipment (production and support) will need a new engine; (c) about 8% of all equipment will need an environmentally conditioned cab; (d) about 34% of all equipment will need a 60–90% replaceable ceramic filter; and (e) 61% of all mines will need some ventilation improvement (16% fan and motor, 45% just motor). The assumptions are based on a January 1998 count of diesel powered equipment that regularly operates in the underground metal and nonmetal mines. The count was performed by MSHA's metal and nonmetal inspectors. This is a conservative estimate; as noted in discussing the possibility of having a lower concentration limit, it does not reflect the possibility that some mines may now be already cleaning up their fleet as they turn over their existing inventory. The cost estimates do reflect some facts noted in part II of this preamble: (a) unlike the coal sector, a large portion of underground metal and nonmetal mines are dieselized; (b) each mine has on average more diesel engines than in the coal sector; and (c) the engines used in these mines are more varied and heavier on average than those used in the coal sector. In addition to the costs to comply with the proposed concentration limit, the costs estimated for this sector include costs for implementing work practice controls that are similar to those already in effect in the underground coal sector.

The Agency is taking a number of steps to mitigate the impact of the rule for the underground metal and nonmetal sector, particularly on the smallest mines in this sector. These are described in detail in the Agency's Initial Regulatory Flexibility Analysis, which the Agency is required to prepare under the Regulatory Flexibility Act in connection with the impact of the rule on small entities. (The regulatory flexibility analysis can be found in part VI of this preamble, or packaged with the Agency's PREA.)

After a careful review of the information about this sector available from the industry economic profile, and the other obligations of this sector under the Mine Act, MSHA has tentatively concluded that a reasonable probability exists that the typical firm in this sector will be able at this time to afford the controls that will be necessary to meet the proposed standard. The Agency endeavored to gather information on examples of how these compliance costs would impact particular companies, and to establish whether existing order plans (e.g. for newer engines) might already contemplate costs which this rule would require, but was unable to find any significant information in this regard. The Agency welcomes information that will provide additional evidence on this important question.

Conclusion: metal and nonmetal mining sector. Based on the best evidence available at this time, the Agency has concluded that the proposed rule for the underground metal and nonmetal sector meets the statutory requirement that the Secretary attain the highest degree of health and safety protection for the miners in that sector, with feasibility a consideration.

Appendix to Part V: Diesel Emission Control Estimator

As noted in the text of this part, MSHA has developed a model that can help it estimate the impact on dpm concentrations of various control variables. The model also permits the estimation of actual dpm concentrations based upon equipment specifications. This model, or simulator, is called the ''Diesel Emission Control Estimator'' (or the ''Estimator'').

The model is capable only of simulating conditions in production or other confined areas of an underground mine. Air flow distribution makes modeling of larger areas more complex. The Estimator can be used in any type of underground mine.

While the calculations involved in this model can be done by hand, use of a computer spreadsheet system facilitates prompt comparison of the results of alternative combinations of controls. Changing a particular entry instantly changes all dependent outputs. Accordingly, MSHA developed the Estimator as a spreadsheet format. It can be used in any standard spreadsheet program.

A paper discussing this model has been presented and published as an SME Preprint (98–146) in March 1998 at the Society for Mining and Exploration Annual Meeting. It was demonstrated at a workshop at the Sixth International Mine Ventilation Congress, Pittsburgh, Pa., in June 1997. The Agency is making available to the mining community the software and instructions necessary to enable it to perform simulations for specific mining situations. Copies may be obtained by contacting: Dust Division, MSHA, Pittsburgh Safety and Health Technology Center, Cochrans Mill Road, P.O. Box 18233, Pittsburgh, Pa., 15236. The Agency welcomes comments on the proposed rule that include information obtained by using the Estimator. The Agency also welcomes comments on the model itself, and suggestions for improvements.

Determining the Current DPM Concentration. The Estimator was designed to provide an indication of what dpm concentration will remain in a production area once a particular combination of controls is applied. Its baseline is the current dpm concentration, which of course reflects actual equipment and work practices.

If the actual ambient dpm concentration is known, this information provides the best baseline for determining the outcome from applying control technologies. Any method that can reliably determine ambient dpm concentrations under the conditions involved can be utilized. A description of various methods available to the mining community is described in part II of this preamble.

If the exact dpm concentration is not known, estimates can be obtained in several ways. One way is to take a percentage of the respirable dust concentration in the area. Studies have shown that dpm can range from 50–90% of the respirable dust concentration, depending on the specific operation, the size distribution of the dust and the level of controls in place. Another method is simply to choose a value of 644 for an underground coal mine, or 830 for an underground metal or nonmetal mine. These values correspond to the average mean concentration which MSHA sampling to date has measured in such underground mines. Or, depending upon mine conditions, some other value from the range of mean mine concentrations displayed in part III of this preamble might be an appropriate baseline — for example, an average similar to that of mine sections like the one for which controls are required.

The Estimator has been designed to automatically compute another estimate of current ambient dpm concentration, and to provide outputs using this estimate even when the actual ambient dpm concentration is available and used in the model. This is done by using emissions data for the engines involved—specific manufacturer emissions data where available, or an average using the known range of emissions for each type of engine being used.

As with other estimates of current ambient dpm concentration, using engine data to derive this baseline measure does not produce the same results as actual dpm measurements. The Agency's experience is that the use of published engine emissions rates provides a good estimate of dpm exposures when the engines involved are used under heavy duty cycle conditions; for light duty cycle equipment, the published emission rates will generally overestimate the ambient particulate exposures. Also, such an approach assumes that the average ambient concentration derived is representative of the workplace where miners actually work or travel.

Columns. An example of a full spreadsheet from the Estimator is displayed as Figure V–5. The example here involves the application of various controls in an underground metal and nonmetal mine. As illustrated in the discussion in this part, the Estimator can be used equally well to ascertain what happens to dpm concentrations in an underground coal mine when the high-efficiency filters required by the proposed rule are used under various ventilation and section dpm intake conditions. Underground coal mine operators who are interested in ascertaining what impact it might have on dpm concentrations in their mines if the proposed rule permitted the use of alternative controls, or required the use of additional controls (e.g. filters on light duty equipment), can use the Estimator for this purpose as well.

FIGURE V–5.—EXAMPLE OF ESTIMATOR SPREADSHEET RESULTS FOR A SECTION OF AN UNDERGROUND METAL AND NONMETAL MINE

[Work Place Diesel Emissions Control Estimator; Mine Name: Underground Metal and Nonmetal]

	Column A	Column B
1. MEASURED OR ESTIMATED IN MINE DP EXPOSURE (µg/m3)	330 µg/m3	
2. VEHICLE EMISSION DATA		
EMISSIONS OUTPUT (gm/hp-hr)		
VEHICLE 1 INDIRECT INJECTION 0.3–0.5 gm/hp-hr FEL	0.1 gm/hp-hr	0.1 gm/hp-hr
VEHICLE 2 OLD DIRECT INJECTION 0.5–0.9 gm/hp-hr Truck 1	0.2 gm/hp-hr	0.2 gm/hp-hr
VEHICLE 3 NEW DIRECT INJECTION 0.1–0.4 gm/hp-hr Truck 2	0.1 gm/hp-hr	0.1 gm/hp-hr
VEHICLE 4	0.0	0.0 gm/hp-hr
VEHICLE OPERATING TIME (hours)		
VEHICLE 1 FEL	9 hours	9 hours
VEHICLE 2 Truck 1	9 hours	9 hours
VEHICLE 3 Truck 2	9 hours	9 hours
VEHICLE 4	0	0 hours
VEHICLE HORSEPOWER (hp)		
VEHICLE 1 FEL	315 hp	315 hp
VEHICLE 2 Truck 1	250 hp	250 hp
VEHICLE 3 Truck 2	330 hp	330 hp
VEHICLE 4	0 hp	0 hp
SHIFT DURATION (hours)	10 hours	10 hours
AVERAGE TOTAL SHIFT PARTICULATE OUTPUT (gm)	0.09 gm/hp-hr	0.12 gm/hp-hr
3. MINE VENTILATION DATA		
FULL SHIFT INTAKE DIESEL PARTICULATE CONCENTRATION	50 µg/m3	50 µg/m3
SECTION AIR QUANTITY	155000 cfm	155000 cfm
AIRFLOW PER HORSEPOWER	173 cfm/hp	73 cfm/hp
4. CALCULATED SWA DP CONCENTRATION WITHOUT CONTROLS		551 µg/m3
5. ADJUSTMENTS FOR EMISSION CONTROL TECHNOLOGY		
ADJUSTED SECTION AIR QUANTITY	155000 cfm	155000 cfm
VENTILATION FACTOR (INITIAL CFM/FINAL CFM)	1.00	1.00
AIRFLOW PER HORSEPOWER	173 cfm/hp	173 cfm/hp
OXIDATION CATALYTIC CONVERTER REDUCTION (%)		
VEHICLE 1	0%	20%
VEHICLE 2 IF USED ENTER 0–20%.	0%	20%
VEHICLE 3	0%	0%
VEHICLE 4	0%	0%
NEW ENGINE EMISSION RATE (gm/hp-hr)		
VEHICLE 1	0.1 gm/hp-hr	0.1 gm/hp-hr
VEHICLE 2 ENTER NEW ENGINE EMISSION (gm/hp-hr).	0.2 gm/hp-hr	0.2 gm/hp-hr
VEHICLE 3	0.1 gm/hp-hr	0.1 gm/hp-hr
VEHICLE 4	0.0 gm/hp-hr	0.0 gm/hp-hr
AFTER FILTER OR CAB EFFICIENCY (%)		
VEHICLE 1 Cabs	60%	60%
VEHICLE 2 USE 65–95% FOR AFTERFILTERS.	60%	60%
VEHICLE 3 USE 50–80% FOR CABS.	60%	60%
VEHICLE 4	0%	0%
6. ESTIMATED FULL SHIFT DP CONCENTRATION	162 µg/m^3	184 µg/m^3

*NOTE: Use of the Estimator does not free operators from the requirements of the rule. It is intended to serve as a guide.

A full spreadsheet from the Estimator has two columns, labeled A and B. Column A displays information on computations where the baseline is the measured ambient dpm concentration, or whose baselines are estimated as a percentage of respirable dust or by using the mean concentration for the sector. Column B displays information on computations in which the baseline itself was derived from engine emission information entered into the Estimator.

Sections. The Estimator spreadsheet is divided into 6 sections. Sections 1 through 4 contain information on the baseline situation in the mine section. Section 5 contains information on proposed new controls, and Section 6 displays the dpm concentration expected to remain after the application of those new controls. Table V–4 summarizes the information in each section of the Estimator.

TABLE V–4.—INFORMATION NEEDED FOR OR PROVIDED BY EACH SECTION OF THE ESTIMATOR MODEL

Speadsheet section	Input/output	Mine information
Section 1	Input	Measured DP Level, µg/m^3.

TABLE V–4.—INFORMATION NEEDED FOR OR PROVIDED BY EACH SECTION OF THE ESTIMATOR MODEL—Continued

Speadsheet section	Input/output	Mine information
Section 2	Input	Engine Emissions, gm/hp-hr. Engine Horsepower, hp. Operation Times, hr. Shift Duration, hr.
Section 3	Input	Section Airflow, cfm Intake DP Level, µg/m^3.
Section 4	Output	Current DP Level, µg/m^3.
Section 5	Input	DP Controls: Airflow, cfm. Oxid. Cat. Converter, percent. Engine Emissions, gm/hp-hr. after-filters, percent. Cabs, percent.
Section 6	Output	Projected DP Level, µg/m^3.

Section 1. This is the place to enter data on baseline dpm concentrations if obtained by actual measurement, estimate based on respirable dust concentration, or mean concentration in the mining sector. Measurements should be entered in terms of whole diesel particulate matter for consistency with engine information. Information need not be entered in this section, in which case only engine-emission derived estimates will be produced by the Estimator (in Column B).

Sections 2 and 3. Section 2 is the place to enter data about the existing engines and engine use, and section 3 is the place to enter data about current ventilation practices. This information is used in two ways. First, the Estimator uses this information to derive an estimated baseline dpm concentration (for column B). Second, by comparing this information with that in section 5 on proposed controls that would change engines, engine use, or ventilation practices, the Estimator calculates the improvement in dpm that would result.

The first information entered in section 2 is the dpm emission rate (in gm/hp-hr) for each vehicle. The Estimator in its current form provides room to enter appropriate identification information for up to four vehicles. However, when multiple engines of the same type are used, the spreadsheet can be simplified and the number of entries conserved by combining the horsepower of these engines. For example, two 97 hp, 0.5 gm/hp-hr engines can be entered as a single 194 hp, 0.5 gm/hp-hr engine. However, if the estimate is to involve the use of different controls for each engine, the data for each engine must be entered separately. In order to account for the duty cycle, the engine operating time for each piece of equipment must then be entered in section 2, along with the length of the shift.

The last item in section 2, the ''average total shift particulate output'' in grams, is calculated by the Estimator based on the measured concentration entered in section 1 (for column A, or the engine emission rates for column B), the intake concentration, engine horsepower, engine operating time, and airflow. For column A, the average total shift diesel particulate output is calculated from the formula:

E(a) = (DPM(m) − I)×(Q(I)/35200)/[Sum (Hp(I)×To(I))]

Where:

E(a) = Average engine output, gm/hp-hr
DPM(m) = Measured concentration of diesel particulate, µg/m^3
Q(I) = Initial section ventilation, cfm
I = Intake concentration, µg/m^3
Hp(I) = Individual engine Horsepower, hp
To(I) = Individual engine operating times, hours

For column B, the average total shift diesel particulate output is calculated from the formula:

E(a) = [Sum (E(I)×Hp(I)×To(I))]/[Sum (Hp(I))]/Ts

Where:

E(a) = Average engine output, gm/hp-hr
E(I) = Individual engine emission rates, gm/hp-hr
Hp(I) = Individual engine Horsepower, hp
To(I) = Individual engine operating times, hours
Ts = Shift length, hours

The ''average total shift particulate'' provides useful information in determining what types of controls would be most useful. If the average output is less than 0.3, controls such as cabs and afterfilters would have a large impact on dpm. If the average output is greater than 0.3, new engines would have a large impact on dpm.

There are two data elements concerning existing ventilation in the section that must be entered into section 3 of the Estimator: the full shift intake dpm concentration, and the section air quantity. The former can be measured, or an estimate can be used. Based upon MSHA measurements to date, an estimate of between 25 and 100 micrograms of dpm per cubic meter would account for the dpm contribution coming into the section from the rest of the mine.

The last item in section 3, the airflow per horsepower, is calculated by the Estimator from the information entered on these two items in sections 2 and 3, as an indication of ventilation system performance. If the value is less than 125 cfm/hp, consideration should be given to increasing the airflow. If the value is greater than 200 cfm/hp, primary consideration would focus on controls other than increased airflow.

Section 4. Section 4 only displays information in Column B. Using the individual engine emissions, horsepower, operating time, section airflow , intake DPM and shift length, the Estimator calculates a presumed dpm concentration. The presumed dpm concentration is calculated by the formula:

DPM(a) = {[[Sum (E(I)× Hp(I) × To(I))] × 35,300/Q(I)]+I}×[Ts/8]

Where:

35,300 is a metric conversion factor
DPM(a) = Shift weighted average concentration of diesel particulate, µg/m^3
E(I) = Individual engine emission rates, gm/hp-hr
Hp(I) = Individual engine Horsepower, hp
To(I) = Operating time hours
Ts = Shift length, hours
Q(I) = Initial section ventilation, cfm
I = Intake concentration, µg/m^3

Section 5. Information about any combination of controls likely to be used to reduce dpm emissions in underground mines—changes in airflow, the addition of oxygen catalytic converters, the use of an engine that has a lower dpm emission rate, and the addition of either a cab or aftertreatment filter—is entered into Section 5. Information is entered here, however, only if it involves a change to the baseline conditions entered into Sections 2 and 3. Entries are cumulative.

The first possible control would be to increase the system air quantity. The minimum airflow should either be the summation of the Particulate Index (PI) for all heavy duty engines in the area of the mine, or 200 cfm/hp. The spreadsheet displays the ratio between the air quantity in section 5 and that in section 3, and the airflow per horsepower.

The second possible control would be to add an oxidation catalytic converter to one or more engines if not initially present. When such converters are used, a dpm reduction of up to 20 percent can be obtained (as noted in MSHA's Toolbox). The third possible control would be to change one or more engines to newer models to reduce emissions. As noted in part II of this preamble, clean engine technology has emissions as low as 0.1 and 0.2 gm/hp-hr.

Finally, each piece of equipment could be equipped with either a cab and an aftertreatment filter. Since MSHA considers it unlikely an operator would use both controls, the Estimator is designed to assume that no more than one of these two possible controls would be used on a particular engine. Ceramic aftertreatment filters that can reduce emissions by 65–80% are currently on the market; MSHA is soliciting information about the potential for future improvements in ceramic filtration efficiency. Paper filters can remove up to 95% or more of dpm, but these can only be used on equipment whose exhaust is appropriately cooled to avoid igniting the paper (i.e., permissible coal equipment, or other equipment equipped with a water scrubber or other cooling device). Air conditioned cabs can reduce the exposure of the equipment operator by anywhere from 50–80%. (See part II, section 6, for information on filters and cabs). But while the Estimator will produce an estimate of the full shift dpm concentration that includes the effects of using such cabs, it should be remembered that such an estimate is only directly relevant to equipment operators. Thus, cabs are a viable control for sections where the miners are all equipment operators, but they will not impact the dpm concentrations to which other miners are exposed.

Section 6. The Estimator displays in this section an estimated full shift dpm concentration. If a measured baseline dpm concentration was entered in section 1, this information will be displayed in column A. Column B displays an estimate based on the engine emissions data.

Here is how the computations are performed.

The effect of control application is calculated in Section 6, Column A from the following formula:

$$DPM(c) = \{Sum\ [(To(I) / Ts) \times 1000 \times [(E(a) / 60) \times Hp(I) \times (35300 / Q(I)) \times (Q(I) / Q(f)) \times (1-R(o)) \times (1-R(f)) \times (1-R(e))]]\} + I$$

Where:

DPM(c) = Diesel particulate concentration after control application/$\mu g/m^3$,
E(a) = Average engine emission rate, gm/hp-hr,
Hp(I) = Individual engine Horsepower, hp.
To(I) = Operating time hours,
I = Intake DPM concentration, $\mu g/m^3$,
Q(I) = Initial section ventilation, cfm,
Q(f) = Final section ventilation, cfm,
R(o) = Efficiency of oxidation catalytic converter, decimal
R(f) = Efficiency of after filters or cab, decimal,
R(e) = Reduction for new engine technology, decimal, and
R(e) = (Ei—Ef) / Ei

Where:

R(e) = Reduction for new engine technology, decimal,
E(i) = Initial engine emission rates, gm/hp-hr,
E(f) = New engine emission rates, gm/hp-hr,

The effect of control application is calculated in Section 6, Column B from the following formula:

$$DPM(c) = \{Sum[(E(I) \times Hp(I) \times To(I)) \times (35,300 / Q(I)) \times (1-R(o)) \times (1-R(f)) \times (1-R(e))] \times [Q(I) / Q(f)]\}+I$$

Where:

DPM(c) = Diesel particulate concentration after control application/$\mu g/m^3$,
E(I) = Individual engine emission rates, gm/hp-hr,
Hp(I) = Individual engine Horsepower, hp,
To(I) = Operating time hours,
I = Intake DPM concentration, $\mu g/m^3$,
Q(I) = Initial section ventilation, cfm,
Q(f) = Final section ventilation, cfm,
R(o) = Efficiency of oxidation catalytic converter, decimal,
R(f) = Efficiency of after filters or cab, decimal,
R(e) = Reduction for new engine technology, decimal, and
R(e) = (Ei—Ef) / Ei

Where:

R(e) = Reduction for new engine technology, decimal,
E(i) = Initial engine emission rates, gm/hp-hr,
E(f) = New engine emission rates, gm/hp-hr.

VI. Impact Analyses

This part of the preamble reviews several impact analyses which the Agency is required to provide in connection with proposed rulemaking. The full text of these analyses can be found in the Agency's PREA.

(A) Costs and Benefits: Executive Order 12866

In accordance with Executive Order 12866, MSHA has prepared a Preliminary Regulatory Economic Analysis (PREA) of the estimated costs and benefits associated with the proposed rule for the underground metal and nonmetal sector.

The key conclusions of the PREA are summarized, together with cost tables, in part I of this preamble (see Question and Answer 5). In addition, a summary of the assumptions made by MSHA about the largest cost component of the proposed rule—the costs for equipment that the underground metal and nonmetal sector will need to comply with the proposed concentration limit—can be found in part V of this preamble, in the discussion of the feasibility of the proposed rule for that sector. The complete PREA is part of the record of this rulemaking, and is available from MSHA.

The Agency considers this rulemaking ''significant'' under section 3(f) of Executive Order 12866, and has so designated the rule in its semiannual regulatory agenda (RIN 1219–AB11). However, based upon the PREA, MSHA has determined that the proposed rule does not constitute an ''economically significant'' regulatory action pursuant to section 3(f)(1) of Executive Order 12866.

(B) Regulatory Flexibility Certification and Initial Regulatory Flexibility Analysis (IRFA)

Introduction. Pursuant to the Regulatory Flexibility Act of 1980, MSHA has analyzed the impact of this rule upon small businesses. MSHA specifically solicits comments on the cost data and assumptions concerning the initial regulatory flexibility analysis for underground metal and nonmetal mine operators.

To facilitate public participation in the rulemaking process, MSHA will mail a copy of the proposed rule and this preamble to every underground metal and nonmetal mine operator. In addition, the entire IRFA is reprinted here.

Definition of Small Mine. Under SBREFA, in analyzing the impact of a proposed rule on small entities, MSHA must use the SBA definition for a small entity or, after consultation with the SBA Office of Advocacy, establish an alternative definition for the mining industry by publishing that definition in the **Federal Register** for notice and comment. MSHA has not taken such an action, and hence is required to use the SBA definition.

The SBA defines a small mining entity as an establishment with 500 employees or less (13 CFR 121.201). MSHA's use of the 500 or less employees includes all employees (miners and office workers). Almost all mines (including underground coal mines) fall into this category and hence, can be viewed as sharing the special regulatory concerns which the RFA was designed to address. That is why MSHA has, for example, committed to providing to all underground metal and nonmetal mine operators a copy of a compliance guide explaining provisions of this rule.

The Agency is concerned, however, that looking only at the impacts of the proposed rule on all the mines in this sector does not provide the Agency with a very complete picture on which to make decisions. Traditionally, the Agency has also looked at the impacts of its proposed rules on what the mining community refers to as ''small mines''—those with fewer than 20 miners. The way these small mines perform mining operations is generally recognized as being different from the way other mines operate which has led to special attention by the Agency and the mining community.

This analysis complies with the legal requirements of the RFA for an analysis of the impacts on ''small entities'' while continuing MSHA's traditional look at ''small mines''.

Underground Metal and Nonmetal Mines: Initial Regulatory Flexibility Analysis. Since MSHA has not recently prepared an initial regulatory flexibility analysis in connection with a proposed rule, the mining community has not had an opportunity to review such an analysis. Accordingly, some background may be helpful.

The requirements for an initial RFA should describe the impact of the proposed rule on small entities. Each initial RFA analysis shall contain:

''(1) A description of the reasons why action by the Agency is being considered;

(2) A succinct statement of the objectives of, and legal basis for, the proposed rule;

(3) A description of and, where feasible, an estimate of the number of small entities to which the proposed rule will apply;

(4) A description of the projected reporting, recordkeeping and other compliance requirements of the proposed rule, including an estimate of the classes of small entities which will be subject to the requirement and the type of professional skills necessary for preparation of the report or record;

(5) An identification, to the extent practicable, of all relevant Federal rule which may duplicate, overlap or conflict with the proposed rule.''

In addition, ''Each initial regulatory flexibility analysis shall also contain a description of any significant alternatives to the proposed rule which accomplish the stated objectives of applicable statutes and which minimize any significant economic impact of the proposed rule on small entities. Consistent with the stated objective of applicable statutes, the analysis shall discuss significant alternatives such as:

(1) The establishment of differing compliance or reporting requirements or timetables that take into account the resources available to small entities;

(2) The clarification, consolidation, or simplification of compliance and reporting requirements under the rule for such small entities;

(3) The use of performance rather than design standards;

(4) and an exemption from coverage of the rule, or any part thereof, for such entities.''

MSHA would encourage the mining community to structure its comments on these points in a similar manner so that the Agency will be able to clearly respond to them in its final analysis.

MSHA hopes the presentation that follows will provide reviewers enough information to readily grasp the implications of the rule for small entities in particular, but it strongly encourages reviewers to also pursue the referenced discussions of risk, feasibility, historical and other information in the preamble accompanying the proposed rule.

Reasons Why Agency Action is Being Considered. A rule is needed for underground metal and nonmetal mines to assure that a significant risk of material impairment to the health of miners working in these mines is reduced to the extent economically and technologically feasible for this sector as a whole. The risk is created by the presence of diesel engines in the closed environment of underground metal and nonmetal mines which generate in their emissions very high concentrations of particulate matter. These very small particles penetrate to the deepest regions of the lung. As explained in detail in Part III of the preamble accompanying the proposed rule, exposure to high concentrations of diesel particulate matter puts miners at significant risk of material impairment to their health. These elevated risks include, but are not limited to, an increased risk of lung cancer. At the present time, many underground miners, including many miners in underground metal and nonmetal mines, are exposed to levels of diesel particulate matter that far exceed the exposures of any other group of workers in the United States. The reductions in exposure to diesel particulate required in this sector will necessitate changes in mine equipment and practices that are too significant to bring about without regulatory action.

Objectives of the Rule; Legal Basis. MSHA has two related objectives it hopes to accomplish through the rulemaking for underground metal and nonmetal mines. For miners in this sector, it is MSHA's objective that they will no longer be exposed to diesel particulate matter in far greater concentrations than any other group of workers in this country. For mine operators in this sector, it is MSHA's objective to provide each with flexibility as to the controls they may implement to reduce the concentration of diesel particulate matter to the prescribed limit.

The proposed rule won't eliminate the risk of harm, nor even reduce exposures to the level which industry experts are considering establishing as a Threshold Limit Value, but it would reduce miner exposures to levels comparable to those faced by workers in other industries who work around diesel powered equipment. While MSHA has tentatively concluded that there may remain a significant risk to miner health even with this proposed rule, the Agency has also tentatively concluded that: (a) the proposed rule would provide substantial health benefits; and (b) additional controls beyond those provided for in the proposed rule may not be feasible for the underground metal and nonmetal sectors at this time.

Initially, MSHA had an additional objective in this rulemaking: to establish a uniform rule for all mining sectors because uniformity tends to be the most effective solution for worker's health and for industry compliance. After exploring the implications of such an approach, however, the Agency concluded that a uniform approach does not appear to be feasible at this time. MSHA has tentatively concluded that while there is a technological fix available for underground coal mine operators, the best solution for underground metal and nonmetal mine operators will vary considerably. Moreover, while the Agency has confidence that there is a validated method for measuring diesel particulate matter concentrations in underground metal and nonmetal mines, it believes some further work is necessary before recommending that such an approach be used in underground coal mines due to the possibility of contamination of the samples by coal dust. The Agency will reconsider this approach in light of the record in this proceeding before finalizing a rule, but at this point has concluded that it cannot justify proposing a uniform approach to this problem at this time.

MSHA has an obligation under § 101(a)(6)(A) of the Federal Mine Safety and Health Act of 1977 (the ''Mine Act'') which requires the Secretary to set standards which most adequately assure, on the basis of the best available evidence, that no miner will suffer material impairment of health over the miner's working lifetime. The Mine Act makes no distinction between the obligations of operators based on size.

Number and Description of Small Entities Affected. Number and Description of Small Entities Affected

Underground metal and nonmetal mine operators have used diesel-powered equipment for a long time, and they are highly dependent upon such equipment for production. As discussed in detail in part II of the preamble accompanying the proposed rule, a major role of such equipment involves haulage. For example, front-end loaders or load-haul-dump machines remove the metal or mineral deposits from where it was blasted or cut in the mine. However, other types of diesel machinery can also be found in underground metal and nonmetal mines. Examples of some of these other types of diesel powered machines are: roof bolters, jumbo drills, scalers, water trucks, and transport or maintenance vehicles. MSHA's January 1998 count of the number of diesel powered equipment in underground metal and nonmetal mines, shows that of the 261 underground metal and nonmetal mines, there are 203 mines that use diesel powered equipment on a regular basis.

Under MSHA's traditional definition of a small mine (those that employ less than 20), about 40 percent of the 203 underground metal and nonmetal mines that use diesel powered equipment (82 mines) would be considered small underground mines. Approximately 69 percent of these small underground mines (57 mines ÷ mines) are involved in the production of limestone (47 mines) or gold (10 mines). The largest number of small underground mines that are involved in the production of the same commodity are limestone mines. Underground limestone mines account for 57 percent of small mines (47 mines ÷ mines). These 82 small underground mine operators employ approximately 5 percent of all underground metal and nonmetal mine employment, and account for about 15 percent of the diesel powered equipment found in underground metal and nonmetal mines. On average, about 7.5 diesel powered machines are in a small mine, when MSHA's definition of a small mine is used.

Under the SBA definition of a small mine (those that employ 500 or less), about 97 percent of the 203 underground metal and nonmetal mines that use diesel powered equipment (196 mines) would be considered small underground mines. Approximately 68 percent of these small underground mines (134 mines ÷ 196 mines) are involved in the production of: limestone (85 mines), gold (27 mines), Salt (12 mines), and Zinc (10 mines). Again, the largest number of small underground mines that are involved in the production of the same commodity are limestone mines. Underground limestone mines account for 43 percent of small mines (85 mines ÷ 196 mines). These 196 small underground mine operators employ approximately 70 percent of all underground metal and nonmetal mine employment, and account for about 83 percent of the diesel powered equipment found in underground metal and nonmetal mines. On average, about 17 diesel powered machines are in a small mine, when SBA's definition of a small mine is used.

The industry profile in part II of this document provides some further information concerning the characteristics of underground metal and nonmetal mines.

Proposed Rule Requirements. The compliance requirements of the proposed rule for underground metal and nonmetal mine operators are described in detail in the preamble to the rule. The compliance costs to mine operators are described in detail in the PREA. The material following briefly summarizes key elements of the proposed rule.

The proposed rule would require that underground metal and nonmetal mine operators, including small mine operators, observe a set of ''best practices'' underground to reduce engine emissions of diesel particulate matter. (Similar practices are already in effect in underground coal mines as a result of MSHA's diesel equipment rule).

Only low-sulfur diesel fuel and EPA-approved fuel additives would be permitted to be used in diesel-powered equipment in underground areas. Idling of such equipment that is not required for normal mining operations would be prohibited. In addition, diesel engines would have to be maintained in good condition to ensure that deterioration does not lead to emissions increases—approved engines would have to be maintained in approved condition; the emission related components of non-approved engines would have to be maintained in accordance with manufacturer specifications; and any installed emission device would have to be maintained in effective condition. Equipment operators in underground metal and nonmetal mines would be authorized to tag equipment with potential pollution problems, and tagged equipment would have to be ''promptly'' referred for a maintenance check. As an additional safeguard in this regard, maintenance of this equipment would have to be done by persons qualified by virtue of training or experience to perform the maintenance.

The proposed rule would also require 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, 60 days after the date the rule is promulgated, must be an engine approved by MSHA under Part 7 or Part 36. The composition of the existing fleet would not be impacted by this part of the proposed rule.

In addition, the proposed rule would establish a limit on the concentration of diesel particulate matter permitted in areas of an underground metal or nonmetal mine where miners normally work or travel.

All underground metal and nonmetal mine operators would be given a full five years to meet this limit. However, starting eighteen months after the rule is published, underground metal and nonmetal mine operators would have to observe an interim limit. No limit at all on the concentration of diesel particulate matter would be applicable for the first eighteen months following promulgation. Instead, this period would be used to provide compliance assistance to the underground metal and nonmetal mining community to ensure it understands how to measure and control diesel particulate matter concentrations in individual operations.

An underground metal and nonmetal mine operator would have to use engineering or work practice controls to keep diesel particulate matter concentrations below the applicable limit. Administrative controls (e.g., the rotation of miners) and personal protective equipment (e.g., respirators) do not reduce the concentration of diesel particulate, and so are not permitted as a means of permanent compliance with this standard. When a mine operator is granted an extension to come into compliance with the concentration limit under the narrow range of circumstances permitted in the rule, MSHA may require the mine operator to utilize personal protective equipment or administrative controls during the duration of the extension period. An underground operator could 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 would be left to the operator's discretion. MSHA has published a ''toolbox'' of approaches that can be used to reduce diesel particulate matter. MSHA will make available an ''Estimator'' that operators can plug into a standard spreadsheet program to enable them to evaluate the effects of alternative controls in an area of a mine before purchasing and implementation decisions are made.

MSHA has studied a number of metal and nonmetal mines, as described in part V of the preamble accompanying the proposed rule, which the Agency had reason to think might have particular difficulty in controlling diesel particulate matter concentrations. As a result of these studies, the Agency believes that in combination with the required ''best practices,'' engineering and work practice controls are available that can bring diesel particulate matter concentrations in all underground metal and nonmetal mines down to the interim and final concentration limits in a timely manner. Nevertheless, the proposed rule would provide that if an operator of an underground metal or nonmetal mine can demonstrate that there is no combination of controls that can, due to technological constraints, be implemented within that time to reduce the concentration of diesel particulate matter to the limit, MSHA may approve an application for an extension of time to comply with the diesel particulate matter concentration limit. Such a special extension is available only once, and is limited to 2 years.

Sampling to determine compliance with the diesel particulate matter concentration limit would be performed directly by MSHA, rather than relying upon underground metal and nonmetal mine operator samples; however, the proposed rule would also require all underground metal and nonmetal mine operators using diesel-powered equipment to sample as often as necessary to effectively evaluate diesel particulate matter concentrations at the mine.

The proposed rule would require that if an underground metal or nonmetal mine operator is in violation of the applicable limit on the concentration of diesel particulate matter, a diesel particulate matter compliance plan must be established and remain in effect for 3 years. Reflecting practices in this sector, the plan would not have to be preapproved by MSHA, but must be retained at the mine site. The plan would include information about the diesel-powered equipment in the mine and applicable controls. The proposed rule would require operator sampling to verify that the plan is effective in bringing diesel particulate matter levels at or below the applicable limit, with the records kept at the mine site with the plan to facilitate review.

To enhance miner awareness of the hazards involved, underground mine operators using diesel-powered equipment must annually train miners exposed to diesel particulate matter on the hazards associated with that exposure, and in the controls being used by the operator to limit diesel particulate matter concentrations. Underground mine operators may propose to include this training in their existing Part 48 training plans.

Table VI–1 summarizes the compliance costs of the proposed rule, including paperwork costs, to underground metal and nonmetal mine operators. As can be seen in the table, of the approximately $19.2 million per year estimate of total compliance cost for all underground metal and nonmetal mine operators, mines with 19 or fewer miners are estimated to incur approximately $4.6 million per year (an average cost of about $56,100 per year per small mine). When the definition of a small mine operator is 500 or less employees, then nearly all underground metal and nonmetal mine operators would be included (under such a definition, MSHA estimates that approximately $17.2 million of the total $19.2 million would be incurred by small mine entities (an average cost of about $87,800 per year per small mine). A discussion of the benefits of the proposed rule can be found in part I of this preamble (see response to Question 5).

TABLE VI-1
COMPLIANCE COSTS FOR
UNDERGROUND METAL AND NONMETAL MINE OPERATORS
(DOLLARS X 1,000)

	Small Mines With 19 or less miners	All Mines
Detail	Per Year Costs[1]	Per Year Costs[1]
57.5060 (a)	$2,677	$11,046
57.5060 (b)	$1,627	$6,537
57.5060(c)	$2	$12
57.5062	$1	$6
57.5066	$8	$38
57.5067	$121	$852
57.5070	$5	$203
57.5071	$122	$486
57.5075	$1	$4
Total	$4,564	$19,184

1.Per year compliance costs is composed of the addition of annualized and annual compliance costs.

With respect to underground metal and nonmetal mine operators the paperwork requirements include paperwork associated with training for persons maintaining diesel powered equipment, annual training for those miners affected by the hazards of diesel particulate matter, sampling for diesel particulate matter, observation of sampling, and tagging equipment with pollution problems. In addition, there are paperwork requirements for a small portion of underground metal and nonmetal mines that pertain to writing applications to extend the period to comply with the proposed concentration limits, and for writing a diesel particulate control plan.

With a few exceptions, MSHA estimates that all recordkeeping and recording related compliance costs, and all of the other requirements of the standard, will require no special professional background beyond that currently found in the managers of the underground mines in this sector. Based on a small mine definition of less than 20 employees, all small underground metal and nonmetal mine operators, as well as half of the large mines, are assumed to have sampling performed by an independent contractor, because this would be cheaper than setting up their own sampling program and purchasing the required sampling equipment. Also, regardless of what definition is used to define small mines, all underground metal and nonmetal mine operators would have the sample analysis performed by an independent contractor, since the underground mines do not have the expertises or equipment to analyze for diesel particulate matter. Again, no matter what definition is used to define small mines, underground metal and nonmetal mine operators would need to go outside of the mine expertise to receive a portion of their maintenance training.

Based on a small mine definition of less than 20 miners, the total number of annual burden hours to the 82 small underground metal and nonmetal mine operators would be 436. When the definition of a small mine is 500 or less employees, the total number of annual burden hours to 196 small underground metal and nonmetal mine operators would be 3,472.

Impact of Other Federal Rules. There are no other Federal (or for that matter State) rules of which MSHA is aware that would duplicate, overlap or conflict with the proposed rule for underground metal and nonmetal mines.

Significant Alternatives Considered. The Agency considered, and adopted as part of the proposed rule, features designed to minimize the impacts on small entities, and the smallest metal and nonmetal mines in particular, consistent with the stated objectives of the Mine Act. It is important to note in this regard that in implementing the Mine Act's requirement that the Secretary attain the highest degree of safety and health protection, consistent with feasibility, the Agency based its decisions on the technological and economic feasibility of the proposed rule on detailed information about the impacts on mines with 500 or fewer employees and, separately, that segment of these mines with less than 20 employees. Part V of the preamble accompanying the proposed rule reviews the decisions made by the Agency with respect to this statutory obligation.

Under the proposed rule no limit on diesel particulate concentration would be in effect for 18 months, during which time the Agency would provide extensive compliance assistance to the mining community. During this time, MSHA would be working with small underground metal and nonmetal mine operators to provide help concerning the measuring of diesel particulate concentrations. In addition, MSHA would use this time to provide technical assistance about control methods to small mine operators.

In fact, this individualized compliance assistance would supplement general guidance the Agency has already started to provide to the mining industry, and to small mines in particular. In 1995, the Agency held three workshops in various areas of the country to enable the mining community to share ideas on practical ways to control diesel emissions, and made transcripts of these workshops widely available. Subsequently, the Agency published a ''toolbox'' to disseminate this information in a format designed to facilitate use by small mines in particular (appended to the end of this document is a copy of an MSHA publication, ''Practical Ways to Reduce Exposure to Diesel Exhaust in Mining—A Toolbox). Moreover, before the rule goes into effect, the Agency will also develop and distribute a compliance guide, as required by SBREFA, and will provide information to small mines through such other formats as may be suggested by the mining community. For example, MSHA is also considering creating a one page fact sheet or card that can be used by the mining industry to complement training requirements concerning notification of affected miners of the hazards associated with diesel particulate. This can be of particular help to small mine operators who have training resources that may not be as extensive as those found in large mining operations. MSHA will also mail a copy of the proposed rule to every underground mine operator which primarily benefits small operators.

Beyond the initial 18 months the proposed rule would provide for compliance assistance. Also, the proposed rule reflects a preliminary decision by the agency to delay for a full 5 years after promulgation of a final rule the effective date of the requirement which will have the most significant impact on small underground metal and nonmetal mines—the concentration limit for diesel particulate. An interim concentration limit would apply until that date—a limit that should not be at all difficult for small mines to reach, particularly after all of the compliance assistance that precedes it. This extended time for full implementation of the proposed rule ensures that technological issues can be timely resolved prior to the final rule's effective date. It also recognizes that this rule is a significant one for the underground metal and nonmetal sector, that almost all mines in this sector are considered small entities under SBA's definition, and that having adequate time to come into full compliance is of particular importance to the smallest mines in this sector.

Finally, MSHA is including a one-time two-year extension for mines that require additional time to adopt to the final concentration limits.

Other features of the proposed rule also reflect MSHA's recognition of the size distribution of the entities which have to implement any requirements. Special attention was paid to making the rule's requirements comprehensible to the mining community, including the provision of a chart summarizing recordkeeping requirements, and comments in that regard are being solicited. Training and operator sampling requirements were specifically designed to be performance oriented to minimize costs, while at the same time ensure that the important protections that flow from such approaches are included in every mine operator's approach to this health problem.

MSHA did consider a regulatory approach that would have focused on limiting worker exposure rather than limiting particulate concentration. Under such an approach, operators would have been able to use administrative controls (e.g., rotation of personnel) and respiratory protection equipment to reduce diesel particulate exposure. It is generally accepted industrial hygiene practice, however, to eliminate or minimize hazards before resorting to personal protective equipment. Moreover, while rotation of workers may be a perfectly acceptable practice for a hazard like noise (where reducing exposure can allow the ear to recover, thus avoiding any harm), such a practice is generally not considered acceptable in the case of carcinogens since it merely places more workers at risk. Also, allowing use of these practices would not necessarily help the smallest mines, not all small mines can efficiently rotate workers. Accordingly, the agency declined to propose such an approach for this serious health hazard, although it welcomes comments in this regard.

MSHA is proposing dpm concentration limits as the core of the rule. Although the Agency has developed costs in terms of assumptions about the numbers of engineering controls that will be required to meet the standard, design standards are not the point of the regulation. Rather, the Agency has suggested as broad a menu of compliance techniques as is practicable, so that individual mines can select specific techniques that best fit their circumstances.

The Agency has also declined to propose alternatives involving design standards or specific frequency requirements, which it believes would have had a more significant impact on small entities in the underground metal and nonmetal mining sector—although it will certainly take another look at these if the rulemaking record so warrants. Section 101(a)(6)(A) of the Mine Act requires the Secretary when promulgating standards dealing with toxic substances or harmful physical agents to base such mandatory standards on the best available evidence, to most adequately assure that no miner will suffer material impairment of health over his working lifetime. The Act also requires that when promulgating such standards, other factors such as the latest scientific data in the field, the feasibility of the standard and experience gained under the Act and other health and safety laws be considered. Thus, the Mine Act requires that the Secretary, in promulgating a standard, attain the highest degree of health and safety protection for the miner, based on the ''best available evidence'', with feasibility as a consideration.

As a result of this requirement, MSHA seriously considered alternatives that would have significantly increased costs for both large and small mine operators. For example, in light of the health risks involved, and the existing environmental restrictions on particulate matter, the Agency considered proposing for underground metal and nonmetal mine operators a lower limit on the concentration of diesel particulate, and shortening the time frame to get to a final limit. The Agency has tentatively concluded, however, that such approaches would not be feasible for this sector as a whole. The Agency also considered requiring more stringent work practice and engine controls in this sector than those ultimately proposed—i.e., practices exactly like those applicable in the underground coal sector. Such an alternative would have required: (a) weekly emissions tests of diesel powered equipment in underground metal and nonmetal mines instead of just tagging suspect equipment for prompt inspection; (b) requiring these mines to establish training programs for maintenance personnel; and (c) requiring the metal and nonmetal diesel powered fleet to be turned over completely within a few years so as to have only approved engines. The Agency concluded, however, that the concerns which warranted such an approach in underground coal mines had not been established in underground metal and nonmetal mines; and that with respect to the risks created by diesel particulate matter, the approach taken in the proposed rule could provide adequate protection in a cost effective manner.

MSHA also considered other rigorous requirements such as: requiring the installation of a particulate filter on every new piece of diesel powered equipment added to the underground metal and nonmetal diesel powered fleet regardless of the diesel particulate matter concentration level as an added layer of miner protection, establishing a fixed schedule for operator monitoring of the concentration of diesel particulate emissions, and requiring that diesel particulate control plans be preapproved by MSHA before implementation to ensure that their effectiveness had been verified. These approaches were not included in the proposed rule because MSHA concluded that less stringent alternatives could achieve the same level of protection with less adverse impact on underground mining operations, especially small underground mining operations.

MSHA welcomes comments on whether there are significant alternatives it should consider that would accomplish the previously stated purpose and objectives of this rulemaking while reducing the impact on small entities. In this regard, the Agency would also welcome suggestions for alternatives that focus on addressing special concerns on the very smallest mines in this sector—those with less than 20 miners. It is important to remember, however, that under the Mine Act, smaller mines must provide the same level of protection to their workers as larger mines.

As required under the law, MSHA will be consulting with the Chief Counsel for Advocacy on the initial regulatory flexibility analysis for the underground metal and nonmetal mining sector. Consistent with agency practice, notes of any meetings with the Chief Counsel's office on this rule, or any written communications, will be placed in the rulemaking record. The Agency will continue to consult with the Chief Counsel's office as the rulemaking process proceeds.

(C) Unfunded Mandates Reform Act of 1995

MSHA has determined that, for purposes of § 202 of the Unfunded Mandates Reform Act of 1995, this proposed rule does not include any Federal mandate that may result in increased expenditures by State, local, or tribal governments in the aggregate of more than $100 million, or increased expenditures by the private sector of more than $100 million. Moreover, the Agency has determined that for purposes of § 203 of that Act, this proposed rule does not significantly or uniquely affect small governments.

The Unfunded Mandates Reform Act was enacted in 1995. While much of the Act is designed to assist the Congress in determining whether its actions will impose costly new mandates on State, local, and tribal governments, the Act also includes requirements to assist Federal agencies to make this same determination with respect to regulatory actions.

Based on the analysis in the Agency's preliminary Regulatory Economic Statement, the compliance costs of this proposed rule for the underground metal and nonmetal mining industry are about $19.2 million per year. Accordingly, there is no need for further analysis under § 202 of the Unfunded Mandates Reform Act.

MSHA has concluded that small governmental entities are not significantly or uniquely impacted by the proposed regulation. The proposed rule affects only underground metal and nonmetal mines, and MSHA is not aware of any state, local or tribal government ownership interest in underground mines. MSHA seeks comments of any state, local, and tribal government which believes that they may be affected by this rulemaking.

(D) Paperwork Reduction Act of 1995 (PRA)

This proposed rule contains information collections which are subject to review by the Office of Management and Budget (OMB) under the Paperwork Reduction Act of 1995 (PRA95). Tables VI–2 and VI–3 show the estimated annual reporting burden hours associated with each proposed information collection requirement. These burden hour estimates are an approximation of the average time expected to be necessary for a collection of information, and are based on the information currently available to MSHA. Included in these estimates are the time for reviewing instructions, gathering and maintaining the data needed, and completing and reviewing the collection of information.

MSHA invites comments on: (1) Whether any proposed collection of information presented here (and further detailed in the Agency's PREA) is necessary for proper performance of MSHA's functions, including whether the information will have practical utility; (2) the accuracy of MSHA's estimate of the burden of the proposed collection of information, including the validity of the methodology and assumptions used; (3) ways to enhance the quality, utility, and clarity of information to be collected; and (4) ways to minimize the burden of the collection of information on respondents, including through the use of automated collection techniques, when appropriate, and other forms of information technology.

Submission. The Agency has submitted a copy of this proposed rule to OMB for its review and approval of these information collections. Interested persons are requested to send comments regarding this information collection, including suggestions for reducing this burden, to the Office of Information and Regulatory Affairs, OMB New Executive Office Bldg., 725 17th St. NW., Rm. 10235, Washington, DC 20503, Attn: Desk Officer for MSHA. Submit written comments on the information collection not later than December 28, 1998.

The Agency's complete paperwork submission is contained in the PREA/IRFA, and includes the estimated costs and assumptions for each proposed paperwork requirement (these costs are also included in the Agency's cost and benefit analyses for the proposed rule). A copy of the PREA/IRFA is available from the Agency. These paperwork requirements have been submitted to the Office of Management and Budget for review under section 3504(h) of the Paperwork Reduction Act of 1995.

Respondents are not required to respond to any collection of information unless it displays a current valid OMB control number.

Description of Respondents. Those required to provide the information are underground metal and nonmetal mine operators and diesel engine manufacturers.

Description. The proposed rule contains information collection requirements for: underground metal and nonmetal mine operators in §§ 57.5060, 57.5062, 57.5066, 57.5070, 57.5071 and 57.5075; and for diesel engine manufacturers in Part 7, subpart E. Annual burden hours are 3,865 for underground metal and nonmetal mines. There are 36 burden hours related to manufacturers of diesel powered engines which would recur annually.

Tables VI–2 and VI–3 summarize the burden hours for mine operators and manufacturers by section.

TABLE VI–2.—UNDERGROUND METAL AND NONMETAL MINES BURDEN HOURS

Detail	Large	Small	Total
57.5060	306	123	429
57.5062	49	11	60
57.5066	207	76	283
57.5070	136	6	142
57.5071	2,600	213	2,813
57.5075	131	7	138
Total	3,429	436	3,865

TABLE VI–3.—DIESEL ENGINE MANUFACTURERS BURDEN HOURS

Detail	Total
Part 7, Subpart E	36
Total	36

(E) National Environmental Protection Act

The National Environmental Policy Act (NEPA) of 1969 requires each Federal agency to consider the environmental effects of proposed actions and to prepare an Environmental Impact Statement on major actions significantly affecting the quality of the human environment. MSHA has reviewed the proposed standard in accordance with the requirements of the NEPA (42 U.S.C. 4321 et seq.), the regulation of the Council on Environmental Quality (40 CFR Part 1500), and the Department of Labor's NEPA procedures (29 CFR Part 11). As a result of this review, MSHA has preliminarily determined that this proposed standard will have no significant environmental impact.

Commenters are encouraged to submit their comments on this determination.

(F) Executive Order 13045

In accordance with Executive Order 13045, protection of children from environmental health risks and safety risks, MSHA has evaluated the environmental health or safety effects of the proposed rule on children. The Agency has determined that this proposal would not have an adverse impact on children.

Part VII. References

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Supplementary References:

Below is a list of supplemental references that MSHA reviewed and considered in the development of the proposed rule. These documents are not specifically cited in the preamble discussion, but are applicable to MSHA's findings:

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List of Subjects in 30 CFR Part 57

Diesel particulate matter, Metal and nonmetal, Mine safety and health, Underground mines.

Dated: October 16, 1998.

J. Davitt McAteer,

Assistant Secretary for Mine Safety and Health.

It is proposed to amend Chapter I of Title 30 of the Code of Federal Regulations as follows:

PART 57—[AMENDED]

1. The authority citation for Part 57 continues to read as follows:

Authority: 30 U.S.C. 811, 957, 961.

2. The heading of Subpart D of Part 57 is revised to read as follows: ''Subpart D—Air Quality, Radiation, Physical Agents, and Diesel Particulate Matter''

3. Sections 57.5060 through 57.5075, and in undersigned center heading, are added to Subpart D to read as follows:

Subpart D—Air Quality, Radiation, Physical Agents and Diesel Particulate Matter

Diesel Particulate Matter—Underground Only

§ 57.5060 Limit on concentration of diesel particulate matter.

(a) After [the date 18 months after the date of publication of the final rule] and until [the date 5 years after the date of publication of the final rule], any mine operator covered by this part shall limit the concentration of diesel particulate matter to which miners are exposed by restricting the average eight-hour equivalent full shift airborne concentration of total carbon, where miners normally work or travel, to 400 micrograms per cubic meter of air (400_{TC} μg/m^3).

(b) After [the date 5 years after the date of publication of the final rule], 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).

(c)(1) If, as a result of technological constraints, a mine requires additional time to come into compliance with the limit specified in paragraph (b) of this section, the operator of the mine may file an application with the Secretary for a special extension.

(2) No mine may be granted more than one special extension, nor may the time otherwise available under this section to a mine to comply with the limit specified in paragraph (b) of this section be extended by more than two years.

(3) The application for a special extension may be approved, and the additional time authorized, only if the application includes information adequate for the Secretary to ascertain:

(i) That diesel-powered equipment was used in the mine prior to October 29, 1998;

(ii) That there is no combination of controls that can, due to technological constraints, bring the mine into full compliance with the limit specified in paragraph (b) of this section within the time otherwise specified in this section;

(iii) The lowest achievable concentration of diesel particulate, as demonstrated by data collected under conditions that are representative of mine conditions using the method specified in § 57.5061(b); and

(iv) The actions the operator will take during the duration of the extension to:

(A) Maintain the lowest concentration of diesel particulate; and

(B) Minimize the exposure of miners to diesel particulate.

(4) An application for a special extension may be approved only if:

(i) The application is filed at least 180 days prior to the date the mine is required by this section to be in full compliance with the limit established by paragraph (b) of this section; and

(ii) The application certifies that one copy of the application has been posted at the mine site for 30 days prior to the date of application, and another copy has been provided to the authorized representative of miners.

(5) A mine operator shall comply with the terms of any approved application for a special extension. A copy of an approved application for a special extension shall be posted at the mine site for the duration of the special extension period.

(d) An operator shall not utilize personal protective equipment, nor shall an operator utilize administrative controls, to comply with the requirements of either paragraph (a) or paragraph (b) of this 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.

§ 57.5062 Diesel particulate matter control plan.

(a) In the event of a violation by the operator of an underground metal or nonmetal mine of the applicable concentration limit established by § 57.5060, the operator, in accordance with the requirements of this section, must—

(1) Establish a diesel particulate matter control plan for the mine if one is not already in effect, or modify the existing diesel particulate matter control plan, and

(2) Demonstrate that the new or modified diesel particulate matter

control plan is effective for controlling the concentration of diesel particulate matter to the applicable concentration limit specified in § 57.5060.

(b) A diesel particulate control plan shall describe the controls the operator will utilize to maintain the concentration of diesel particulate matter to the applicable limit specified by § 57.5060. The plan shall also include a list of diesel-powered units maintained by the mine operator, together with information about any unit's emission control device and the parameters of any other methods used to control the concentration of diesel particulate matter. The plan may be consolidated with the ventilation plan required by § 57.8520. A copy of the current diesel particulate matter control plan shall be retained at the mine site during its duration and for one year thereafter.

(c) An operator shall demonstrate plan effectiveness by monitoring, using the measurement method specified by § 57.5061(b), sufficient to verify that the plan will control the concentration of diesel particulate matter to the applicable limit under conditions that can be reasonably anticipated in the mine. A copy of each verification sample result shall be retained at the mine site for five years. Such operator monitoring shall be in addition to, and not in lieu of, any sampling by the Secretary pursuant to § 57.5061.

(d) The records required by paragraphs (b) and (c) of this section shall be available for review upon request by the authorized representative of the Secretary, the authorized representative of the Secretary of Health and Human Services, or the authorized representative of miners. In addition, upon request by the District Manager or the authorized representative of miners for a copy of any records required to be maintained pursuant to paragraph (b) or (c) of this section, the operator shall provide such copy.

(e)(1) A control plan established as a result of this section shall remain in effect for 3 years from the date of the violation which caused it to be established, except as provided in paragraph (e)(3) of this section.

(2) A control plan modified as a result of this section shall remain in effect, as so modified, for 3 years from the date of the violation which caused the plan to be modified, except as provided in paragraph (e)(3) of this section.

(3) An operator shall modify a diesel particulate matter control plan during its duration as required to reflect changes in mining equipment or circumstances, and shall, upon request from the Secretary, demonstrate the effectiveness of the modified plan by monitoring, using the measurement method specified by § 57.5061(b), sufficient to verify that the plan will control the concentration of diesel particulate matter to the applicable limit under conditions that can be reasonably anticipated in the mine.

(f) Failure of an operator to comply with the provisions of the diesel particulate matter control plan in effect at a mine or to conduct required verification sampling shall be a violation of this part without regard for the concentration of diesel particulate matter that may be present at any time.

§ 57.5065 Fueling and idling practices.

(a) Diesel fuel used to power equipment in underground areas shall not have a sulfur content greater than 0.05 percent. The operator shall retain purchase records evidencing compliance with this requirement for one year after the date of purchase.

(b) Only fuel additives registered by the U.S. Environmental Protection Agency shall be used in diesel powered equipment operated in underground areas.

(c) Idling of mobile diesel-powered equipment in underground areas is prohibited except as required for normal mining operations.

§ 57.5066 Maintenance standards.

(a) Any diesel powered equipment operated at any time in underground areas shall meet the following maintenance standards:

(1) Any approved engine shall be maintained in approved condition;

(2) The emission related components of any non-approved engine shall be maintained to manufacturer specifications; and

(3) Any emission or particulate control device installed on the equipment shall be maintained in effective operating condition.

(b)(1) A mine operator shall authorize and require each miner operating diesel powered equipment covered by paragraph (a) of this section to affix a visible and dated tag to such equipment at any time the miner notes any evidence that the equipment may require maintenance in order to comply with the maintenance standards of paragraph (a) of this section.

(2) A mine operator shall ensure that any equipment tagged pursuant to this section is promptly examined by a person authorized by the mine operator to maintain diesel equipment, and the affixed tag shall not be removed until such examination has been completed.

(3) A mine operator shall retain a log of any equipment tagged pursuant to this section. The log shall include the date the equipment is tagged, the date an examination was made of such equipment, the name of the person making such examination, and any action taken as a result of such examination. The information in the log with respect to any piece of equipment examined as a result of this section shall be retained for one year after the date of examination.

(c) Persons authorized by a mine operator to maintain diesel equipment covered by paragraph (a) of this section must be qualified, by virtue of training or experience, to ensure that the maintenance standards of paragraph (a) of this section are observed. An operator shall retain appropriate evidence of the competence of any person to perform specific maintenance tasks in compliance with those standards for one year after the date of any maintenance, and shall upon request provide such documentation to the authorized representative of the Secretary.

§ 57.5067 Engines.

Any diesel engine introduced into an underground area of a mine covered by this part after [date 60 days after date publication of the final rule], other than an engine in an ambulance or fire fighting equipment which is utilized in accordance with mine fire fighting and evacuation plans, must have affixed a plate evidencing approval of the engine pursuant to subpart E of Part 7 of this title or pursuant to Part 36 of this title.

§ 57.5070 Miner training.

(a) All miners at a mine covered by this part who can reasonably be expected to be exposed to diesel emissions on that property shall be trained annually in—

(1) The health risks associated with exposure to diesel particulate matter;

(2) The methods used in the mine to control diesel particulate matter concentrations;

(3) Identification of the personnel responsible for maintaining those controls; and

(4) Actions miners must take to ensure the controls operate as intended.

(b) An operator shall retain at the mine site a record that the training required by this section has been provided for one year after completion of the training.

§ 57.5071 Environmental monitoring.

(a) Mine operators shall monitor as often as necessary to effectively evaluate, under conditions that can be reasonably anticipated in the mine—

(1) Whether the concentration of diesel particulate matter in any area of

the mine where miners normally work or travel exceeds the applicable limit specified in § 57.5060; and

(2) The average full shift airborne concentration of diesel particulate matter at any position or on any person designated by the Secretary.

(b) The mine operator shall provide affected miners and their representatives with an opportunity to observe exposure monitoring required by this section. Mine operators must give prior notice to affected miners and their representatives of the date and time of intended monitoring.

(c) If any monitoring performed under this section indicates that the applicable concentration limit established by § 57.5060 has been exceeded, an operator shall promptly post notice of the corrective action being taken, initiate corrective action by the next work shift, and promptly complete such corrective action.

(d)(1) The results of monitoring for diesel particulate matter, including any results received by a mine operator from sampling performed by the Secretary, shall be posted on the mine bulletin board within 15 days of receipt and shall remain posted for 30 days, and a copy shall be provided to the authorized representative of miners.

(2) The results of any samples collected by a mine operator as a result of monitoring under this section, and information about the sampling method used for obtaining such samples, shall be retained for five years from the date of the sample.

§ 57.5075 Diesel particulate records.

(a) The table entitled ''Diesel Particulate Recordkeeping Requirements'' lists the records which must be retained by operators pursuant to §§ 57.5060 through 57.5071, and the duration for which particular records need to be retained.

DIESEL PARTICULATE RECORDKEEPING REQUIREMENTS

Record	Section reference	Retention time
Approved application for extension of time to comply with final concentration limit	§ 57.5060(c)	1 year beyond duration of extension.
Control plan	§ 57.5062(b)	1 year beyond duration of plan.
Compliance plan verification sample results	§ 57.5062(c)	5 years from sample date.
Purchase records noting sulfur content of diesel fuel	§ 57.5065(a)	1 year beyond date of purchase.
Maintenance log	§ 57.5066(b)	1 year after date any equipment is tagged.
Evidence of competence to perform maintenance	§ 57.5066(c)	1 year after date maintenance performed.
Annual training provided to potentially exposed miners	§ 57.5070(b)	1 year beyond date training completed.
Sampling method used to effectively evaluate mine particulate concentration, and sample results	§ 57.5071	5 years from sample date.

(b)(1) Any record listed in this section which is required to be retained at the mine site may, notwithstanding such requirement, be retained 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 shall promptly provide access to any record listed in the table in this section.

(3) A miner, former miner, or, with the miner's or former miner's written consent, a personal representative of a miner, shall have access to any record required to be maintained pursuant to § 57.5071 to the extent the information pertains to the miner or former miner. Upon request by such person, the operator shall provide the first copy of such record requested by a person at no cost to that person, and any additional copies requested by that person at reasonable cost.

(c) Whenever an operator ceases to do business, that operator shall transfer all records required to be maintained by this part, or a copy thereof, to any successor operator who shall receive these records and maintain them for the required period.

BILLING CODE 4510–43–P

Appendix to Preamble—Background Discussion—MSHA's Toolbox

Note: This Appendix will not appear in the Code of Federal Regulations. It is provided here as a guide.

PRACTICAL WAYS TO REDUCE EXPOSURE TO DIESEL EXHAUST IN MINING - - A TOOLBOX

U.S. Department of Labor
Alexis M. Herman, Secretary

Mine Safety and Health Administration
J. Davitt McAteer, Assistant Secretary

Andrea M. Hricko, Deputy Assistant Secretary

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ACKNOWLEDGEMENTS

The Mine Safety and Health Administration (MSHA) held a series of workshops in the fall of 1995 to obtain input from the mining community on ways of reducing miners' exposure to diesel particulate matter from the exhaust of diesel engines.

MSHA thanks those who attended the workshops and willingly shared their ideas on practical ways to reduce exposure to diesel emissions in mining. These practical ideas have been utilized in producing this "Toolbox." A key objective of the toolbox is to facilitate the exchange of practical information on ways to reduce miner exposure to diesel exhaust emissions.

Thanks are also extended to former U.S. Bureau of Mines scientists, from whose diesel-related publications the text of this handbook draws, and to Robert Waytulonis, Associate Director of the University of Minnesota's Center for Diesel Research.

Credit is given to the following MSHA staff for their efforts in organizing the Diesel Exhaust Workshops, their role in selecting pertinent quotations from the workshop transcripts, and in contributing to or reviewing this manual: Kathy Alejandro, Janet Bertinuson, Teresa Carruthers, Jerry Collier, James Custer, George Dvorznak, Guy Fain, Ron Ford, Don Gibson, Hal Glassman, Jerry Lemon, Pamela King, James Kirk, Jon Kogut, Cheryl McGill, William McKinney, Ed Miller, Charlotte Richardson, Bryan Sargeant, Erik Sherer, Pete Turcic, and Sandra Wesdock. Thanks also to Liz Fitch and Mike Doyle for their help in reviewing early drafts, to Todd Taubert for help with the section on lugging, to Reggie McBee and Bria Culp for editorial support, to Anne Masters for graphic design support, and to Bill West for internet conversions.
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In addition, MSHA thanks other segments of the mining industry that provided comments for consideration in the Toolbox.

Andrea Hricko, Deputy Assistant Secretary of MSHA, provided guidance in organizing the Diesel Workshops and worked closely with Winthrop Watts of the University of Minnesota, and Thomas Tomb, Chief of MSHA's Dust Division, as well as with Robert Haney and George Saseen of MSHA's Office of Technical Support, in creating this "Toolbox." Thanks to Peter Galvin for consolidating the final draft while on detail to MSHA from the Office of the Solicitor and to Keith Gaskill for shepherding the "Toolbox" through to publication.

Special thanks to Winthrop F. Watts, Jr., Ph.D., of the University of Minnesota, Center for Diesel Research, for conceptualizing the "Toolbox" and for writing the first drafts of this manual under contract to the Mine Safety and Health Administration.

HOW TO USE THIS PUBLICATION

Who should use this publication?

If your mine uses diesel-powered equipment, or is contemplating its use, you will find this Toolbox to be a useful guide. So too will those who help mine operators select or maintain mining equipment. The Toolbox can be read cover-to-cover as a basic reference, or used as a troubleshooting guide by diesel equipment operators and mechanics. Some knowledge of engines is assumed, although a glossary is provided.

Is this only of interest to underground mines?

No. While some sections are of special interest only to underground mines (e.g., ventilation), most of this publication is of value to surface mines as well.

Is the Toolbox useful in any type of mining?

Yes. The ideas and concepts are just as relevant in metal and nonmetal mines as they are in coal mines, and many of the controls described are available to operators in both sectors.

How can I find what I need quickly?

The Table of Contents on the first page of this handbook can be used to quickly locate a topic of interest. Technical terms or materials are discussed or referenced in appendices.

If I follow the recommendations in the Toolbox, will I be in compliance with MSHA requirements?

This publication is NOT a guide to applicable Federal or State regulations on the use of diesel engines, or the measurement or control of their emissions on mining property. Selection of an approach from the toolbox must be made in light of the need to comply with such requirements. Appendix D references some of the requirements which should be consulted. Please contact your local MSHA office if you have any questions about applicable requirements.

As of the date of this Toolbox printing, MSHA is making final decisions on proposing some additional regulations about diesel emissions. These proposed new rules would help the mining community address the risks created by miner exposure to diesel particulate matter—the very small particles that are part of the diesel exhaust. The Agency expects to publish these proposed rules for comment early in 1998. While the 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.

Does MSHA want my input on this subject?

MSHA welcomes your suggestions on how to improve future editions of this Toolbox, and information on your experiences in reducing exposure to diesel emissions. Please direct any comments to: Chief, Pittsburgh Safety and Health Technology Center, Cochrans Mill Road, P.O. Box 18233, Pittsburgh, Pa. 15236. You may also fax them to 412-892-6928, or e-mail them to chiefpshtc @msha.gov.

Special Note on Regulations Involving the Use of Diesel-powered Equipment in Underground Coal Mines

On April 25, 1997, certain key provisions of MSHA's final rule on the use of diesel-powered equipment in underground coal mines went into effect. Other provisions of that rule will go into effect over the next three years. Some of these regulations require the implementation of particular strategies recommended in this Toolbox.

Since the mining community is still becoming familiar with these requirements, some of them are noted in the text at appropriate places, using italics. MSHA hopes this will serve as a useful reminder for underground coal mine operators, without being distracting to the remainder of the mining community.

A compliance guide for the new underground coal mine diesel regulations, in the form of Questions and Answers, has been prepared by MSHA, and is being widely circulated. While this Toolbox is not a substitute for the compliance guide or a copy of the regulations, neither are the compliance guide or the regulations a substitute for this Toolbox—all three documents will be useful for underground coal mine operators and miners.

INTRODUCTION

The Problem

Diesel engines are widely used in mining operations because of their high power output and mobility. Many mine operators prefer diesel-powered machines because they are more powerful than most battery-powered equipment and can be used without electrical trailing cables which can restrict equipment mobility. Underground coal and metal and nonmetal mines currently use approximately 10,000 diesel machines and about 35 percent of these are used for heavy-duty mining production applications. The use of diesel equipment in mining is on the rise, as described by speakers at a series of Workshops on Controlling Diesel Emissions sponsored by MSHA in the fall of 1995:

"In 1985, we had a total mine horsepower of 6,851 horsepower. Today, in 1995, our horsepower has risen to 14,885 horsepower in the mine."

—David Music,
Akzo Nobel Salt's Cleveland Mine

"...Today we have over a hundred pieces of diesel equipment, large and small, anywhere from a Bobcat to large section scoops, generators, welders, compressors, trucks that are used on open highways, and diesel trucks."

—Forrest Addison,
UTAH Coal Miner (UMWA)

The estimated distribution of diesel equip-ment in mining is shown in Table 1. An estimated 30,000 miners work at underground mines using such equipment and approximately 200,000 miners work at surface operations using such equipment.

Table 1. Estimated Distribution of Diesel Equipment

Mines Using Diesel Engines				
	Underground		Surface	
Type	#Mines	#Engines	#Mines	#Engines
Coal	180	2,950	1,700	22,00
Metal and Nonmetal	250	7,800	10,500	97,000
Totals	430	10,750	12,000	119,000

There is a downside, however, to the use of diesel equipment, especially in the underground mining environment. The problem is the potential acute and long-term health effects of exposure to various constituents of diesel exhaust, which consists of noxious gases and very small particles.

The gases in diesel emissions include carbon monoxide, carbon dioxide, oxides of nitrogen, sulfur dioxide, aromatic hydrocarbons, aldehydes and others. MSHA sets limits on miner exposure to a number of these gases. These limits are specified in Title 30 CFR § 75.322 and § 71.700 for underground and surface coal mines and § 57.5001 and § 56.5001 for underground and surface metal and nonmetal mines.

The particles in diesel emissions are known as "diesel particulate" (DP), or "diesel particulate matter" (DPM). Diesel particulate matter is small enough to be inhaled and retained in the lungs. The particles have hundreds of chemicals from the exhaust adsorbed (attached) onto their surfaces.

The mining community is very familiar with the specific hazards long associated with other particulates of respirable dimensions–like coal mine dust and dust that contains silica. A recent body of evidence, based on studies of air pollution, suggests that exposure to smaller particles (including those present in diesel exhaust) is likewise associated with increased rates of death and disease. Specific evidence has also been accumulating that exposure to high levels of DPM can increase the risk of cancer. In 1988, the National Institute for Occupational Safety and Health recommended that whole diesel exhaust be regarded as a "potential occupational carcinogen," and that reductions in workplace exposure be implemented to reduce cancer risks. In 1989, the International Agency for Research on Cancer declared that "diesel engine exhaust is probably carcinogenic to humans." In 1995, the American Conference of Governmental Industrial Hygienists (ACGIH) added DPM to its "Notice of Intended Changes" for 1995-96, recommending a threshold limit value (TLV®) for a conventional 8-hour work day of 150 micrograms per cubic meter (150 $\mu g/m^3$).

Note on Diesel Particulate Matter Measurements: Microgram v. Milligram

In this Toolbox, measurements of DPM are expressed in micrograms (μg) per cubic meter of air. A microgram is one millionth of a gram. However, in many references, you may see the DPM measurements expressed as milligrams (mg) per cubic meter of air. A milligram is one thousandth of a gram.

1 $\mu g/m^3$=1 milligram per cubic meter of air
1 $\mu g/m^3$=1 microgram per cubic meter of air

1 milligram=1,000 micrograms. So if you want to convert from milligrams to micrograms, multiply by 1000–or move the decimal point three places to the right.

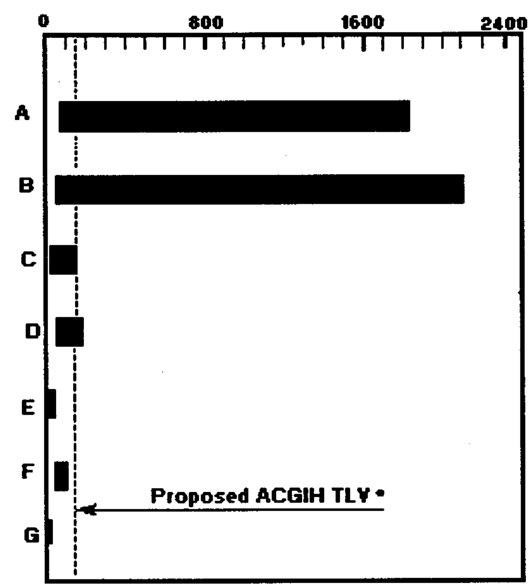
For example, 0.15 mg/m^3=150 $\mu g/m^3$.

Many non-mining workplaces where diesel equipment is used have levels of DPM well below the recommended ACGIH TLV®.In contrast, studies conducted by various scientific researchers demonstrate that exposures to DPM in mining environments can be significantly higher than exposures in the ambient air or in other workplaces.

Figure 1 provides a rough visual picture of the range of DPM exposures of miners, as compared with the range of exposures of other groups of workers who routinely work with diesel-powered equipment. As can be readily seen, the range of exposures in mining environments are significantly higher than in other environments.

Figure 1. Diesel Particulate Exposures in Several Industry Segments

Range of Average DPM Exposures, µg/m³.



A=Underground Metal and Nonmetal Mine
B=Underground Coal Miners
C=Surface Miners
D=Railroad Workers
E=Truck Drivers
F=Dock Workers
G=Ambient Air (Urban)

Table 2 provides additional detail about the levels of exposure in U.S. mines. The higher concentrations in underground mines are typically found in the haulageways and face areas where numerous pieces of diesel equipment are operating, or where insufficient air is available to ventilate the operation. In surface mines, the higher concentrations are typically associated with truck drivers and front-end loader operators.

Table 2. Measured Full-Shift Diesel Particulate Matter Exposure in U.S. Mines

Type	Range of exposure, mg/m^3	Mean exposure, mg/m^3
Surface	9-380	88
Underground Coal	0-3,650	644
Underground Metal and Nonmetal	10-5,570	830

In 1988, MSHA's Advisory Committee on Diesel-Powered Equipment in Underground Coal Mines recognized a number of risks related to the use of diesel-powered equipment in such mines, including the potential risks of exposing miners to diesel emissions. The Committee made recommendations to address its concerns.

Since that time, MSHA has taken several actions relative to diesel exhaust. In 1989, MSHA proposed "air quality" regulations which would, among other things, set stricter limits on some diesel exhaust gases. These regulations remain under review. In 1996, after notice and comment, MSHA issued final regulations for the use of diesel-powered equipment in underground coal mines. These rules will go into effect over a 3-year period. And in response to a specific recommendation of the Advisory Committee that, "The Secretary (of Labor) should set in motion a mechanism whereby a diesel particulate standard can be set…", MSHA is developing a proposed rule toward that end.

There are some cases where alternative power sources (e.g., electricity or batteries) may be the solution. But when diesel engines are used, the mining community needs to understand the potential health risks they present and take steps to reduce the hazards.

"...We're very dependent on diesel engines. At the same time, air quality in the mine is very important to IMC. We realized a long time ago that it affects both miner health and morale, and for us morale and productivity go hand in hand. So beginning in the 1970s we consciously undertook a program of improving our air quality...."

—Scott Vail, Ph.D.,
IMC Global Carlsbad Mine

"...Of all the health issues that we're dealing with in the mining industry, this issue is at the top of the list...As I travel across this country, I hear more about exposure to diesel exhaust than any other single issue in the mining industry."

—Joe Main,
United Mine Workers of America

Addressing the Problem:

The Experience of the Mining Community

In 1995, MSHA established an internal working group to explore measures to reduce miners' exposure to DPM. This group organized a series of workshops to solicit input from the mining community. The workshops were designed to discuss the potential health risks to miners from exposure to DPM, ways to measure and limit DPM in mine environments, and regulatory or other approaches to ensure a healthful work environment. These workshops provided a useful forum to exchange views and concerns about limiting diesel exhaust exposure. More than 500 members of the mining community attended these workshops, providing evidence that reducing miners' exposure to diesel exhaust emissions, especially in underground mines, is a high priority for the mining industry.

The experience of the mining community appears to support several conclusions:

- The levels of exposure to DPM in mines depend upon engine exhaust emissions, the use of exhaust aftertreatment and its efficiency and, particularly in underground mines, ventilation rate and system design.
- Engine emissions are governed by engine design, work practices, duty cycle, fuel quality and maintenance. Reducing engine emissions will decrease the amount of DPM that needs to be controlled by other means and will reduce the exposure of miners.
- There is no single emission control strategy that is a panacea for the entire mining community.
- Diesel engine maintenance is the cornerstone of a diesel emission control program.

A major objective of this publication is to facilitate the exchange of practical information within the mining community on ways to reduce miners' exposure to diesel exhaust emissions. The Toolbox focuses on currently available methods of control as opposed to methods in the research and development stages. Each of the various technologies presented in the Toolbox will assist in reducing or monitoring worker exposure.

Where possible, the Toolbox quotes specific examples of methods tested or used by the mining industry to reduce exposure to diesel emissions. These quotations are taken directly from public transcripts of the 1995 MSHA workshops, and were selected to provide a representative sample of views expressed. All quotations are offset from the main text in bold lettering. The Toolbox also draws extensively from diesel-related publications prepared by former U.S. Bureau of Mines scientists. Please note that key words and phrases are highlighted in **bold** type for easy reference. [ ] brackets are used to insert explanations not found in the original quotation, "..." are used to indicate that words were removed to make the quote shorter.

MSHA hopes that the mining community will benefit from the exchange of this practical information and will take steps to reduce miners' exposure to diesel emissions, utilizing the variety of techniques described in this publication and other methods as they are developed. The Agency encourages an ongoing exchange of information on strategies to further reduce exposure to diesel emissions and to protect the health of miners.

The quotations cited in this publication do not necessarily represent the views and/or policies of MSHA, nor of the organizations or companies at which the speakers work (or worked). MSHA recognizes that some affiliations have changed since the workshops. Names and affiliations at the time of the workshop are used. Finally, reference to specific manufacturers and/or products does not imply endorsement by MSHA or the U.S. Government.

The Reason for a "Toolbox" Approach

This publication introduces a "toolbox" approach to reducing miners' exposure to diesel exhaust emissions. A toolbox offers a choice of tools, each with a specific purpose. One tool after another may be used to find a solution to a problem or several tools may be tried at the same time.

Reducing exposure to diesel emissions lends itself to a toolbox approach because no single method or approach to reducing exposure may be suitable for every situation. Examples of the "toolbox" approach to reducing exposure to diesel emissions in a mine were described at the 1995 MSHA workshops:

"Since the mid-1980s Homestake has initiated a number of work steps and tests to control the diesel emission components, and these are engine alternatives, maintenance, exhaust aftertreatments, fuels, dilution ventilation and engine type....To summarize our experiences with diesel particulate matter, we've had good luck with respirators, maintenance and fuels. We've had mixed results with diesel particulate filters and with airflows. And results are still pending on engine type. We are going to continue working in all of these areas."

—John Marks,
Homestake Mining Company

"At Galatia a three-point approach is used to ensure safe and healthy diesel operating conditions. First, the mine is designed to provide vast volumes of air to all the active workings... Second, a well-conceived maintenance program strives to maintain optimum engine performance and thereby control diesel exhaust emissions. The maintenance program consists of regularly scheduled replacements of fluids and filters, operating performance evaluations and additional weekly permissibility inspections, a regularly scheduled emissions test...and...a training program to educate maintenance personnel in the engine operating recommendations and requirements. The third point in our approach is the use of control technology...All permissible vehicles...at Galatia use a wet scrubber for initial particulate reduction. Additionally, 10 Ramcars that are normally assigned to production units have been retrofitted with the pleated paper diesel particulate filter. Additional vehicles are being retrofitted during equipment rebuilds."

—Keith Roberts,

Kerr McGee's Galatia Mine

"...Ventilation is an important control.... Through clean-burning diesel engines, low sulfur fuels, and effective aftertreatment technology, we can reduce emissions at the engine."

—Jeff Duncan,
United Mine Workers of America

The Toolbox is divided into nine sections—

- use of low emission engines
- use of low sulfur fuel, fuel additives and alternative fuels
- use of aftertreatment devices
- use of ventilation
- use of enclosed cabs
- diesel engine maintenance
- work practices and training
- fleet management
- respiratory protective equipment

Each section covers specific methods that are being used to reduce emissions or exposure. Use of these methods will be determined by the specific circumstances found at each mine.

"There is no single control that is a panacea for all the emission problems. Due to differences in the mine design and the mine geology, the equipment types and sizes, and their duty cycles...different types of controls are used."

—Robert Waytulonis,
Center for Diesel Research,
University of Minnesota

"Because of the interrelationship of the various control technologies on workers' exposures, mine operators often use a combination of controls....These may include

ventilation…reducing engine emissions or utilizing aftertreatment devices.”

—Robert Haney,
Mine Safety and Health Administration

The Toolbox

Low Emission Engines

Low emission engines are produced by engine manufacturers to meet increasingly stringent Environmental Protection Agency (EPA) regulations. Mine operators can benefit from discussing the condition of their diesel fleet with diesel manufacturers prior to ordering new diesel engines. Moreover, benefits can be gained by replacing older model engines that require more maintenance with newer engines. In addition, lower emissions and greater machine availability (i.e., the machine does not break down as often) are normally achieved with a newer type engine.

Low-emission engines typically operate at high fuel injection pressures which provide more efficient and complete combustion of fuel. These engines are frequently turbocharged to optimize power, performance, and emissions. After-cooling (cooling intake air that is compressed and heated by the turbocharger prior to induction into the combustion chamber) is used to reduce oxides of nitrogen (NO_x). Electronic engine control is another technological improvement, which optimizes the fuel-to-air ratio resulting in lower emissions.

As a result of EPA regulations in 1988, "on-highway" heavy duty diesel engine emissions have been significantly reduced. Emissions standards have driven particulate emissions levels for such engines from 0.6 grams per horsepower-hour (g/hp-h) in 1988 to less than 0.1 g/hp-h in 1994, and oxides of nitrogen emissions from 10.7 g/hp-h in 1985 to 5.0 g/hp-h in 1991. The EPA regulations provide a schedule for continued improvement. Pursuant to an agreement with the engine industry, the EPA has also proposed a new round of emission reductions in highway engines to begin with models produced in 2004.

In 1996, the EPA established emission regulations for almost all land-based non-road ("off-highway") diesels, such as construction equipment. These regulations specify emission levels that non-road engines must meet depending on the horsepower of the engine. Currently, the regulations affect only non-road engines from 175-750 horsepower. For this category, the 1996 standard reduces particulate emissions from as high as 1.0 g/hp-h to 0.4 g/hp-h and oxides of nitrogen emissions to below 6.9 g/hp-h. The rule phases in limits for other horsepower engines. Modern engines developed for non-road use are expected to provide the mining industry with a greater choice of low emission engines for use underground. It should be noted that diesel engines used in underground coal mines are primarily indirect injection engines (pre-chamber), which in some cases could meet certain EPA non-road requirements. In September 1997, pursuant to an agreement with the engine industry, the EPA proposed a new round of emission reductions in non-road engines to begin with models produced in 1999.

Engines that have been approved or certified by agencies such as MSHA, EPA or the state of California generally have lower emissions. Larger on-highway type engines built after 1988 and non-road engines built after 1996 have been designed to produce lower emissions to meet the stringent on-highway emission standards discussed above. For engines approved under Part 7, subpart E for underground mining applications, MSHA determines a particulate index (PI). The PI indicates the quantity of ventilation air required to dilute particulate emissions from a specific engine operated over a test cycle to a concentration of 1 milligram (1000 micrograms) per cubic meter of air. Mine operators and machine manufacturers of mining equipment can use the PI in selecting and purchasing engines. The lower the PI number, the lower the particulate emissions for the same horsepower engine. Mine operators may also use the PI to roughly estimate each engine's contribution to the mine's levels of total respirable dust in coal mines or the levels of diesel particulate in metal/nonmetal mines. In underground coal mines, all engines must be Msha-approved engines by November 25, 1999.

"...Diesel engines continue to become cleaner; there will be more emission legislation out there in the future.... Diesel engine fuel efficiency has improved at the same time; power density has continued to climb; diesel engine life has steadily increased."

—Peter Woon,
Cummins Engine

"In over the road truck engines, there has been about a 90 percent reduction in just going to cleaner engine technologies, and these are results that apply to well-maintained, new engines..."

—David Hofeldt, Ph.D.,
University of Minnesota

"Now, this class of engines [modern, low emission engines] has high horsepower, typically from 250 hp up to 500 hp, so they are not suitable for all types of mining equipment.... They have the advantage of producing 80-90 percent less particulate than the conventional naturally-aspirated prechamber engines. They consume on the order of 25 percent less fuel. In the case of the Cat 3306 swirl, it's a drop-in replacement for some of the older 3306 technology."

—Robert Waytulonis,
Center for Diesel Research,
University of Minnesota

"[Start] with buying a clean engine as opposed to some of these polluting engines that dump out all kinds of NO_x's and carbon monoxide. Buy the cleaner engines..."

—Joe Main,
United Mine Workers of America

"We felt that the problems we had with filters...were so severe and caused so many problems that it was a lot better to clean up the source, and so we got cleaner engines. We are using one manufacturer's engine. We're getting another—in fact, we're getting one of the new...Detroit Diesel engines with electronic controls just for that reason in the next machine we buy.... Utilization of highway-type diesel engines in our replacement engine program is providing us cleaner burning, reliable engines at a lower cost than the regular mining-type engines and a post-combustion device..."

—Ray Ellington,

Morton Salt

USE OF LOW SULFUR FUEL, FUEL ADDITIVES AND ALTERNATE FUELS

In general, emissions can vary from engine to engine and across different engine load conditions, even though all engines are operated using the same basic type of fuel and fuel additive package. Variations occur because the details of the combustion process differ with engine design and methods used to control fuel to the engine as well as with the duty cycle of the engine. Therefore, the following comments on fuel composition and additives should be viewed as generally applicable to an average diesel engine operated over a range of duty cycles.

The quality of the **diesel fuel** influences emissions. Sulfur content, cetane number, aromatic content, density, viscosity, and volatility are interrelated fuel properties which can influence emissions. Sulfur content can have a significant effect on diesel particulate matter emissions. In addition, it affects sulfur oxide (SO_x) emissions, all forms of which are toxic. Moreover, SO_x emissions can poison catalytic converters, and the continued use of high sulfur fuel will contribute to increased piston ring and/or cylinder liner wear.

Cetane number affects all regulated pollutants, and fuel aromatic content affects DPM and nitrogen oxides (NO_x). Therefore, it is important to provide fuel distributors with specific fuel specifications and recommended property limits when purchasing diesel fuel. Table 3 lists recommended property limits for diesel fuel. However, some of the property limits listed may not be commercially available in all areas at this time.

Table 3. Recommended Property Limits for Diesel Fuel

Property	Limit
Cetane number	>48
Aromatic Content	<20%
90% distillation temperature	<600° F
Sulfur content	<0.05% by mass

Use of **low sulfur diesel fuel** (< 0.05 percent sulfur) reduces the sulfate fraction of DPM emissions, reduces objectionable odors associated with diesel use, and allows oxidation catalysts to perform properly. Another benefit from the use of low sulfur fuel is reduced engine wear and maintenance costs. Fuel sulfur content is particularly important when the fuel is used in low emission diesel engines. Low sulfur diesel fuel is available nationwide due to EPA regulations. *As of April 25, 1997, diesel-powered equipment in underground coal mines must use low-sulfur fuel.*

"...There is an ASTM-975-93 specification [on low sulfur fuel] from the EPA. All you have to do is to specify that fuel on your purchase order, and this is the fuel they have to deliver. You just have to insist on it."

—Norbert Paas,
Paas Technology

"...Homestake used a straight No. 2 diesel fuel with up to 0.5 percent fuel sulfur until 1991 when we switched to a premier No. 2 with 0.12 percent fuel sulfur. Since about the start of 1995 we've gone to the 0.05 percent No. 2."

—John Marks,
Homestake Mining Company

"For fuel we use a low sulfur diesel fuel that typically averages 0.041 percent sulfur and a cetane number of 54."

—Bill Olsen,
Mountain Coal Company,
West Elk Mine

The cetane number of U.S. diesel fuel can range between 40 and 57. Increased cetane number and volatility, (as measured by a fuel's distillation temperature characteristics) reduces both hydrocarbon emissions and the tendency to produce white smoke, which occurs when an engine is either cold or under low load. White smoke is mostly water vapor, unburned fuel and a small portion of lube oil. Fuel with a cetane number greater than 48 and a seasonably adjusted cloud point reduces cold-start hydrocarbon emissions, odor, noise, irritant and fuel system wax separation problems.

"...Cetane number is very important—needed for good starting, good combustion and for emission performance of engine.... When cetane number is improved, either by cetane additive or base fuel composition...so that cetane number is improved from 45 to 55, there's a dramatic reduction in hydrocarbons...and...in carbon monoxide...and more than 10 percent reduction in particulates"

—Kashmir Virk,
Texaco, Inc.

Typical No. 2 diesel fuel in the U.S. has an aromatic hydrocarbon content of 20 to 40 percent. Reducing the aromatic hydrocarbon content and the 90 percent distillation temperature of the fuel reduces the soluble organic fraction of DPM and NO_x emissions.

A variety of **fuel additives** are available to reduce emissions. For example, cetane improvers increase the cetane number of the fuel, which may reduce emissions and improve starting. Oxygenated additives increase the availability of oxygen needed to oxidize hydrocarbons in the fuel. Detergents are used primarily to keep the fuel injectors clean. Dispersants or surfactants prevent the formation of thicker compounds that can form deposits on the fuel injectors or plug filters. Lubricity additives are similar to corrosion inhibitors and are frequently added to fuel by petroleum producers. There are also stability additives which prevent the fuel from breaking down when it is stored for long periods of time. Only additives registered by the EPA are recommended for use, to ensure that no harmful agents are introduced into the mine environment. *As of April 25, 1997, only diesel fuel additives that have been registered by the epa may be used in diesel-powered equipment in underground coal mines.*

"...There's a variety of different types of compounds you can add that contain oxygen. Typical diesel fuel doesn't have much oxygen.... [When significant quantities of oxygenates are added to fuel, the oxygen content of the fuel is increased], ...You end up seeing...reductions in particulate emissions, hydrocarbon emissions and CO..., and NO_x levels may increase or decrease slightly depending on the engine and load cycle."

—David Hofeldt, Ph.D.,
University of Minnesota

"We took a very serious look at metal additives...for on-highway trucks.... We–Caterpillar–and the industry decided not to go that way...[One] concern was [that] these chemicals may actually cause health effects in their own rights..."

—John Amdall,
Caterpillar

"...Detergent-type additives in the fuel primarily prevent coking or fouling [partial plugging] of the injectors. And if you don't use a detergent additive, pretty much all your emissions go up over time... [However] just using a detergent is not going to make up for an engine that's wearing out or isn't properly adjusted or maintained. ...Metals as a group reduce the visible smoke output. ...The problem with metal additives is they show up on the particulate. Metals don't burn up. ...Metals are known to have some biological effects just like diesel particulates would. So I would not recommend that you [use] any of the metal additives for reducing [diesel particulates]."

—David Hofeldt, Ph.D.,
University of Minnesota

Another promising control technology is **alternative fuel**, especially biodiesel fuels made from methyl esters derived from soybeans, although these are not readily available on the market.

This type of fuel contains about 10 percent oxygen, has a high cetane number, and a much higher flash point. These properties improve combustion, starting, performance and safety characteristics of the fuel. To maximize the reductions in exhaust emissions, it is recommended that biodiesel fuels be used with a diesel oxidation catalyst. EPA has certified a biodiesel brand known as Envirodiesel®, which is being used in combination with diesel oxidation catalyst by urban bus transit operators.

"The Bureau of Mines demonstrated that the combination of methyl soyate fuel and modern diesel exhaust catalyst is a passive control scheme that is very effective.... [In tests conducted at the Homestake Gold Mine], a Wagner load-haul-dump was operated using a 100 percent methyl soyate fuel and a modern catalyst. Compared to baseline emissions, a 70 percent reduction in the ambient levels of [diesel] particulate matter was achieved...."

—Robert Waytulonis,
Center for Diesel Research,
University of Minnesota

"...Homestake cooperated with the [former]Bureau of Mines to successfully evaluate a soy methyl ester [biodiesel] fuel...miner acceptance was good, and the leftover [biodiesel] fuel was quickly used by our miners."

—John Marks,
Homestake Mining Company

USE OF AFTERTREATMENT DEVICES

Water scrubbers are basically a safety device used on "permissible" equipment in underground mines. Water scrubbers perform three functions: cool exhaust gases to safe temperatures, arrest sparks and arrest flames.

The exhaust airflow from a diesel engine passes through water, making direct contact with the water. This direct contact with the water cools the air and quenches flames and sparks. Although not intended as an emission control device, scrubbers have been shown to remove about 30 percent of DPM from an engine's exhaust stream. Moreover, because water scrubbers cool the exhaust gases, they enable the equipment to be fitted with high efficiency paper filters that reduce DPM. Water scrubbers have no signifcant effect on gaseous emissions.

"The water scrubber...is not an emission control, it's a safety control, but incidentally, it will remove 20 to 30 percent of the particulate.... They require frequent maintenance."

—Robert Waytulonis,
Center for Diesel Research,
University of Minnesota

"Water scrubbers are not a pollution control, they are a fire control system..., but scrubbers create condensation in the air and increase mine air humidity...and with several pieces of diesel equipment using water scrubbers [on a section], the increased heat effect because of the humidity is a significant concern...."

—Joe Main,
United Mine Workers of America

The **exhaust location** can make a big difference in the concentration of pollution to which equipment operators and nearby miners are exposed. The location should be such that exhaust is directed away from the vehicle operator. The exhaust gas can be directed across the radiator, thus providing immediate dispersal by the radiator fan, or an exhaust extender can be used to **redirect the exhaust away** from the operator or nearby miners. These workers can be exposed to significant concentrations of diesel exhaust constituents before they can be diluted, even at surface mines. **Exhaust dilutors** can also be used in vented headings and tunnels.

"Wouldn't it be nice if we could take that exhaust and put it somewhere else on the vehicle, so then, at the very least, the Ramcar operator is not subject to his own vehicle's emissions?"

—Jan Mutmansky, Ph.D.,
Pennsylvania State University

Exhaust filtration devices capture DPM from the exhaust before it enters the mine atmosphere. Filters used to capture particulate or other exhaust constituents are called **after-treatment devices**.The most commonly used exhaust filtration devices are: **disposable diesel exhaust paper filters and catalyzed or uncatalyzed diesel particulate ceramic filters**.

Particulate control systems using these components typically have removal efficiencies ranging between 50 and 95 percent; that is, they remove 50 to 95 percent of the particulate. It is important to note that an aftertreatment device that is 90 percent efficient is twice as effective for removing DPM as an 80 percent efficient device: only10 percent instead of 20 percent of the particulate would remain in the exhaust.

The **disposable diesel exhaust filter** is similar to the intake air filter used on over-the-road haulage vehicles. It is placed downstream of a water scrubber or a water jacketed heat exchanger, capturing DPM from the exhaust stream. The filter is discarded after being loaded with DPM. Some states such as Pennsylvania require the loaded filters to be bagged and brought to the surface for disposal.

Tests of the disposable diesel exhaust paper filters at two underground coal mines resulted in up to 95 percent reduction in DPM. Utilization of different filtration media and careful application of these filters combined with cleaning and reuse can extend the life of the filters. When used with a water scrubber, proper maintenance of the water level is necessary to eliminate the risk of hot exhaust gases igniting the filter.

"...Disposable paper filters are installed on the Ramcars such that the exhaust first passes through the water scrubber, then through a water trap or baffle system to prevent water droplets from being carried by the exhaust stream to the filter, and then finally through the low-temperature paper filter. There's an exhaust temperature shutdown installed in front of the paper filter to prevent the exhaust gases from reaching 212o F, which is the maximum safe operating temperature of the filter. There's a back pressure gauge mounted in the operator's cab to help them know when the filters need to be changed out."

—Bill Olsen,
Mountain Coal Company,
West Elk Mine

"Today, the best strategy to use on a diesel Ramcar is to use the changeable paper filters that many mining companies are currently using."

—Jan Mutmansky, Ph.D.,
Pennsylvania State University

"...the Ramcar operators quickly accepted the filters and wanted them installed on all the face equipment. We have since installed the disposable diesel exhaust filters on our Wagner 25xs, Teletrams and Petitto Mule.... ...We typically get about six hours off the Ramcar and Petitto Mules. On our Wagner systems we average approximately four hours of service life...."

—Bill Olsen,
Mountain Coal Company,
West Elk Mine

"...In our experience, the lifetime of the filters has varied anywhere from 8 hours to 32 hours–provided that the engine on which the filter is installed is tuned properly so that it is not putting out too much soot. [The actual time between filter changes will vary depending upon the vehicle and engine's state-of-maintenance, duty cycle and other parameters.]"

—Bob Waytulonis,
Center for Diesel Research,
University of Minnesota

Catalyzed or uncatalyzed ceramic diesel particulate filters currently available can reduce DPM emissions from 60 to 90 percent. Exhaust passes through the ceramic or metallic diesel particulate filter which traps the particulate matter. As exhaust continues to pass through the filter, filtering continues, and the filter slowly becomes clogged with DPM. Clogging increases the exhaust back pressure which can lead to engine damage unless the exhaust back pressure is lowered by cleaning the filter.

Vehicles which have sufficiently high exhaust temperature (at least 325oC, 25 percent of the time) can automatically clean the filter using a process called autoregeneration or self-cleaning. During autoregeneration the high exhaust temperature causes the trapped DPM to ignite and burn, thus reducing the exhaust back pressure on the engine and allowing more DPM to be trapped. For other vehicles, regeneration can be assisted by the application of a catalyst to the filter, which lowers the regeneration temperature, or by the use of on- or off-board regeneration systems.

"There are approximately 1,000 diesel particulate filters presently [being used] on mining vehicles throughout the world."

—Dale McKinnon,
Manufacturers of Emission Control Association

"In 1989 Homestake initiated a test on ceramic wall flow diesel particulate filters. Eight units were tested on a Cat 3306, different loaders from three different suppliers. One failed right away and was replaced by the supplier. Five lasted on the average about 2,000 hours, and two went over 3,000 hours. Miner acceptance was good when the filters were working properly."

—John Marks,
Homestake Mining Company

Although ceramic diesel particulate filters are useful, they may present problems for some users.

"...Number one, while ceramic filters give good results early in their life cycle, they have a relatively short life, are very expensive and unreliable. Number two, other post-combustion devices are not readily available for the larger horsepower production equipment we are currently using. When evaluated for lower horsepower support equipment, they appear to be very costly with no proven reliability..."

—Ray Ellington,
Morton Salt

Oxidation catalytic converters (OCCs) are used to reduce the quantity of carbon monoxide and hydrocarbons (including harmful aldehydes) in diesel exhaust. Oxidation catalytic converters also decrease the soluble organic fraction of DPM as well as gas phase hydrocarbons, which can reduce DPM emissions by up to 50 percent. The soluble organic fraction of the DPM exhaust contains known carcinogenic compounds such as benzo(a)pyrene and other polycyclic aromatic hydrocarbons.

Use of low sulfur fuel (<0.05 percent sulfur) with OCCs is critical because air quality is harmed when fuel containing moderate or high sulfur (>0.1 percent) is used. An OCC oxidizes sulfur dioxide to form sulfates which increase particulate emissions. OCCs can also oxidize nitric oxide to more harmful nitrogen dioxide. Modern catalysts are formulated to minimize the production of sulfate particulate matter and nitrogen dioxide, provided they are used with high quality low sulfur fuel.

The OCC should be located as close as possible to the exhaust manifold to ensure maximum exhaust gas temperature. The catalyst formulation and its operating temperature are critical factors in converter performance. The temperatures required for 50 percent conversion of carbon monoxide and hydrocarbons are typically about 370oF and 500oF , respectively. As higher exhaust gas temperatures are attained, conversion efficiency increases. The use of high sulfur fuel reduces the life of catalytic converters. New catalyst technology and the availability of low sulfur fuel make the use of OCCs on underground mine vehicles an attractive tool for reducing diesel particulate emissions.

"There are also over 10,000 oxidation catalysts that have been put into the mining industry over the years. ...Sulfation is key in particulate control; you don't want a catalyst to cause any oxidation of the sulfur. I remem-ber once I was in India, and there was a complaint that they put a catalyst on and they were saying it caused smoke. And it did, a lot of smoke. I took a fuel sample and the fuel had 2.2 percent sulfur in it, not 0.25 percent. ...Engine, fuel and aftertreatment control technology must work together."

—Dale McKinnon,
Manufacturers of Emission Control Association

"The Homestake Mine has had extensive experience with oxidation catalysts.... We have always had them on our diesel units. And I know there's been a controversy on whether they might improve the work environment or harm it, but with low sulfur fuel I don't think there's any doubt they are a benefit. They oxidize the CO to CO_2, and they burn off some of the unburned hydrocarbons and some of the components of diesel exhaust. We like them. The [modern] catalytic purifiers, to my knowledge, limit the NO-to-NO_2 conversion, and with the low sulfur fuel you don't get the sulfates coming out. So we think we're better off with them."

—John Marks,
Homestake Mining Company

Dry system technology. An alternative to water scrubbers for meeting the exhaust gas cooling, spark arresting, and flame arresting requirements is the Dry System Technology (DST®). With this technology, the exhaust gas does not come into direct contact with cooling water, but is indirectly cooled by a water-cooled heat exchanger such as a tube and shell heat exchanger. This cooling process does not involve the evaporation of water. Spark and flame arrest are provided by mechanical means.

The DST® also includes a water-jacketed oxidation catalytic converter and a disposable diesel exhaust filter to reduce diesel emissions. The oxidation catalytic converter is located upstream of the water-cooled heat exchanger. Exhaust then passes through the water-jacketed heat exchanger, a paper filter and a flame arrestor. This system reduces diesel particulate by 95 to 98 percent. The DST® includes a complete set of diagnostic gauges to monitor system performance. The DST® has been approved by MSHA under 30 CFR Part 36. It can be used in coal or gassy metal and nonmetal mines where permissible equipment is required. In addition, the heat exchanger technology could be applied to nonpermissible engines in order to cool the exhaust gases so that disposable diesel exhaust filters (paper filters) could be used to reduce particulates.

"This system [the DST®], I think, represents, from everything that I've seen, the state-of-art of the industry...the best technology on the market today.... This gives us the ability for the first time in a long time to change direction and try to solve problems [with exposure to diesel exhaust]."

—Joe Main,
United Mine Workers of America

The DST® has been tried on a number of vehicles retrofitted to use it. "...It was a welding truck, at Shoshone. It was put in November, 1992. That's coming up pretty close to three years. Has operated very successfully; have had no problems. There's a 913 scoop; that's at Twenty-Mile since January, 1994.... We retrofitted a 25X Wagner shield hauler...."

—Norbert Paas,
Paas Technology

USE OF VENTILATION

Today the primary means used to reduce exposure to diesel exhaust pollutants underground **is to dilute exhaust pollutants** with fresh air from the mine's ventilation system. The concentration of pollutants is inversely proportional to changes in ventilation air quantity; that is, as the air quantity increases the pollutant concentrations decrease. The mine ventilation system can work in conjunction with the other methods of contaminant control such as maintenance, exhaust treatment, etc. Any control system must then be supplemented with checks to ensure that all aspects are working as designed. One way to check the control system is to conduct periodic sampling of diesel contaminants to detect changes in the system.

Mine ventilation systems where diesel engines are operated generally supply between 100 and 200 cubic feet of air per minute per brake horsepower (cfm/bhp). This air quantity is normally sufficient to dilute gaseous emissions from the diesel equipment to applicable standards for those gases. However, MSHA's experience in underground mines has shown that with these air quantities, DPM levels will still range between 200 μg/m3 and 1,800 μg/m3. As a general reference, about 35,300 cfm of air are required to dilute one gram per minute of DPM to 1,000 $\mu g/m^3$. Therefore, to significantly cause a reduction of DPM concentrations in underground mines through ventilation, it may be necessary to supply air quantities above those currently being used.

There are special ventilation requirements when diesels are used in underground coal mines. When a single piece of diesel equipment is operated, the nameplate airflow must be provided as a minimum airflow requirement. For each individual piece of diesel equipment operating in a coal mine, the approval plate air quantity must be maintained in any working place where the equipment operates, at the section loading point, and in outby entries where the equipment operates. The MSHA regulations also allow the District Manager to add areas where the approval plate air quantity may be required, such as fueling locations. When multiple pieces of diesel equipment are operated, the minimum section airflow is the sum of the nameplate airflows for the individual pieces of equipment. This requirement was developed to reduce the gaseous diesel emissions. However, not all equipment is operated on a continuous basis and some equipment, such as transportation and supply vehicles, may be excluded from this calculation. (Prior to the 1996 diesel powered equipment rule, a 100-75-50 percent guideline was used to establish minimum section air quantity requirements.) Any excluded equipment must be approved by the District Manager and listed in the ventilation plan for the mine. The intent here is to allow for the exclusion of equipment that does not significantly add to the miners' exposure level. These air quantities must be maintained in the last open crosscut of working sections, the intake to longwall sections, and the intake to pillar lines. The multiple unit quantity also applies to the areas where mechanized mining equipment is being installed or removed. Quantities other than the multiple unit formula can be approved by the MSHA District Manager if samples show that such reduced quantity will not result in overexposures.

"...Ventilation can take care, in my opinion, of most diesel equipment in the main haulageway, even in the sub-mains. However, when you approach the face area, you don't have that velocity and that quantity of air; then the control of engine exhaust may be necessary depending on the size of the engine and the concentration."

—Pramod Thakur, Ph.D.,

Consol, Inc.

Metal and nonmetal mines can be ventilated in a variety of ways. In single level mines, working areas are generally ventilated in series. The exhaust of one area becomes the intake for the next area. Multilevel mines may have a separate air split to each level or to several levels. Separation between intake and exhaust air courses is essential to prevent leakage or loss of fresh air. Auxiliary and booster fans should be installed throughout the mine to optimize distribution of workplace airflow.

Changing a mine's ventilation system to reduce pollutant exposure is frequently expensive and may require a long time to implement. Simple changes can include repairing an individual brattice or reducing leaks in an entire brattice line. However, significant improvements in air quality often are achieved only by complex changes such as redesigning the entire mining system to reduce airflow leakage, modifying the main fan installation, or adding a new air shaft.

"The mine ventilation system must be designed to provide and distribute sufficient airflow to areas of the mine where diesel equipment is being used. Typical ventilation rates in metal and nonmetal mines range from 75 to 200 cfm per brake horsepower in use. In coal mines the name plate airflow has been used to determine plan airflow requirements."

—Robert Haney,
Mine Safety and
Health Administration

"Ventilation continues to be an important method of controlling diesel particulate matter concentrations, and our studies have shown that significant reductions can be achieved by changing the ventilation around in the section."

—Jan Mutmansky, Ph.D.,
Pennsylvania State University

"Ventilation still remains the vanguard against diesel emissions. Toward the end of 1992 we reduced overall airflows to cut costs as part of a mine optimization process, and this summer we returned to those airflows. We currently have a mine migration of about 115 cfm/bhp. We designed with the 100 percent rule. We don't use 100 percent, 75 and 50 percent thereafter, although that's the way it sometimes works out. We try and keep all of our diesels on parallel splits as much as possible."

—John Marks,
Homestake Mining Company

"All permissible diesel face equipment is ventilated according to MSHA-required nameplate values. These are usually required to make in excess of 18,000 cfm in the last open break and 40,000 cfm on the section. In normal operation these values are 35,000 cfm in the last open break and 45,000 cfm on the section."

—Chris Pritchard,
Tg Soda Ash Incorporated

"Looking a little closer at ventilation, in one of our larger panels, typically at any one time you'll see three Ramcars at 139 horsepower operating, a roof bolter, a powder wagon and roughly two service vehicles…for more or less a total horsepower of…610. With an air volume of 100,000 cfm, we have an effective air-to-horsepower ratio in an operating panel of 164 cfm. If you look at the entire mine, installed horsepower, the air-to-horsepower ratio is about 95 cfm. New Mexico has a standard of 75 cfm, so we're somewhat better than that."

—Scott Vail, Ph.D.,
IMC Global Carlsbad Mine

"We control air flow in the mine using air doors and air walls. …We will shotcrete or gunite some areas to prevent leakage. We build airwalls throughout the mine using waste rock and used conveyor belt. The rock is piled up half to two-thirds of the way to the back and conveyor belt is cut into strips and pinned to the back overlapping by about six inches. This produces a very efficient air wall in the mine."

—Regina Henry,
Dravo Lime Company

"Our stoppings consist of brattice cloth or waste salt piled to within 10 feet of the roof and brattice cloth. We have auxiliary fans located throughout the mine that mix the gases as they come off the sections. Our main intake ventilates all of the sections in B-bed, then returns to the production shaft. Right now our C-bed is on its own split of air, and we continue to keep it that way. Several years ago when our fans were old and running at a maximum capacity, we decided…to see what we needed to do to build a better ventilation system. We conducted several pressure and air quality surveys, and the results were put into a computer simulation model. From this model, we found out that we definitely needed new fans…. We also decided that when we were developing C-bed, that we did not want to continue with the way we were currently ventilating the mine. In other words, we did not want to have one single split ventilating all the sections. So at that time we sat down and we worked out a way to ventilate each section on its own separate split, which is what most coal mines do. We feel that this will give us a better air quality … and it will help clear the air out faster."

—David Music,
Akzo Nobel Salt's Cleveland Mine

"…We believe mine design and ventilation is an important…control. The fact of the matter

is, though, that… mine ventilation is not a stand alone system [for reducing exposure to diesel emissions]…. "Even coupled with the water scrubber exhaust cooling systems that have become the industry standard, we haven't reduced particulate exposure to [what we would consider] an acceptable level…."

—Jeff Duncan,
United Mine Workers of America

USE OF ENCLOSED CABS

Properly designed and maintained environmentally conditioned cabs can reduce equipment operators' exposure to diesel emissions. Cabs should be pressurized and use high-efficiency particulate air (HEPA) filters. Many surface mines are currently using properly designed environmentally conditioned cabs and some efforts are being made to use enclosed cabs on underground mining equipment. The same principles apply to the use of underground booths designed to protect miners.

Question:
"I recently completed a study of a surface coal mine, and they were using pressurized cabs to minimize exposures…. Has this been given some thought in your design [of Ramcars] at Jeffrey?…."

—Robert Wheeler,
Consultant

Response:
"We may be getting very close to that, because just recently we produced the first Ramcar-type of vehicle ever with a cab, with some climate controls. …One of the problems with exposure in underground mines is not the operator of the machine. Because of the close confines, it's the people around the equipment and, of course, the pressurized cab does not affect them at all."

—John Smith,
Jeffrey Mining Products

DIESEL ENGINE MAINTENANCE

Engine maintenance is an important part of a mine's overall strategy for reducing workers' exposure to diesel emissions. Without proper maintenance, diesel engines will perform poorly, thus reducing the effectiveness of all other emission control strategies.

"It has been definitively proven, that when engine maintenance is neglected [especially if it involves regulating the fuel and air handling systems of engines] the particulate, and carbon monoxide, and hydrocarbons, all skyrocket."

—Robert Waytulonis,
Center for Diesel Research,
University of Minnesota

"...We had a lack of maintenance on these pieces of diesel equipment. They were running the equipment until they broke down, and they would fix them, and they would run them again until they broke down..."

—Glen Pierson,
Alabama Coal Miner (UMWA)

"We're having problems with respect to maintenance of diesels. We're having problems with untuned diesels. When we go to do longwall moves, we're working in an environment where the blue smoke is so heavy sometimes you can't see. We don't have a good maintenance system. We don't have a good inspection system."

—Joe Main,
United Mine Workers of America

A good preventive maintenance program will maintain near-original performance of an engine, and maximize vehicle productivity and engine life, while keeping exhaust emissions down. Engine maintenance activities which should be performed by mine maintenance personnel include maintenance of the following systems: air intake, cooling, lubrication, fuel injection and exhaust. These systems must be maintained according to manufacturer's specifications and on a regularly scheduled basis to keep the system operating efficiently. Measuring tailpipe CO emissions while the engine is under load provides a good indication when maintenance is required. However, daily checks of engine oil level, coolant, fuel and air filters, water tank, exhaust piping and gauges should be made. *There are very specific requirements for maintenance of diesel equipment in underground coal mines; some are noted below.*

The air intake system removes airborne particles before they enter the engine and cause abrasion of internal engine surfaces. Intake air filters should be replaced when the pressure drop indicator exceeds the manufacturers' specifications, usually 20 to 25 inches of water. *As of November 25, 1997, for diesel-powered equipment used in underground coal mines, intake air filters must be replaced or serviced when the intake air pressure device so indicates, or when the engine manufacturer's maximum allowable air pressure drop level is exceeded.*

"...Maintenance is extremely critical.... It takes two days to screw up the engine in the mine