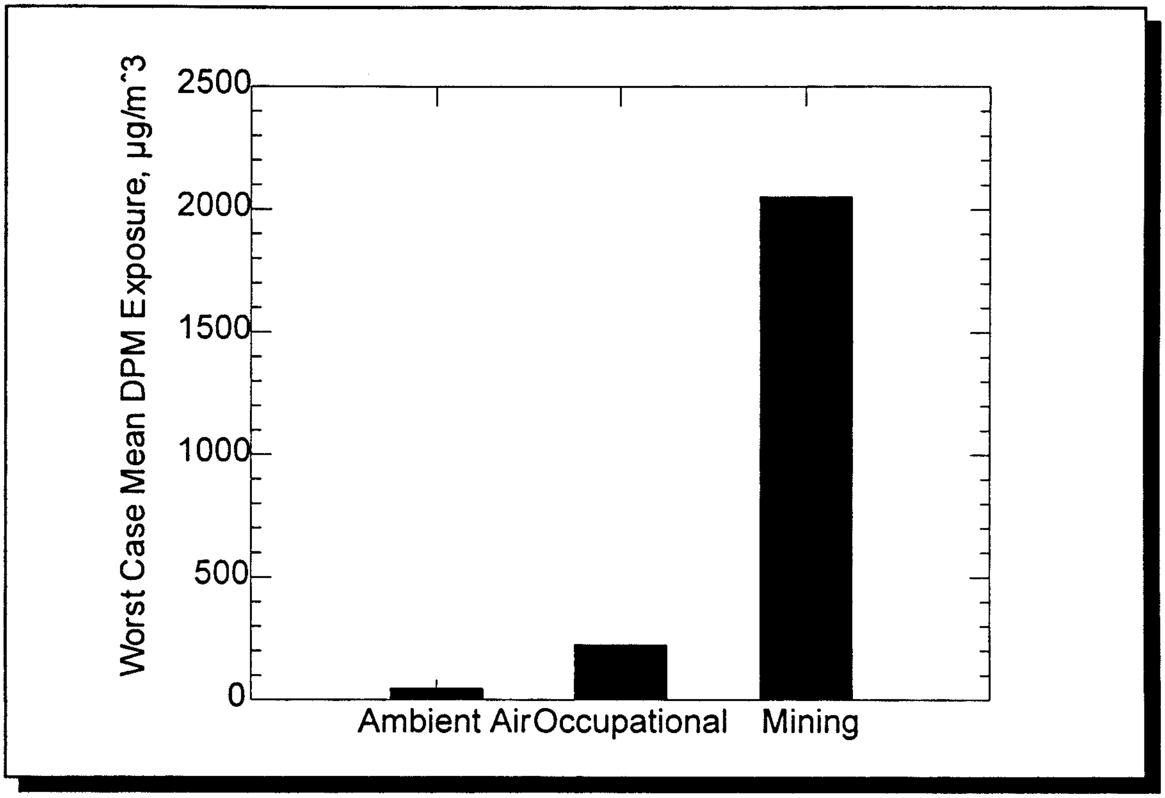

Figure III-5.--Worst case observed or reported mean diesel particulate exposure concentrations for urban ambient air, occupations other than mining, and mining. Worst case for mining is mean dpm measured within an underground mine. Worst case for occupations other than mining is mean respirable particulate matter, other than cigarette smoke, reported for railroad workers classified as hostlers (Woskie et al., 1988). Worst case for ambient air is mean estimated for peak months at most heavily polluted site in Los Angeles area (Cass and Gray, 1995), multiplied by 4.7 to adjust for comparability with occupational lifetime exposure levels.

Given the significantly increased mortality and other acute, adverse health effects associated with increments of 25 µg/m^3 in fine particulate concentration (Table III–3), the relative risk for some miners, especially those already suffering respiratory problems, appears to be extremely high. Acute responses to dpm exposures have been detected in studies of stevedores, whose exposure was likely to have been less than one-tenth the exposure of some miners on the job.

Both existing meta-analyses of human studies relating dpm exposure and lung cancer suggest that, on average, occupational exposure is responsible for a 30- to 40-percent increase in lung cancer risk across all industries studied (Lipsett and Alexeeff, 1998; Bhatia et al., 1998). Moreover, the epidemiological studies providing the evidence of this increased risk involved average exposure levels estimated to be far below levels to which some underground miners are currently exposed. Specifically, the elevated risk of lung cancer observed in the two most extensively studied industries—trucking (including dock workers) and railroads—was associated with average exposure levels estimated to be far below levels observed in underground mines. The highest average concentration of dpm reported for dock workers—the most highly exposed occupational group within the trucking industry—is about 55 µg/m^3 total elemental carbon at an individual dock (NIOSH, 1990). This translates, on average, to no more than about 110 µg/m^3 of dpm. Published measurements of dpm for railworkers have generally been less than 140 µg/m^3 (measured as respirable particulate matter other than cigarette smoke). The reported mean of 224 µg/m^3 for hostlers displayed in Figure III–5 represents only the worst case occupational subgroup (Woskie et al., 1988). Indeed, although MSHA views extrapolations from animal studies as subordinate to results obtained from human studies, it is noteworthy that dpm exposure levels recorded in some underground mines (Figures III–1 and III–2) have been well within the exposure range that produced tumors in rats (Nauss et al., 1995).

The significance of the lung cancer risk to exposed underground miners is also supported by a recent NIOSH report (Stayner et al., 1998), which summarizes a number of published quantitative risk assessments. These assessments are broadly divided into those based on human studies and those based on animal studies. Depending on the particular studies, assumptions, and methods of assessment used, estimates of the exact degree of risk vary widely even within each broad category. MSHA recognizes that a conclusive assessment of the quantitative relationship between lung cancer risk and specific exposure levels is not possible at this time, given the limitations in currently available epidemiological data and questions about the applicability to humans of responses observed in rats. However, *all* of the very different approaches and methods published so far, as described in Stayner et al. 1998, have produced results indicating that levels of dpm exposure measured at some underground mines present an unacceptably high risk of lung cancer for miners—a risk significantly greater than the risk they would experience without the dpm exposure.

Quantitative risk estimates based on the human studies were generally higher than those based on analyses of the rat inhalation studies. As indicated by Tables 3 and 4 of Stayner et al. 1998, a working lifetime of exposure to dpm at 500 µg/m³ yields estimates of excess lung cancer risk ranging from about 1 to 200 excess cases of lung cancer per thousand workers based on the rat inhalation studies and from about 50 to 800 per 1000 based on the epidemiological assessments. Even the lowest of these estimates indicates a risk that is clearly significant under the quantitative rule of thumb established in the benzene case. [*Industrial Union* vs. *American Petroleum;* 448 U.S. 607, 100 S.Ct. 2844 (1980)].

Stayner et al. 1998 concluded their report by stating:

The risk estimates derived from these different models vary by approximately three orders of magnitude, and there are substantial uncertainties surrounding each of these approaches. Nonetheless, the results from applying these methods are consistent in predicting relatively large risks of lung cancer for miners who have long-term exposures to high concentrations of DEP [i.e., dpm]. This is not surprising given the fact that miners may be exposed to DEP [dpm] concentrations that are similar to those that induced lung cancer in rats and mice, and substantially higher than the exposure concentrations in the positive epidemiologic studies of other worker populations.

The Agency is also aware that a number of other governmental and nongovernmental bodies have concluded that the risks of dpm are of sufficient significance that exposure should be limited:

(1) In 1988, after a thorough review of the literature, the National Institute for Occupational Safety and Health (NIOSH) recommended that whole diesel exhaust be regarded as a potential occupational carcinogen and controlled to the lowest feasible exposure level. The document did not contain a recommended exposure limit.

(2) In 1995, the American Conference of Governmental Industrial Hygienists placed on the Notice of Intended Changes in their Threshold Limit Values (TLV's) for Chemical Substances and Physical Agents and Biological Exposure Indices Handbook a recommended TLV of 150 µg/m³ for exposure to whole diesel particulate.

(3) The Federal Republic of Germany has determined that diesel exhaust has proven to be carcinogenic in animals and classified it as an A2 in their carcinogenic classification scheme. An A2 classification is assigned to those substances shown to be clearly carcinogenic only in animals but under conditions indicative of carcinogenic potential at the workplace. Based on that classification, technical exposure limits for dpm have been established, as described in part II of this preamble. These are the minimum limits thought to be feasible in Germany with current technology and serve as a guide for providing protective measures at the workplace.

(4) The Canada Centre for Mineral and Energy Technology (CANMET) currently has an interim recommendation of 1000 µg/m³ respirable combustible dust. The recommendation was made by an Ad hoc committee made up of mine operators, equipment manufacturers, mining inspectorates and research agencies. As discussed in part II of this preamble, the committee has presently established a goal of 500 µg/m³ as the recommended limit.

(5) Already noted in this preamble is the U.S. Environmental Protection Agency's recently enacted regulation of fine particulate matter, in light of the significantly increased health risks associated with environmental exposure to such particulates. In some of the areas studied, fine particulate is composed primarily of dpm; and significant mortality and morbidity effects were also noted in those areas.

(6) The California Environmental Protection Agency (CALEPA) has tentatively concluded that diesel exhaust appears to meet the definition of a toxic air contaminant (as stated in their Health and Safety Code, Section 39655). According to that section, a toxic air contaminant is an air pollutant which may cause or contribute to an increase in mortality or in serious illness, or which may pose a present or potential hazard to human health. At the present time, this tentative conclusion is still subject to revision.

(7) The International Programme on Chemical Safety (IPCS), which is a joint venture of the World Health Organization, the International Labour Organisation, and the United Nations Environment Programme, has issued a health criteria document on diesel fuel and exhaust emissions (IPCS, 1996). This document states that the data support a conclusion that inhalation of diesel exhaust is of concern with respect to both neoplastic and non-neoplastic diseases. It also states that the particulate phase appears to have the greatest effect on health, and both the particle core and the associated organic materials have biological activity, although the gas-phase components cannot be disregarded.

Based on both the epidemiological and toxicological evidence, the IPCS criteria document concluded that diesel exhaust is ''probably carcinogenic to humans'' and recommended that ''in the occupational environment, good work practices should be encouraged, and adequate ventilation must be provided to prevent excessive exposure.'' Quantitative relationships between human lung cancer risk and dpm exposure were derived using a dosimetric model that accounted for differences between experimental animals and humans, lung deposition efficiency, lung particle clearance rates, lung surface area, ventilation, and elution rates of organic chemicals from the particle surface.

As the Supreme Court pointed out in the benzene case, the appropriate definition of significance also depends on policy considerations of the Agency involved. In the case of MSHA, those policy considerations include special attention to the history of the Mine Act. That history is intertwined with the toll to the mining community due to silicosis and coal miners' pneumoconiosis (''black lung''), along with billions of dollars in Federal expenditures.

At one of the 1995 workshops on diesel particulate cosponsored by MSHA, a miner noted:

People, they get complacent with things like this. They begin to believe, well, the government has got so many regulations on so many things. If this stuff was really hurting us, they wouldn't allow it in our coal mines * * * (dpm Workshop; Beckley, WV, 1995).

Referring to some commenters' position that further scientific study was necessary before a limit on dpm exposure could be justified, another miner said:

* * * if I understand the Mine Act, it requires MSHA to set the rules based on the best set of available evidence, not possible evidence * * * Is it going to take us 10 more years before we kill out, or are we going to do something now * * *? (dpm Workshop; Beckley, WV, 1995).

Concern with the risk of waiting for additional scientific evidence to support regulation of dpm was also expressed by another miner who testified:

What are the consequences that the threshold limit values are too high and it's loss of human lives, sickness, whatever, compared to what are the consequences that the values are too low? I mean, you don't lose nothing if they're too low, maybe a little money. But * * * I got the indication that the diesel studies in rats could no way be compared to humans because their lungs are not the same * * * But * * * if we don't set the limits, if you remember probably last year when these reports come out how the government used human guinea pigs for radiation, shots, and all this, and aren't we doing the same thing by using coal miners as guinea pigs to set the value? (dpm Workshop; Beckley, WV, 1995).

III.3.c. Substantial Reduction of Risk by Proposed Rule

A review of the best available evidence indicates that reducing the very high exposures currently existing in underground mines can substantially reduce health risks to miners—and that greater reductions in exposure would result in even lower levels of risk. Although there are substantial uncertainties involved in converting 24-hour environmental exposures to 8-hour occupational exposures, Table III–3 suggests that reducing occupational dpm concentrations by as little as 75 µg/m^3 (corresponding to a reduction of 25 µg/m^3 in 24-hour ambient atmospheric concentration) could lead to significant reductions in the risk of various adverse acute responses, ranging from respiratory irritations to mortality. The Agency recognizes that a conclusive, quantitative dose-response relationship has not been established between dpm and lung cancer in humans. However, the epidemiological studies relating dpm exposure to excess lung cancer were conducted on populations whose average exposure is estimated to be less than 200 µg/m^3 and less than one tenth of average exposures observed in some underground mines. Therefore, the best available evidence indicates that lifetime occupational exposure at levels currently existing in some underground mines presents a significant excess risk of lung cancer.

In the case of underground coal mines, calculations by the Agency indicate that the filtration required by the proposed rule would reduce dpm concentrations to below 200 µg/m^3 in most underground coal mines.[17] The Agency recognizes that although health risks would be substantially reduced, the best available evidence indicates a significant risk of adverse health effects could remain. However, as explained in Part V of this preamble, MSHA has tentatively concluded that, because of both technology and cost considerations, the underground coal mining sector as a whole cannot feasibly reduce dpm concentrations further at this time.

Conclusions

MSHA has reviewed a considerable body of evidence to ascertain whether and to what level dpm should be controlled. It has evaluated the information in light of the legal requirements governing regulatory action under the Mine Act. Particular attention was paid to issues and questions raised by the mining community in response to the Agency's Advance Notice of Proposed Rulemaking and at workshops on dpm held in 1995. Based on its review of the record as a whole to date, the agency has tentatively determined that the best available evidence warrants the following conclusions:

1. The health effects associated with exposure to dpm can materially impair miner health or functional capacity. These material impairments include sensory irritations and respiratory symptoms; death from cardiovascular, cardiopulmonary, or respiratory causes; and lung cancer.

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

3. The proposed rule for underground coal mines is justified because the reduction in dpm exposure levels that would result from implementation of the proposed rule would substantially reduce the significant health risks currently faced by underground miners exposed to dpm.

TABLE III–2.—STUDIES OF ACUTE HEALTH EFFECTS USING FILTER BASED OPTICAL INDICATORS OF FINE PARTICLES IN THE AMBIENT AIR

City	Study years	Indicator*	Reference
Acute Mortality			
London	1963–1972, winters	BS	Thurston et al., 1989.
	1965–1972, winters		Ito et al., 1993.
	1975–1987		Katsouyanni et al., 1990.
Athens	July, 1987	BS	Katsouyanni et al., 1993.
	1984–1988		Touloumi et al., 1994.
	1970–1979		Shumway et al., 1988.
Los Angeles	1970–1979	KM	Kinney and Ozkaynak, 1991.
Santa Clara	1980–1986, winters	COH	Fairley, 1990.
Increased Hospitalization			
Barcelona	1985–1989	BS	Sunyer et al., 1993.
Acute Change in Pulmonary Function			
Wageningen, Netherlands		BS	Hoek and Brunkreef, 1993.
Netherlands		BS	Roemer et al., 1993.

*BS (black smoke), KM (carbonaceous material), and COH (coefficient of haze) are optical measurements that are most directly related to elemental carbon concentrations, but only indirectly to mass. Site specific calibrations and/or comparisons of such optical measurements with gravimetric mass measurements in the same time and city are needed to make inferences about particle mass. However, all three of these indicators preferentially measure carbon particles found in the fine fraction of total airborne particulate matter. (EPA, 1996).

TABLE III–3.—STUDIES OF ACUTE HEALTH EFFECTS USING GRAVIMETRIC INDICATORS OF FINE PARTICLES IN THE AMBIENT AIR

	Indicator	RR(± CI)/25 µg/m^3 PM increase	Mean PM levels (min/max)†
Acute Mortality			
Six Cities[A]			

[17] These calculations are discussed in detail in Part V, which reviews the extent to which the proposed rule meets the Agency's statutory obligation to attain the highest degree of health and safety protection feasible for a miner.

TABLE III–3.—STUDIES OF ACUTE HEALTH EFFECTS USING GRAVIMETRIC INDICATORS OF FINE PARTICLES IN THE AMBIENT AIR—Continued

	Indicator	RR(± CI)/25 μg/m³ PM increase	Mean PM levels (min/max)†
Portage, WI	$PM_{2.5}$	1.030 (0.993,1.071)	11.2 (±7.8)
Topeka, KS	$PM_{2.5}$	1.020 (0.951,1.092)	12.2 (±7.4)
Boston, MA	$PM_{2.5}$	1.056 (1.038,1.0711)	15.7 (±9.2)
St. Louis, MO	$PM_{2.5}$	1.028 (1.010,1.043)	18.7 (±10.5)
Kingston/Knoxville, TN	$PM_{2.5}$	1.035 (1.005,1.066)	20.8 (±9.6)
Steubenville, OH	$PM_{2.5}$	1.025 (0.998,1.053)	29.6 (±21.9)
Increased Hospitalization			
Ontario, CAN[B]	SO_4=	1.03 (1.02,1.04)	Min/Max = 3.1–8.2
Ontario, CAN[C]	SO_4=	1.03 (1.02,1.04)	Min/Max = 2.0–7.7
	O_3	1.03 (1.02,1.05)	
NYC/Buffalo, NY[D]	SO_4=	1.05 (1.01,1.10)	NR
Toronto, CAN[D]	H^+ (Nmol/m³)	1.16 (1.03,1.30)¹	28.8 (NR/391)
	SO_4=	1.12 (1.00,1.24)	7.6 (NR, 48.7)
	$PM_{2.5}$	1.15 (1.02,1.78)	18.6 (NR, 66.0)
Increased Respiratory Symptoms			
Southern California[F]	SO_4=	1.48 (1.14,1.91)	R = 2–37
Six Cities[G]	$PM_{2.5}$	1.19 (1.01,1.42)²	18.0 (7.2,37)³
(Cough)	$PM_{2.5}$ Sulfur	1.23 (0.95,1.59)²	2.5 (3.1,61)³
	H^+	1.06 (0.87,1.29)²	18.1 (0.8,5.9)³
Six Cities[G]	$PM_{2.5}$	1.44 (1.15–1.82)²	18.0 (7.2,37)³
(Lower Resp. Symp.)	$PM_{2.5}$ Sulfur	1.82 (1.28–2.59)²	2.5 (0.8,5.9)³
	H^+	1.05 (0.25–1.30)³	18.1 (3.1,61)³
Denver, CO[P]	$PM_{2.5}$	0.0012 (0.0043)³	0.41–73
(Cough, adult asthmatics)	SO_4=	0.0042 (0.00035)³	0.12–12
	H^+	0.0076 (0.0038)³	2.0–41
Decreased Lung Function			
Uniontown, PA[E]	$PM_{2.5}$	PEFR 23.1 (−0.3,36.9) (per 25 μg/m³).	25/88 (NR/88)
Seattle, WA[Q]	$b_{ext.}$	FEV1 42 ml (12,73)	5/45
Asthmatics	calibrated by $PM_{2.5}$	FVC 45 ml (20,70)	

(EPA, 1996)

[A] Schwartz et al. (1996a).
[B] Burnett et al. (1994).
[C] Burnett et al. (1995).
[D] Thurston et al. (1992, 1994).
[E] Neas et al. (1995).
[F] Ostro et al. (1993).
[G] Schwartz et al. (1994).
[Q] Koenig et al. (1993).
[P] Ostro et al. (1991).
† Min/Max 24-h PM indicator level shown in parentheses unless otherwise noted as (±S.D.), 10 and 90 percentile (10,90).
* Change per 100 nmoles/m³.
** Change per 20 μg/m³ for $PM_{2.5}$; per 5 μg/m³ for $PM_{2.5}$ sulfur; per 25 nmoles/m³ for H^+.
*** 50th percentile value (10,90 percentile).
**** Coefficient and SE in parenthesis.

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Table III-4. Summary of published information from cohort studies on lung cancer and exposure to diesel exhaust.

Authors (Date)	Occupation	No. of Subjects	Follow-up period	Exposure Assessment	Smk Adj.	Findings[a]	Stat. Sig.[b]	Comments
Ahlberg et al. (1981)	Male truck drivers	35,883	1961-73	Occupation only		RR = 1.33 for drivers of "ordinary" trucks.	*	Risk relative to males employed in trades thought to have no exposure to "petroleum products or other chemicals." Comparison controlled for age and province of residence (Sweden). Based on comparison of smoking habits between truck drivers and general Stockholm population, authors concluded that excess rate of lung cancer could not be entirely attributed to smoking.
Ahlman et al. (1991)	Underground sulfide ore miners	597	1968-86	Job histories from personnel records. Measurements of alpha energy concentration from radon daughters at each mine worked.		RR = 1.45 overall. RR = 2.9 for 45-64 age group.		Age-adjusted relative risk compared to males living in same area of Finland. No excess observed among 338 surface workers at same mines, with similar smoking and alcohol consumption, based on questionnaire. Based on calculation of expected lung cancers due to radon, excess risk attributed by author partly to radon exposure and partly to diesel exhaust.
Balarajan & McDowall (1988)	Professional drivers	3,392	1950-84	Occupation only		SMR = 0.86 for taxi drivers. SMR = 1.42 for bus drivers. SMR = 1.59 for truck drivers.	*	Possibly higher rates of smoking among bus and truck drivers than among taxi drivers.
Bender et al. (1989)	Highway maintenance workers	4,849	1945-84	Occupation only		SMR = 0.69		No adjustment for healthy worker effect.

Boffetta et al. (1988)	Railroad Wrkr. Truck driver Heavy Eq. Op. Miner General Popula.	2,973 16,208 855 2,034 476,648	1982-84	Occupation and diesel exposure by questionnaire	✔	RR = 1.59 for railroad workers. RR = 1.24 for truck drivers. RR = 2.60 for heavy Eq. Op's. RR = 2.67 for miners. RR = 1.18 for subjects reporting diesel exposure compared to subjects reporting no diesel exposure.	* *	Overall RR adjusted for occupational exposures to asbestos, coal and stone dusts, coal tar & pitch, and gasoline exhaust (in addition to age and smoking). Possible biases due to volunteered participation and relatively high lung cancer rate among 98,026 subjects with unknown dpm exposure.
Dubrow & Wegman (1984)	Truck & tractor drivers	not reported	1971-73	Occupation only		sMOR = 1.73 based on 176 deaths.	*	Excess cancers observed over the entire respiratory system and upper alimentary tract.
Edling et al. (1987)	Bus workers	694	1951-83	Occupation only		SMR = 0.7 for overall cohort		Small size of cohort lacks statistical power to detect excess risk of lung cancer. No adjustment for healthy worker effect.
Garshick et al. (1988)	Railroad workers	55,407	1959-80	Job in 1959 & years of diesel exposure since 1959		RR = 1.20 for 1-4 yr. exposure. RR = 1.24 for 5-9 yr. exposure. RR = 1.32 for 10-14 yr. exposure. RR = 1.72 for ≥15 yr. exposure. Higher RR for each exposure group if shopworkers and hostlers are excluded. RR = 1.45 within highest-exposed age group (40-44).	* * * * *	Exposure groups based on exposure accumulated more than 4 yr prior to observation. Subjects with likely asbestos exposure excluded from cohort. Statistically significant results corroborated if 12,872 shopworkers and hostlers possibly exposed to asbestos are also excluded. Missing 12% of death certificates. Cigarette smoking judged to be uncorrelated with diesel exposure within cohort.
Guberan et al. (1992)	Professional drivers	1,726	1961-86	Occupation only		SMR = 1.50	*	Approx. 1/3 to 1/4 of cohort reported to be long-haul truck drivers. SMR based on regional lung cancer mortality rate.
Gustafsson et al. (1986)	Dock workers	6,071	1961-80	Occupation only		SMR = 1.32 (mortality). SMR = 1.68 (morbidity).	* *	

Gustavsson et al. (1990)	Bus garage workers	708	1952-86	Semi-quantitative based on job history & exposure intensity estimated for each job.		SMR = 1.22 for overall cohort. SMR = 1.27 for highest-exposed subgroup.		Lack of statistical significance may be attributed to small size of cohort.
Hansen (1993)	Truck drivers	14,225	1970-80	Occupation only		SMR = 1.60 for overall cohort. Some indication of increasing SMR with age (i.e., greater cumulative exposure).	*	Compared to unexposed control group of 38,301 laborers considered to "resemble the group of truck drivers in terms of work-related demands on physical strength and fitness, educational background, social class, and life style." Correction for estimated differences in smoking habits between cohort and control group reduces SMR from 1.60 to 1.52. Results judged "unlikely *** [to] have been seriously confounded by smoking habit differences."
Howe et al. (1983)	Railroad workers	43,826	1965-77	Jobs classified by diesel exposure		RR = 1.20 for "possibly exposed." RR = 1.35 for "probably exposed."	* *	Risk is relative to unexposed subgroup of cohort. Similar results obtained for coal dust exposure. Possible confounding with asbestos and coal dust.
Kaplan (1959)	Railroad workers	32000 (Approx.)	1953-58	Jobs classified by diesel exposure		SMR=0.88 for operationally exposed. SMR = 0.72 for somewhat exposed. SMR = 0.80 for rarely exposed.		No adjustment for healthy worker effect. Clerks (in rarely exposed group) found more likely to have had urban residence than occupationally exposed workers. No attempt to distinguish between diesel and coal-fired locomotives. Results may be attributable to short duration of exposure and/or inadequate follow-up time.
Leupker & Smith (1978)	Truck drivers	183,791	May-July, 1976	Occupation only		SMR = 1.21		Lack of statistical significance may be due to inadequate follow-up period.
Lindsay et al. (1993)	Truck drivers	not reported	1965-79	Occupation only		SMR = 1.15	*	
Menck & Henderson (1976)	Truck drivers	34,800 estimated	1968-73	Occupation only		SMR = 1.65	*	Number of subjects in cohort estimated from census data.

Raffle (1957)	Transport engineers	2,666 Est. from man-years at risk	1950-55	Occupation only		SMR = 1.42		SMR calculated by combining data presented for four quadrants of London.
Rafnsson & Gunnarsdottir (1991)	Truck drivers	868	1951-88	Occupation only		SMR = 2.14	*	No trend of increasing risk with increased duration of employment or increased follow-up time. Based on survey of smoking habits in cohort compared to general male population, and fact that there were fewer than expected deaths from respiratory disease, authors concluded that differences in smoking habits were unlikely to be enough to explain excess rate of lung cancer. However, not all trucks were diesel prior to 1951, and there is possible confounding by asbestos exposure.
Rushton et al. (1983)	Bus maintenance workers	8,480	5.9 yrs (mean)	Occupation only		SMR = 1.01 for overall cohort. SMR = 1.33 for "general hand" subgroup.	*	Short follow-up period. SMR based on comparison to national rates, with no adjustment for regional or socioeconomic differences, which could account for excess lung cancers observed among general hands.
Schenker et al. (1984)	Railroad workers	2,519	1967-79	Job histories, with exposure classified as unexposed, high, low, or undefined.		RR = 1.50 for low exposure subgroup. RR = 2.77 for high exposure subgroup.		Risk relative to unexposed subgroup. Jobs considered to have similar socioeconomic status. Differences in smoking calculated to be insufficient to explain findings. Possible confounding by asbestos exposure.
Waller (1981)	Bus workers	16,828 Est. from manyears at risk	1950-74	Occupation only		SMR = 0.79 for overall cohort.		Lung cancers occurring after retirement or resignation from London Transport Authority were not counted. No adjustment for healthy worker effect.
Waxweiler et al. (1973)	Potash miners	3,886	1941-67	Miners classified as underground or surface		SMR = 1.12 for surface miners. SMR = 1.08 for underground miners.		No adjustment for healthy worker effect. SMR based on national lung cancer mortality, which is about 1/3 higher than lung cancer mortality rate in New Mexico, where miners resided. A substantial percentage of the underground subgroup may have had little or no occupational exposure to diesel exhaust.

Wong et al. (1985)	Heavy equipment operators	34,156	1964-78	Job histories, latency, & years of union membership		SMR = 0.99 for overall cohort. SMR = 1.07 for ≥20 yr member. SMR = 1.12 for ≥20 yr. latency. SMR = 1.30 for 4,075 "normal" retirees.	*	Increasing trend in SMR with latency and (up to 15 yr) with duration of union membership. Statistically significant excess lung cancers for dozer operators with 15-19 yr union membership and ≥20 yr latency. No adjustment for healthy worker effect.

a RR = Relative Risk; SMR = Standardized Mortality Ratio. Values greater than 1.0 indicate excess prevalence of lung cancer associated with diesel exposure.

b An asterisk (*) indicates statistical significance based on 2-tailed test at confidence level of at least 95%.

Table III-5 — Summary of published information from case-control studies on lung cancer and exposure to diesel exhaust.

Authors (Date)	Cases	Controls	No. of Cases	No. of Controls	Exposure Assessment	Matching		Findings[a]	Stat. Sig.[b]	Comments
						Smk.	Additional			
Benhamou et al. (1988)	Histologically confirmed lung cancers	Non-tobacco related diseases	1,625	3,091	Occupational history by questionnaire.	✔	Sex, age at diagnosis, hospital, interviewer.	RR = 2.14 for miners RR = 1.42 for professional drivers.	* *	Mine type not reported. No evidence of an increase in risk with duration of exposure
Boffetta et al. (1990)	Hospitalized males with lung cancer	Hospitalized males with no tobacco related disease	2,584	5,099	Occupation classified by probability of diesel exposure	✔	Sex, age, hospital, year of interview.	OR = 0.88 for truck drivers. OR = 0.95 for probable exposure.		Adjusted for race, asbestos exposure, education.
			477	846	Occupational history & duration of diesel exposure by interview			OR = 1.21 for any self-reported diesel exposure. OR = 2.39 for than 30 yr of self-reported diesel exposure.		
Buiatti et al. (1985)	Histologically confirmed lung cancers	Patients at same hospital	376	892	Occupational history from interview	✔	Sex, age, admission date.	OR = 1.8 for taxi drivers.		
Coggon et al. (1984)	Lung cancer deaths of males under 40	Deaths from other causes in males under 40	598	1,180	Occupation from death certificate, classified as high, low, or no diesel exposure		Sex, death year, region, and birth year (approx.)	RR = 1.3 for all jobs with diesel exposure. RR=1.1 for jobs classified as high exposure.	*	Only most recent full-time occupation recorded on death certificate.

Damber & Larsson (1985)	Male patients with lung cancer	One living and one deceased without lung cancer	604	1,071	Job, with tenure, from mailed questionnaire	✔	Sex, death year, age, municipality	RR = 1.9 for non-smoking truck drivers aged <70 yr. RR = 4.5 for non-smoking truck drivers aged ≥70 yr.	*	Ex-smokers who did not smoke for at least last 10 years included with non-smokers.
DeCoufle et al. (1977)	Male patients with lung cancer	Non-neoplastic disease patients	Not reported	Not reported	Occupation only, from questionnaire	✔	Unmatched	RR = 0.92 for bus, taxi, and truck drivers. RR = 0.94 for locomotive engineers.		Selected occupation compared to clerical workers. Positive associations found before smoking adj.
Emmelin et al. (1993)	Deaths from primary lung cancer among dock workers	Dock workers without lung cancer	50	154	Semi-quantitative from work history & records of diesel fuel usage	✔	Date of birth, port, and survival to within 2 years of case's diagnosis of lung cancer	RR = 1.6 for "medium" duration of exposure. RR = 2.9 for "high" duration of exposure.		Increasing relative risk also observed using exposure estimates based on machine usage & diesel fuel consumption. Confounding from asbestos may be significant.
Garshick et al. (1987)	Deaths with primary lung cancer among railroad workers	Deaths from other than cancer, suicide, accidents, or unknown causes	1,256	2,385	Job history and tenure combined with current exposure levels measured for each job	✔	Date of birth and death	RR = 1.41 for 20+diesel-years in workers aged≤64 yr. RR = 0.91 for workers aged ≥65 yr.	*	Adjusted for asbestos exposure. Older workers had relatively short diesel exposure, or none.

Gustavsson et al. (1990)	Deaths from lung cancer among bus garage workers	Non-cases within cohort mortality study	20	120	Semi-quantitative based on job, tenure, & exposure class for each job		Born within two years of case.	RR = 1.34, 1.81, and 2.43 for increasing cumulative diesel exposure categories, relative to lowest exposure category.	*	Authors judged smoking habits to be similar for different exposure categories. RR did not increase with increasing asbestos exposure
Hall & Wynder (1984)	Hospitalized males with lung cancer	Hospitalized males with no tobacco-related diseases	502	502	Usual occupation by interview	✔	Age, race, hospital, and hospital room status	RR = 1.4 for jobs with diesel exposure.		Confounding with other occupational exposures possible.
Hayes et al. (1989)	Lung cancer deaths pooled from 3 studies	Various -- lung disease excluded	2,291	2,570	Occupational history by interview	✔	Sex, age, and either race or area of residence	OR = 1.5 for ≥10 yr truck driving. OR = 2.1 for ≥10 yr operating heavy equipment. OR = 1.7 for ≥10 yr bus driving.	*	OR adjusted for birth-year cohort and state of residence (FL, NJ, or LA), in addition to average cigarette use. Smaller OR for <10 yr in these jobs.
Lerchen et al. (1987)	New Mexico residents with lung cancer	Medicare recipients	506	771	Occupational history, industry, & self-reported exposure, by interview	✔	Sex, age, ethnicity	OR = 0.6 for ≥1 yr occupational exposure to diesel exhaust. OR = 2.1 for underground non-uranium mining.		Small number of cases and controls in diesel-exposed jobs. Possibly insufficient exposure duration. Not matched on date of birth or death.
Milne et al. (1983)	Lung cancer deaths	Deaths from any other cancer	925	6,565	Occupation from death certificate		None	OR = 3.5 for bus drivers. OR = 1.6 for truck drivers.	*	

Morabia et al. (1992)	Male lung cancer patients	Patients without lung cancer or other tobacco-related condition	1,793	3,228	Job, with coal and asbestos exposure durations, by interview	✔	Race, age, hospital, and smoking history	OR = 2.3 for miners. OR = 1.1 for bus drivers. OR = 1.0 for truck or tractor drivers.		Lung cancer reported to be associated with increasing duration of exposure to coal.
Pfluger and Minder (1994)	Professional drivers	Workers in occupational categories with no known excess lung cancer risk.	284	1,301	Occupation only, from death certificate		None.	OR = 1.48 for professional drivers.	*	Stratified by age. Indirectly adjusted for smoking, based on smoking-rate for occupation.
Siemiatycki et al. (1988)	Squamous cell lung cancer patients by type of lung cancer	Other cancer patients	359	1,523	Semi-quantitative, from Occupa. history by interview, & exposure class for each job	✔	None	OR = 1.2 for diesel exposure; OR = 2.8 for mining.		Stratified by age, socioeconomic status, ethnicity, and blue- vs. white-collar job history. Examination of files indicated that most miners "were exposed to diesel exhaust for short periods of time."
Steenland et al. (1990)	Deaths from lung CA among Teamsters	Deaths excluding LC, bladder cancer, and motor vehicle accidents	996	1,085	Occupational history and tenure from next-of-kin, supplemented by IH data	✔	None	OR = 1.27 for diesel truck drivers with 1-24 yr. tenure. OR = 1.26 for diesel truck drivers with 25-34 yr. tenure. OR = 1.89 for diesel truck drivers with ≥35 yr. tenure.	*	Years of tenure not necessarily all at main job (i.e., diesel truck driver). OR adjusted for asbestos exposure.

Swanson et al. (1993) See also Burns & Swanson (1991)	Detroit lung cancers	Colon or rectal cancer cases	5,935	3,956	Occupational history from interview	✔	None	OR = 1.4 for heavy truck drivers with 1-9 yr tenure. OR = 1.6 for heavy truck drivers with 10-19 yr tenure. OR = 2.4 for heavy truck drivers with ≥20 yr tenure. -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- - OR = 1.2 for railroad workers with 1-9 yr tenure. OR = 2.5 for railroad workers with ≥10 yr tenure. -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- OR = 5.03 for mining machine operators.	 * * *	OR for truck drivers & RR workers is for white males, relative to corresponding group with <1 yr tenure, adjusted for age at diagnosis. Pattern of increasing risk with duration of employment also reported for black male railroad workers, based on fewer cases. OR for mining machine operators is for all males, adj. for race and age at diagnosis.
Williams et al. (1977)	Male lung cancer patients	Other male cancer patients	432	2,817	Main lifetime occupation from interview	✔	Sex	OR = 1.52 for male truck drivers.		Controlled for age, race, alcohol use, and socioeconomic status. Unexplained discrepancies in reported number of controls.

[a] RR = Relative Risk; OR = Odds Ratio. Values greater than 1.0 indicate excess prevalence of lung cancer associated with diesel exposure.
[b] An asterisk (*) indicates statistical significance based on 2-tailed test at confidence level of at least 95%.

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TABLE III–6.—HYPOTHESIZED MECHANISMS OF PARTICULATE TOXICITY [a]

Response	Description
Increased Airflow Obstruction	PM exposure may aggravate existing respiratory symptoms which feature airway obstruction. PM-induced airway narrowing or airway obstruction from increased mucous secretion may increase abnormal ventilation/perfusion ratios in the lung and create hypoxia. Hypoxia may lead to cardiac arrhythmias and other cardiac electrophysiologic responses that in turn may lead to ventricular fibrillation and ultimately cardiac arrest. For those experiencing airflow obstruction, increased airflow into non-obstructed areas of the lung may lead to increased particle deposition and subsequent deleterious effects on remaining lung tissue, further exacerbating existing disease processes. More frequent and severe symptoms may be present or more rapid loss of function.
Impaired Clearance	PM exposure may impair clearance by promoting hypersecretion of mucus which in turn results in plugging of airways. Alterations in clearance may also extend the time that particles or potentially harmful biogenic aerosols reside in the tracheobronchial region of the lung. Consequently alterations in clearance from either disturbance of the mucociliary escalator or of macrophage function may increase susceptibility to infection, produce an inflammatory response, or amplify the response to increased burdens of PM. Acid aerosols impair mucociliary clearance.
Altered Host Defense	Responses to an immunological challenge (e.g., infection), may enhance the subsequent response to inhalation of nonspecific material (e.g., PM). PM exposure may also act directly on macrophage function which may not only affect clearance of particles but also increase susceptibility and severity of infection by altering their immunological function. Therefore, depression or over-activation of the immune system, caused by exposure to PM, may be involved in the pathogenesis of lung disease. Decreased respiratory defense may result in increased risk of mortality from pneumonia and increased morbidity (e.g., infection).
Cardiovascular Perturbation	Pulmonary responses to PM exposure may include hypoxia, bronchoconstriction, apnea, impaired diffusion, and production of inflammatory mediators that can contribute to cardiovascular perturbation. Inhaled particles could act at the level of the pulmonary vasculature by increasing pulmonary vascular resistance and further increase ventilation/perfusion abnormalities and hypoxia. Generalized hypoxia could result in pulmonary hypertension and interstitial edema that would impose further workload on the heart. In addition, mediators released during an inflammatory response could cause release of factors in the clotting cascade that may lead to increased risk of thrombus formation in the vascular system. Finally, direct stimulation by PM of respiratory receptors found throughout the respiratory tract may have direct cardiovascular effects (e.g., bradycardia, hypertension, arrhythmia, apnea and cardiac arrest).
Epithelial Lining Changes	PM or its pathophysiological reaction products may act at the alveolar capillary membrane by increasing the diffusion distances across the respiratory membrane (by increasing its thickness) and causing abnormal ventilation/perfusion ratios. Inflammation caused by PM may increase ''leakiness'' in pulmonary capillaries leading eventually to increased fluid transudation and possibly to interstitial edema in susceptible individuals. PM induced changes in the surfactant layer leading to increased surface tension would have the same effect.
Inflammatory Response	Diseases which increase susceptibility to PM toxicity involve inflammatory response (e.g., asthma, COPD, and infection). PM may induce or enhance inflammatory responses in the lung which may lead to increased permeability, diffusion abnormality, or increased risk of thrombus formation in vascular system. Inflammation from PM exposure may also decrease phagocytosis by alveolar macrophages and therefore reduce particle clearance. (See discussions above for other inflammatory effects from PM exposure.)

[a] This table reproduces Table V–2 of the EPA staff paper. The citation in the staff paper indicates the table is derived from information in the EPA criteria document on particulate matter (p. 13–67 to 72; p. 11–179 to 185) and information in Appendix D of EPA staff paper.

IV. Discussion of Proposed Rule

This part of the preamble explains, section-by-section, the provisions of the proposed rule. As appropriate, this part references discussions in other parts of this preamble: in particular, the background discussions on measurement methods and controls in part II, and the feasibility discussions in part V.

The proposed rule would add a new subpart to 30 CFR part 72, Subpart D—Diesel Particulate Matter—Underground, and would also add two new sections (§§ 72.500 and 72.510). The proposal would also amend existing § 75.371 in 30 CFR part 75.

§ 72.500 Diesel Particulate Filtration Systems

Summary

The proposed rule would require the installation and maintenance of high-efficiency particulate filters on the most polluting types of diesel equipment in underground coal mines.

Proposed § 72.500(a) would require that beginning 18 months after the date the rule is promulgated, any piece of permissible diesel-powered equipment operated in an underground coal mine must be equipped with a system capable of removing, on average, at least 95% of the mass of the dpm emitted from the engine.

Paragraph (b) would require that beginning 30 months after the rule is promulgated, any nonpermissible piece of ''heavy duty'' diesel-powered equipment operated in an underground coal mine be equipped with a system capable of removing, on average, at least 95% of the mass of the dpm emitted from the engine. ''Heavy duty'' for this purpose is defined by existing § 75.1908(a).

Paragraph (c) would require that any exhaust aftertreatment device installed to reduce the emission of dpm be maintained in accordance with manufacturer specifications.

Paragraph (d) would set forth the Agency's requirements for determining whether a system is capable of removing, on average, at least 95% of diesel particulate matter by mass. It states that a filtration system would be tested by comparing the results of emission tests of an engine with and without the filtration system in place, using the test cycle specified in Table E–3 of 30 CFR 7.89, ''Tests to Determine

Particulate Index.'' The proposed rule would also require that the filtration system submitted for testing be representative of those actually intended for mining use.

Discussion of Alternatives

Alternative approaches for this sector considered by the Agency are discussed in detail in part V of this preamble concerning feasibility. MSHA's decision to propose an approach requiring a technology capable of reducing engine emissions by a specified amount was driven by several considerations.

First, the Agency is not confident that there is a measurement method for dpm that will provide accurate, consistent and verifiable results at lower concentration levels in underground coal mines. The available measurement methods for determining dpm concentrations in underground coal mines were carefully evaluated by the Agency, including field testing, before the Agency reached this conclusion. The problems are discussed in detail in part II of this preamble. The Agency is continuing to collect data and is consulting with NIOSH to resolve questions about the measurement of dpm in underground coal mines. If at some future time it can be established that a particular measurable component of dpm (e.g., the elemental carbon component of dpm) can be used to accurately quantify the level of dpm, the Agency would reevaluate the question of measurement at underground coal mines in that light.

Second, filtration systems for the diesel equipment used in this sector are available at a reasonable cost, and if properly maintained can provide generally consistent, highly effective elimination of dpm from underground mine atmospheres.

Finally, the Agency believes that alternative approaches that would require each combination of engine plus filtration system to meet a defined dpm emissions requirement might well provide inadequate protection. The statute requires the Agency to adopt the feasible approach that provides maximum protection.

Types of Equipment To Be Filtered

MSHA's field data on dpm emissions in underground coal mines is reviewed in part III of this preamble. The data indicates that it is currently the permissible equipment used for face haulage that contributes most to high dpm levels, but heavy-duty outby equipment can also generate significant dpm emissions.

Because of its statutory obligation to attain the highest degree of safety and health protection for miners, with feasibility a consideration, the Agency explored the implications of requiring all diesel-powered equipment to be filtered; but as discussed in part V of the preamble, the Agency has tentatively concluded that the high costs of filtering all light-duty outby equipment may not be feasible for this sector at this time.

However, MSHA welcomes information about light-duty equipment which may be making a significant contribution to dpm emissions in particular mines or particular situations, and MSHA may consider including in the final rule filtration requirements to address any such problems. The Agency would also welcome comment on whether it would be feasible for this sector to implement a requirement that any new light-duty equipment added to a mine's fleet be filtered. By way of a rough cost estimate, if turnover is only 10% a year, for example, the cost of such an approach would be only about a tenth of that for filtering all light-duty outby. To the extent there may be technological restraints on filtering light-duty equipment with 95% filters, the Agency would welcome comment on the feasibility of requiring that 60–90% filtration be used on some or all of the light-duty fleet. And the agency is interested in comments as to whether it is likely that, in response to the market for high-efficiency filters on other types of equipment, there will soon be developed high-efficiency ceramic filters suitable for light-duty equipment. MSHA welcomes comment on these and other approaches dealing with light-duty equipment in underground coal mines, and will continue to study this issue in light of the record.

Timeframe for Implementation

On permissible equipment, the filters can simply be installed directly on the tailpipes; accordingly, the rule would require these filters to be installed within 18 months. In the case of outby equipment, scrubbers and cooling system upgrades will need to be added to cool the exhaust before the filters are installed, or a dry technology system utilized. Accordingly, an additional year is provided for such equipment.

95% Effective

The proposed rule would define effectiveness of a filtration system in removing dpm mass by reference to a laboratory test, using an engine for the test representative of those to be actually used in mining. The test involves: (a) measuring the average dpm mass of the emissions from the engine (under steady state load conditions specified in Table E–3 of section 7.89 of title 30 of the Code of Federal Regulations) before the filtration system is added; (b) measuring again after the filtration system is added; and (c) determining the efficiency of the filtration system by comparing the results.

As discussed in the background materials in part II of this preamble (including MSHA's toolbox, reprinted as an Appendix at the end of this document), there are several systems presently on the market capable of achieving such reductions. Current permissible engines used in underground coal mines are equipped with power packages that protect the engine against fire and explosion hazards. Power packages are installed with either water scrubbers (wet systems) or with heat exchanger technology (dry systems). For both cases, paper filters have been installed on these systems. The paper filter can be used on permissible equipment due to the limitation of the exhaust gas temperature to below 302°F; above that temperature, the paper could catch fire and burn.

Information concerning the particulate removal capability of these filters has been well documented in field studies and laboratory tests. Overall, the paper filters, when attached to a dry system and when tested in the laboratory on an engine dynamometer using the test cycle specified in the proposed rule, achieve greater than 95% diesel particulate removal (Gautam, dpm Workshop; Beckley, WV, 1995). Field studies have indicated diesel particulate removal using the paper filters on wet systems up to 90% using a wet permissible system (BOM RI 9508).

Nonpermissible equipment can utilize such paper filters if the exhaust is cooled through the addition of heat exchangers or other devices. Dry technology can also be utilized.

As noted in part II, ceramic filters may in the future be capable of achieving reductions of at least 95% in dpm mass. MSHA would welcome information on the development of ceramic filters which can or will soon meet such capabilities. Ceramic filters can be used directly on hot emissions, and hence might be a particularly attractive alternative for nonpermissible equipment. But whether paper, ceramic or some other media, the same test would be utilized to determine particulate removal capabilities.

Maintenance

The proposed rule would require that any filtration system installed to reduce the emission of dpm be maintained in accordance with manufacturer specifications (e.g., changing disposable filters at the proper interval), ensuring cooling devices added to nonpermissible equipment are maintained.

Enforcement

Since a concentration limit is not being established, the proposed rule does not require environmental monitoring of dpm concentrations by either operators or by MSHA specialists. Enforcement of the proposed underground coal requirements would be through observation by MSHA inspectors. Inspectors would observe whether an aftertreatment device that passed the effectiveness test is actually installed on each piece of equipment on which one is required, and whether diesel equipment was emitting black smoke during changes in acceleration or otherwise suggesting lack of required maintenance.

It should be noted that the training and qualifications of those who perform maintenance of diesel-powered equipment is governed by 30 CFR 75.1915, pursuant to MSHA's diesel equipment rule.

§ 72.510 Miner Health Training

Paragraph (a) of this section requires hazard awareness training of underground coal miners who can reasonably be expected to be exposed to dpm. Paragraph (b) includes provisions on records retention, access and transfer.

To ensure miners can better contribute to dpm reduction efforts, underground coal miners who can reasonably be expected to be exposed to diesel emissions must be annually trained about the hazards associated with that exposure and in the controls being used by the operator to limit dpm concentrations.

Proposed § 72.510(a) would require any underground coal miner ''who can reasonably be expected to be exposed to diesel emissions'' to be trained annually in: (a) the health risks associated with dpm exposure; (b) the methods used in the mine to control dpm concentrations; (c) identification of the personnel responsible for maintaining those controls; and (d) actions miners must take to ensure the controls operate as intended.

The purpose of the proposed requirement is to promote miner awareness. Exposure to diesel particulate is associated with a number of harmful effects as discussed in part III of this preamble, and the safe level is unknown. Miners who work in mines where they are exposed to this risk ought to be reminded of the hazard often enough to make them active and committed partners in implementing actions that will reduce that risk.

The training need only be provided to underground coal miners who can reasonably be expected to be exposed at the mine. The training is to be provided by operators; hence, it is to be without fee to the miner.

The rule places no constraints on the operator as to how to accomplish this training. MSHA believes that the required training can be provided at minimal cost and with minimal disruption. The proposal would not require any special qualifications for instructors, nor would it specify the hours of instruction.

Instruction could take place at safety meetings before the shift begins, devoting one of those meetings to the topic of dpm would be a very easy way to convey the necessary information. Simply providing miners with a copy of MSHA's ''toolbox,'' and reviewing how to use it in an individual mine, can cover several of the training requirements. One-on-one discussions that cover the required topics is another approach that can be used.

Operators could also choose to include a discussion on diesel emissions in their part 48 training, provided the plan is approved by MSHA. There is no existing requirement that part 48 training include a discussion of the hazards and control of diesel emissions. While mine operators are free to cover additional topics during the part 48 training sessions, the topics that must be covered during the required time frame may make it impracticable to cover other matters within the prescribed time limits. Where the time is available in mines using diesel-powered equipment, operators would be free to include the dpm instruction in their part 48 training plans. The Agency does not believe special language in the proposed rule is required to permit this action under part 48, but welcomes comment in this regard.

To assist mine operators with the proposed training requirement, it is MSHA's intent to develop an instruction outline that mine operators can use as a guide for training personnel. Instruction materials will be provided with the outline.

The proposal does not require the mine operator to separately certify the completion of the dpm training, but some evidence that the training took place would have to be produced upon request. A serial log with the employee's signature is an acceptable practice.

Proposed § 72.510(b)(1) would require that any log or record produced signifying that the training had taken place would be retained at the mine site for one year.

The records need to be where an inspector can view them during the course of an inspection, as the information in the records may determine how the inspection proceeds. But if the mine site has a fax machine or computer terminal, MSHA would permit the records to be maintained elsewhere so long as they are readily accessible. MSHA's approach in this regard is consistent with Office of Management and Budget Circular A–130.

Under proposed paragraph (b)(2) mine operators must promptly provide access to the training records upon request from an authorized representative of the Secretary of Labor, the Secretary of Health and Human Services, or from an authorized representative of miners. If an operator ceases to do business, all training records of employees are expected to be transferred to any successor operator. The successor operator will be expected to maintain those training records for the required one year period unless the successor operator has undertaken to retrain the employees.

Amendment to § 75.371 Ventilation Plan Modification

The proposed rule would amend existing § 75.371 to add one new requirement to an underground coal mine's ventilation control plan. The information is limited, but is critical to the control of dpm. The proposed added paragraph (qq) would require the ventilation plan to contain a list of the diesel-powered units used by the mine operator together with information about any unit's emission control or filtration system. Included in that information should be details relative to the efficiency of the system and the method(s) used to establish the efficiency of the system for removing dpm. Any amendments to a mine's ventilation plan must, of course, be accomplished pursuant to the requirements of 30 CFR 75.370.

General Effective Date

The proposed rule provides that unless otherwise specified, its provisions take effect 60 days after the date of promulgation of the final rule.

Some provisions of the proposed rule contain delayed effective dates that provide more time for technical assistance to mine operators. For example, the first filtration requirements for underground coal mining equipment would be delayed for 18 months.

V. Adequacy of protection and feasibility of proposed rule

The Mine Act requires that in promulgating a standard, the Secretary, based on the best available evidence, shall attain the highest degree of health and safety protection for the miner with feasibility a consideration.

Overview

This part begins with a summary of the pertinent legal requirements, followed by a general profile of the economic health and prospects of the coal mining industry.

The discussion then turns to the rule being proposed by the Agency for underground coal mines. MSHA is proposing to require that mine operators utilize a particular technological approach to reduce the levels of dpm which result from the emissions generated by diesel equipment engines. No specific concentration limit for dpm would be established for the underground coal sector. Miner hazard awareness training would also be required by the proposal.

This part evaluates the proposed rule for underground coal mines to ascertain if, as required by the statute, it achieves the highest degree of protection for underground coal miners that it is feasible, both technologically and economically, for underground coal mine operators to provide.

Regulatory alternatives to the proposed rule are also reviewed in this regard, for example, establishing a dpm concentration limit for underground coal mines, with operator flexibility on choice of control technologies. After review and considerable study of these alternatives, the Agency has tentatively concluded that compliance with these alternatives discussed below are not technologically or economically feasible for underground coal mine operators at this time. MSHA has also tentatively concluded that the approach being proposed is both economically and technologically feasible for this sector.

Pertinent Legal Requirements

Section 101(a)(6)(A) of the Federal Mine Safety and Health Act of 1977 (Mine Act) states that MSHA's promulgation of health standards must:

* * * [A]dequately assure, on the basis of the best available evidence, that no miner will suffer material impairment of health or functional capacity even if such miner has regular exposure to the hazards dealt with by such standard for the period of his working life.

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

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

Thus, the Mine Act requires that the Secretary, in promulgating a standard, based on the best available evidence, attain the highest degree of health and safety protection for the miner with feasibility a consideration.

In relation to feasibility, the legislative history of the Mine Act states that:

* * * This section further provides that ''other considerations'' in the setting of health standards are ''the latest available scientific data in the field, the feasibility of the standards, and experience gained under this and other health and safety laws.'' While feasibility of the standard may be taken into consideration with respect to engineering controls, this factor should have a substantially less significant role. Thus, the Secretary may appropriately consider the state of the engineering art in industry at the time the standard is promulgated. However, as the circuit courts of appeal have recognized, occupational safety and health statutes should be viewed as ''technology-forcing'' legislation, and a proposed health standard should not be rejected as infeasible when the necessary technology looms in today's horizon. *AFL–CIO* v. *Brennan,* 530 F.2d 109 (1975); *Society of the Plastics Industry* v. *OSHA,* 509 F.2d 1301, *cert. denied,* 427 U.S. 992 (1975).

Similarly, information on the economic impact of a health standard which is provided to the Secretary of Labor at a hearing or during the public comment period, may be given weight by the Secretary. In adopting the language of [this section], the Committee wishes to emphasize that it rejects the view that cost benefit ratios alone may be the basis for depriving miners of the health protection which the law was intended to insure. S. Rep. No. 95–181, 95th Cong., 1st Sess. 21 (1977).

Court decisions have clarified the meaning of feasibility. The Supreme Court, in *American Textile Manufacturers' Institute* v. *Donovan* (OSHA Cotton Dust), 452 U.S. 490, 101 S.Ct. 2478 (1981), defined the word ''feasible'' as ''capable of being done, executed, or effected.'' The Court stated that a standard would not be considered economically feasible if an entire industry's competitive structure was threatened. According to the Court, the appropriate inquiry into a standard's economic feasibility is whether the standard is capable of being achieved.

Courts do not expect hard and precise predictions from agencies regarding feasibility. Congress intended for the ''arbitrary and capricious standard'' to be applied in judicial review of MSHA rulemaking (S.Rep. No. 95–181, at 21.) Under this standard, MSHA need only base its predictions on reasonable inferences drawn from the existing facts. MSHA is required to produce reasonable assessment of the likely range of costs that a new standard will have on an industry. The agency must also show that a reasonable probability exists that the typical firm in an industry will be able to develop and install controls that will meet the standard. See, *Citizens to Preserve Overton Park* v. *Volpe,* 401 U.S. 402, 91 S.Ct. 814 (1971); *Baltimore Gas & Electric Co.* v. *NRDC,* 462 U.S. 87 103 S.Ct. 2246, (1983); *Motor Vehicle Manufacturers Assn.* v. *State Farm Mutual Automobile Insurance Co.,* 463 U.S. 29, 103 S.Ct. 2856 (1983); *International Ladies' Garment Workers' Union* v. *Donovan,* 722 F.2d 795, 232 U.S. App. D.C. 309 (1983), *cert. denied,* 469 U.S. 820 (1984); *Bowen* v. *American Hospital Assn.,* 476 U.S. 610, 106 S.Ct. 2101 (1986).

In developing a health standard, MSHA must also show that modern technology has at least conceived some industrial strategies or devices that are likely to be capable of meeting the standard, and which industry is generally capable of adopting. *United Steelworkers of America* v. *Marshall,* 647 F.2d 1189, 1272 (1980). If only the most technologically advanced companies in an industry are capable of meeting the standard, then that would be sufficient demonstration of feasibility (this would be true even if only some of the operations met the standard for some of the time). *American Iron and Steel Institute* v. *OSHA,* 577 F.2d 825 (3d Cir. 1978); see also, *Industrial Union Department, AFL–CIO* v. *Hodgson,* 499 F.2d 467 (1974).

Industry Profile

The industry profile provides background information describing the structure and economic characteristics of the coal mining industry. This information was considered by MSHA as appropriate in reaching tentative conclusions about the economic feasibility of various regulatory alternatives. MSHA welcomes the submission of additional economic information about the coal mining industry, and about underground coal mining in particular, that will help it make final determinations about the economic feasibility of the proposed rule.

This profile provides data on the number of mines, their size, the number of employees in each segment, as well as selected market characteristics. This profile does not provide information about the use of diesel engines in the industry; information in that regard was provided in the first section of part II of this preamble.

Although this particular rulemaking does not apply to the surface coal sector, information about surface coal mines is provided here in order to give context for the discussions on underground mining.

Overall Mining Industry

MSHA divides the mining industry into two major segments based on commodity, the coal mining industry and the metal and nonmetal (M&NM) mining industry. These major industry segments are further divided based on type of operation (underground mines, surface mines, and independent mills, plants, shops, and yards). MSHA maintains its own data on mine type, size, and employment. MSHA also collects data on the number of contractors and contractor employees by major industry segment.

With respect to mine size, the mining community has traditionally regarded a ''small'' mine as being one with less than 20 miners. This has been a useful dividing line for a number of purposes, including rulemaking, because the nature of the safety and health issues facing such entities tends to be different than for larger mines. MSHA recognizes, however, that the definition of ''small entity'' used by the Small Business Administration in the mining sector is different—500 employees or less. In order to accommodate both perspectives when analyzing the impact of this proposed rule on the mining industry, MSHA has prepared its Preliminary Regulatory Economic Analysis (PREA) in such a way as to focus on the special impacts of both size categories—those with less than 20 employees, and those with less than 500 employees (basically all mines). In this profile, however, the term ''small mine'' refers to one with less than 20 miners.

Table V–1 presents the number of small and large coal mines and the corresponding number of miners, excluding contractors, by major industry segment and mine type. Table V–2 presents MSHA data on the numbers of independent contractors and the corresponding numbers of employees by major industry segment and the size of the operation based on employment.

TABLE V–1.—DISTRIBUTION OF OPERATIONS AND EMPLOYMENT (EXCLUDING CONTRACTORS) BY MINE TYPE, COMMODITY, AND SIZE

Mine type	Small (<20 EES)		Large (≥20 EES)		Total	
	Number of mines	Number of miners	Number of mines	Number of miners	Number of mines	Number of miners
Coal:						
Underground	426	4,371	545	46,206	971	50,577
Surface	776	4,705	370	28,314	1,146	33,019
Shp/Yrd/Mll/Plnt	399	2,538	128	5,010	527	7,548
Office workers	....	657	....	4,500	....	5,157
Total coal mines	1,601	12,271	1,043	84,030	2,644	96,301

Source: U.S. Department of Labor, Mine Safety and Health Administration, Office of Standards, Regulations, and Variances, based on preliminary 1996 MIS data (quarter 1–quarter 4, 1996). MSHA estimates assume that office workers are distributed between large and small operations the same as non-office workers.

TABLE V–2.—DISTRIBUTION OF CONTRACTORS (CONTR) AND CONTRACTOR EMPLOYEES (MINERS) BY MAJOR INDUSTRY SEGMENT AND SIZE OF OPERATION

Contractors	Small (<20)		Large (≥20)		Total	
	No. contr	No. miners	No. contr	No. miners	No. contr	No. miners
Coal:						
Other than office	3,606	13,954	297	13,792	3,903	27,746
Office workers	....	1,034	....	1,022	....	2,056
Total coal	3,606	14,988	297	14,814	3,903	29,802

Source: U.S. Department of Labor, Mine Safety and Health Administration, Office of Standards, Regulations, and Variances, based on preliminary 1996 MIS data (quarter 1—quarter 4, 1996). MSHA estimates assume that office workers are distributed between large and small contractors the same as non-office workers.

MSHA separates the U.S. coal mining industry into two major commodity groups, bituminous and anthracite. The bituminous group includes the mining of subbituminous coal and lignite. Bituminous operations represent over 93% of the coal mining operations, employ over 98% of the coal miners, and account for over 99% of the coal production. About 60% of the bituminous operations are small; whereas, about 90% of the anthracite operations are small.

Underground bituminous mines are more mechanized than anthracite mines in that most, if not all, underground anthracite mines still hand-load. Over 70% of the underground bituminous mines use continuous mining and longwall mining methods. The remaining use drills, cutters, and scoops. As noted in the first section of part II of this preamble, although underground coal mines generally use electrical powered equipment, a growing number of underground coal mines use diesel-powered equipment. (See Table II–1).

Surface mining methods include drilling, blasting, and hauling and are similar for all commodity types. Most surface mines use front-end loaders, bulldozers, shovels, or trucks for coal haulage. A few still use rail haulage. Although some coal may be crushed to facilitate cleaning or mixing, coal processing usually involves cleaning, sizing, and grading. As noted in section 1 of part II of this preamble, diesel power is used extensively in surface mines for all these operations.

Preliminary data for 1996 (MSHA/DMIS, Coal, CM–441, 1996) indicate that there are about 2,650 active coal mines of which 1,600 are small mines (about 60% of the total) and 1,050 are large mines (about 40% of the total). These data indicate employment at coal mines to be about 96,300 of which 12,275 (13% of the total) worked at small mines and 84,025 (87% of the total) worked at large mines. (*Ibid.*). MSHA estimates that the average employment is 8 miners at small coal mines and 81 miners at large coal mines.

The U.S. Department of Energy, Energy Information Administration, reported that the U.S. coal industry produced a record 1.06 billion tons of coal in 1996 with a value of approximately $20 billion. Of the several different types of coal commodities, bituminous and subbituminous coal account for 91% of all coal production (about 940 million tons). The remainder of U.S. coal production is lignite (86 million tons) and anthracite (4 million tons). Although anthracite offers superior burning qualities, it contributes only a small and diminishing share of total coal production. Less than 0.4% of U.S. coal production in 1996 was anthracite (DOE/EIA, 1997, p. 209).

Mines east of the Mississippi account for about 53% of the current U.S. coal production. For the period 1949 through 1996, coal production east of the Mississippi River fluctuated from a low of 395 million tons in 1954 to 630 million tons in 1990. During this same period, however, coal production west of the Mississippi increased each year from a low of 20 million tons in 1959 to a record 505 million tons in 1996. (*Ibid.*). The growth in western coal is due in part to environmental concerns that led to increased demand for low-sulfur coal, which is concentrated in the West. In addition, surface mining which is more prevalent in the West has increased in productivity due to the technological developments of oversized power shovels and draglines.

The 1996 estimate of the average value of coal at the point of production is about $19 per ton for bituminous coal and lignite. (*Ibid.*, at 221). MSHA chose to use $19 per ton as the value for all coal production because anthracite contributes such a small amount to total production that the higher value per ton of anthracite does not greatly impact the total value. The total value of coal production in 1996 was approximately $20 billion of which about $0.9 billion was produced by small mines and $19.1 billion was produced by large mines.

Coal is used for several purposes including the production of electricity. The predominant consumer of U.S. coal is the electric utility industry which used 898 million tons of coal in 1996 or 84% of the coal produced. Other coal consumers include coke plants (31 million tons), residential and commercial consumption (6 million tons), and miscellaneous other industrial uses (71 million tons). This last category includes the use of coal products in the manufacturing of other products, such as plastics, dyes, drugs, explosives, solvents, refrigerants, and fertilizers. (*Ibid.*, at 205).

The U.S. coal industry enjoys a fairly constant domestic demand due to electric utility usage of coal. MSHA does not expect a substantial change in coal demand by utilities in the near future because of the high conversion costs of changing a fuel source in the electric utility industry. Energy experts predict that coal will continue to be the dominant fuel source of choice for power plants built in the future.

Adequacy of Miner Protection Provided by the Proposed Rule for Underground Coal Mines

In evaluating the protection provided by the proposed rule, it should be remembered that MSHA has measured dpm concentrations in production areas and haulageways of underground coal mines as high as $3{,}650_{DPM}$ µg/m^3 with a mean concentration of 644_{DPM} µg/m^3. See Table III–1 and Figure III–1 in part III of this preamble. As discussed in detail in part III of the preamble, these concentrations place underground coal miners at significant risk of material impairment of their health, and the evidence supports the proposition that reducing the exposure reduces the risk. Therefore, to address this risk, the Agency is proposing to develop requirements which reduce these concentrations as much as is both technologically and economically feasible for this sector as a whole.

The proposed rule would require the installation of high-efficiency filters on all permissible and heavy-duty outby diesel-powered equipment in underground coal mines. Operators would have 18 months to install these filters on permissible diesel equipment, and an additional 12 months to do the same for heavy-duty nonpermissible diesel equipment (as defined by 30 CFR 75.1908(a)).

As an example of what filtration can achieve, take the case of a single-section mine with three Ramcars (94hp, indirect injection) and a section airflow of 45,000 cfm. MSHA measured concentrations of dpm in this mine at 610_{DPM} µg/m^3. Of this amount, 25_{DPM} µg/m^3 was coming from the intake to the section, and the remaining 585_{DPM} µg/m^3 was emitted by the engines. Reducing the engine emissions by 95% through the use of aftertreatment filters would reduce the dpm emitted to 29_{DPM} µg/m^3. With an intake amount of 25_{DPM} µg/m^3, the ambient concentration would be about 54_{DPM} µg/m^3. Similarly, dramatic results can be achieved in almost any situation if the filters achieve in practice the predicted reduction in particulate matter; and as the coal fleet turns over, in accordance with the existing diesel equipment rule, to the exclusive use of approved engines, the combination of that change and the use of 95% filters should keep ambient dpm concentrations at much lower levels than at present.

There are some reasons for caution. MSHA's experience with the high-efficiency filters is limited. While they are capable in laboratory tests of achieving a 95% reduction in dpm mass, and this has been confirmed in some field tests, the Agency has not tested them under a variety of actual mining conditions. As discussed in part IV, determination of the efficiency of any filter media is greatly dependent upon the test used to determine efficiency or collection capacity. Therefore, actual performance may be different in the field due to individual mining conditions (e.g., ventilation changes), changes of the equipment due to maintenance, and the type of engine used.

Two factors that come into play are the ventilation rate and the ambient dpm intake into the section. If ventilation levels drop below the nameplate requirements for gaseous emissions, or if many pieces of equipment throughout the mine create a high ambient level of dpm, implementation of the proposed rule may not bring concentrations down as effectively as suggested in the prior example. On the other hand, if the ventilation rate is maintained at a higher level, the engine emissions would be better diluted and the ambient concentration could offset any decrease in filter efficiency under actual mining conditions.

Table V–3 summarizes information from a series of simulations designed to illustrate these variables. The simulations were performed using the tool discussed in the Appendix to this part (MSHA's ''Estimator'') for a mine section with a 94 horsepower engine, with a 0.3 gm/hp-hr dpm emission rate and a nameplate airflow, 5500 cfm. The engine was operated during an eight hour shift. The estimator was used to calculate the values. The same results would be obtained for multiple pieces of equipment provided that the nameplate airflow is additive for each piece of equipment.

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Table V-3: Section DPM Concentrations for Various Airflow Rates, Afterfilter Efficiencies and Intake DPM Concentrations.

Airflow	Intake DPM ($\mu g/m^3$)	Resulting Section DPM Concentration ($\mu g/m^3$)		
		85 Percent After-filter	90 Percent After-filter	95 Percent After-filter
1.0 x Nameplate Airflow	0	452	302	151
2.0 x Nameplate Airflow	0	226	151	75
3.0 x Nameplate Airflow	0	151	101	50
4.0 x Nameplate Airflow	0	113	75	38
1.0 x Nameplate Airflow	25	477	327	176
2.0 x Nameplate Airflow	25	251	176	100
3.0 x Nameplate Airflow	25	176	126	75
4.0 x Nameplate Airflow	25	138	100	63
1.0 x Nameplate Airflow	50	502	352	201
2.0 x Nameplate Airflow	50	276	201	125
3.0 x Nameplate Airflow	50	201	151	100
4.0 x Nameplate Airflow	50	163	125	88
1.0 x Nameplate Airflow	75	527	377	226
2.0 x Nameplate Airflow	75	301	226	150
3.0 x Nameplate Airflow	75	226	176	125
4.0 x Nameplate Airflow	75	188	150	113

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In Table V–3, the intake dpm (second column) increases after every fourth row. Within each group of four rows, the ventilation (first column) increases from one row to the next. The last 3 columns display the ambient dpm concentration with a particular filter efficiency. The first four rows represent a situation where there is no intake dpm. If the mine is ventilated with four times the nameplate airflow (row 4), the ambient dpm concentration using a filter operating at 95% (last column) is reduced to 38_{DPM} µg/m^3. If the filter in this situation only works in practice at 85% efficiency in removing dpm, the ambient dpm concentration is only reduced to 113_{DPM} µg/m^3. And if the ventilation is reduced to the nameplate airflow (first column) and the filter is only 85% efficient, the ambient dpm climbs to 452_{DPM} µg/m^3. The last four rows display the parallel situation but with an ambient intake concentration to the section of 75_{DPM} µg/m^3. In this situation, depending on ventilation and filter effectiveness, the ambient dpm concentration ranges from 113_{DPM} to 527_{DPM} µg/m^3.

In the example discussed above—a single section mine with three 94 hp Ramcars—the airflow of 45,000 cfm represents three times the current nameplate requirements. If this airflow were reduced to the current nameplate requirements, the ambient dpm would have been 1620_{DPM} µg/m^3, and would have been reduced by 95% effective filters to 105_{DPM} µg/m^3.

It should be remembered that the proposed rule does not require the filtration of light-duty equipment; hence, mines with significant light duty equipment will have this exhaust as an ‘‘intake’’ in such calculations. Also, many underground coal mines may use more than the nameplate ventilation to lower methane concentrations at the face.

Based on its experience as to the general effects of mining conditions on the expected efficiency of equipment, and on ventilation rates, MSHA believes that the proposed rule for this sector will substantially reduce the concentrations of dpm to which underground coal miners are exposed. But in order to ensure that the maximum protection feasible is being provided, the Agency has considered some alternatives.

(1) Establish a Concentration Limit in Coal

Under such an approach, a diesel particulate concentration limit would be phased in and operators could select any combination of controls that keep ambient dpm concentrations below the limit.

After careful analysis, the agency has determined that it is not yet ready to conclude that it is technologically feasible to establish a dpm concentration limit for underground coal mines. The problem, as discussed in part IV, is that significant questions remain as to whether there is a sampling and analytical system that can provide consistent and accurate measurements of dpm in areas of underground coal mines where there is a heavy concentration of coal dust. The Agency is continuing to work on the technical issues involved, and should it determine that these technological problems have been resolved, it will notify the mining community and proceed accordingly.

(2) Alternatives to 95% Filters on Permissible and Heavy-duty Equipment

In part IV of this preamble, the agency outlines some approaches that might be considered as alternatives to the requirement in the proposal that *all* permissible and heavy-duty equipment must have a 95% aftertreatment filter installed and properly maintained.

The first alternative would in essence provide some credit in filter selection to those operators who use engines that significantly reduce ambient mine dpm concentration. Under this approach, the engine and aftertreatment filter would be bench tested as a unit; and if the emissions from the unit are below a certain level (e.g., 120_{DPM} µg/m^3, using 50% of the name plate ventilation, the emissions limit applicable under Pennsylvania law), the package would be acceptable without regard to the efficiency of just the filter component. The second option would also provide credit in filter selection for extra ventilation used in an underground coal mine. If the bench test of the combined engine and filter package was conducted at the name plate ventilation, a mine's use of more than that level of ventilation would be factored into the calculation of what package would be acceptable.

One practical effect of these approaches would be to permit some operators to save the costs of installing heat exchangers or other exhaust-cooling devices on nonpermissible heavy-duty equipment. Such devices are necessary in order for this equipment to be fitted with paper filters—and at the moment, these are the only filters on the market capable of providing 95% and more filtration capability. (It is not out of the realm of possibility that once a market develops for 95% filters, makers of ceramic filters will develop models that reach this level of efficiency—hence obviating the need for the heat exchangers or other exhaust cooling technology on the outby equipment; information or comment on this point would be welcome).

It is not clear to the Agency, however, that it would be appropriate, under the statute, to take such an approach. With the proper equipment to cool the exhaust, a 95% paper filter can be installed on any piece of heavy-duty equipment in coal mines—and of course directly on any permissible piece of equipment. And, as indicated herein, the Agency is tentatively concluding that such an approach is economically feasible as well. Installing a 95% efficient filter on an engine lowers the dpm concentration in the mine more than would installing a less efficient filter. Hence for engines which, with a 95% filter, can reduce emissions below 120_{DPM} µg/m^3 (or whatever emissions limit is set), the alternative approach would seem to provide miners with less protection.

In some cases, however, use of such an alternative approach could actually result in a reduction of mine dpm—by forcing out certain older, high-polluting engines. It is not clear to MSHA that 95% filtration of the engines used on the majority of permissible machines in underground coal mines can meet an emissions limit of 120_{DPM} µg/m^3 using MSHA's name plate ventilation. The engines involved just produce too much diesel particulate. Accordingly, adopting a rule with an emissions limit of 120_{DPM} µg/m^3 would in effect require these existing permissible engines to be replaced with cleaner engines. Of course, it follows that such a rule would be more costly than the one proposed, because it would require the 95% filters plus the replacement of these engines.

The second alternative (emissions limit plus credit for ventilation) appears to be less protective in all cases. To provide mines who need extra ventilation for other reasons (e.g., to keep methane in check) with a credit for this fact in determining the required filter efficiency would not reduce dpm concentrations as much as simply requiring a 95% filter.

The Agency welcomes comments on these approaches and information that will help it assess them in light of the requirements of the Mine Act.

MSHA recognizes that a specification standard does not allow for the use of future alternative technologies that might provide the same or enhanced protection at the same or lower cost. MSHA welcomes comment as to whether and how the proposed rule can be modified to enhance its flexibility in this regard.

(3) Accelerate the Time-Frame for Installation of Filters on Underground Coal Equipment

This approach would not change the level of protection ultimately provided to miners when the proposed rule is fully implemented. But it would ensure miners are protected more quickly, and therefore, needs to be considered.

Under the first phase of the proposed rule, 95% effective filters are required on all permissible equipment after 18 months. This equipment constitutes only about 19% of the 2,950 pieces of diesel-powered equipment estimated to be present in underground coal mines; but because of where and how it is used (production areas), it produces extensive amounts of particulate matter.

Cutting the 18 month time-frame does not appear to be practicable for the industry. Eighteen months to obtain and install a relatively new technology is a reasonable time. Time is needed for operators to familiarize themselves with this technology. Also, mine personnel have to be trained in how to maintain control devices in working order.

The second stage of the proposal requires the installation of 95% filters on heavy-duty nonpermissible equipment after 30 months—a year after the permissible equipment must be filtered. Again, speeding up this timeframe may not be practicable. If paper filters indeed have to be used, this equipment would need to be first equipped with water scrubbers, heat exchangers or other systems to cool the exhaust before the filtration can be installed, or dry technology installed. Providing another year also allows additional time for possible perfection of ceramic filtration, with the potential cost savings associated with that approach, or other improvements in filtration that could better protect miners. MSHA believes that providing the industry an extra year to phase in controls for the heavy-duty outby equipment is reasonable.

(4) Require High Efficiency Filters on Any Diesel Equipment in Underground Coal Mines

The proposed rule does not apply to approximately 65% of the equipment in the fleet—light-duty outby. While this equipment does not pollute as heavily as the equipment being covered by MSHA's proposal, it does contribute to the total particulate concentration in underground coal mines. And, as noted above, the Agency at this time lacks confidence in a measurement system that can detect localized concentrations even in outby areas. Accordingly, MSHA has considered the possibility of requiring filtration for such equipment.

The Commonwealth of Pennsylvania has recently adopted legislation for universal high-efficiency filtration based on an agreement in the mining community of that state. The Pennsylvania law requires the use of 95% efficiency filters on all diesel-powered equipment introduced in the future into underground coal mines in that state (in addition to other requirements). Since, however, the State did not allow the use of diesel-powered equipment in underground coal mines prior to enactment of this legislation, in practice the new law achieves a goal of universal filtration.

The Agency decided to consider what it would take to bring the rest of the industry up to the standard established under the Pennsylvania agreement of universal high-efficiency filtration. MSHA has calculated that such a requirement would cost the underground coal industry an additional $17 million a year. This would increase by 70% the costs per operator for the underground coal mining industry. This added cost raises questions because for those mines with permissible and heavy-duty equipment, filtering that equipment can achieve significant reductions in existing dpm concentrations. Given the economic profile of the coal sector, MSHA has tentatively concluded that such a requirement may not be feasible for the underground coal sector at this time.

MSHA welcomes information about light-duty equipment which may be making a particular significant contribution to dpm emissions in particular mines or particular situations, and which is likely to continue to do so after full implementation of the approval requirements of the diesel equipment rule. MSHA will consider including in the final rule filtration requirements that may be necessary to address any such identified problem. The Agency would also welcome comment on whether it would be feasible for this sector to implement a requirement that any new light-duty equipment added to a mine's fleet be filtered. By way of a rough cost estimate, if turnover is only 10% a year, for example, the cost of such an approach would be only about a tenth of that for filtering all light-duty outby. To the extent there may be technological restraints on filtering light-duty equipment with 95% filters, the Agency would welcome comment on the feasibility of requiring that 60–90% filtration be used on some or all of the light-duty fleet. And the agency is interested in comments as to whether it is likely that, in response to the market for high-efficiency filters on other types of equipment, there will soon develop high-efficiency ceramic filters suitable for light-duty equipment. MSHA welcomes comment on these and other approaches to dealing with light-duty equipment in underground coal mines, and will continue to study this issue in light of the record.

(5) Requiring Certain Engines to Meet Defined Particulate Emission Standards

As discussed in part II of this preamble, the Mine Safety and Health Advisory Committee on Standards and Regulations for Diesel-Powered Equipment in Underground Coal Mines recommended the establishment of a particulate index (PI), and MSHA did so in its diesel equipment rule. Under that rule, the PI establishes the amount of air required to dilute the dpm produced by an engine (as determined during its approval test under subpart E of part 7) to 1000 $\mu g/m^3$. In the preamble of the diesel equipment rule, MSHA explicitly deferred until this rulemaking the question of whether to require engines used in mining environments to meet a particular PI. It noted that mine operators and machine manufacturers would find it useful to consider the engine PI in selecting and purchasing decisions.

Since the publication of the PI is a relatively new requirement, the agency does not believe it has enough information at this time to evaluate the feasibility of a requirement that certain engines must meet a particular PI to be used in underground coal mines. Presumably, coupling such a requirement with a requirement for a 95% filter would provide more protection to miners than requiring only the 95% filter; but without information about what is technologically available for any type of engines, the Agency would have difficulty in selecting the PI to require.

MSHA solicits comments on whether it should limit the PI or the PI per horsepower of engines used in underground coal mines.

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

The technology exists to implement the proposed rule's requirements for 95% filtration of permissible and ''heavy-duty'' equipment. As widely recognized now by the mining community (see, e.g., MSHA's ''Toolbox''), there are disposable paper filters available for permissible coal mine equipment equipped with water scrubbers that meet the proposed rule's requirements for efficiency. In addition, a dry technology (known as the DST®) of very high efficiency is also available for this type of equipment. Based on its long experience with diesel-powered outby equipment, the Agency is also confident that the disposable paper filters can be used on this equipment too—once the equipment is equipped with water scrubbers, heat exchangers, or other systems to first cool the exhaust enough so the paper filters will not burn. The dry technology used on permissible equipment can also work on the outby equipment. MSHA understands that filtration systems that meet the efficiency requirements in the proposed rule, and which are specifically designed to fit on outby equipment are under development; additional information in this regard would be welcome.

The total costs for the proposed rule for underground coal mines are about $10 million per year beyond the $10.3 million per year costs this sector is already absorbing to implement the requirements of MSHA's recent diesel equipment rule. The costs per dieselized mine are expected to be about $58,000 a year (the diesel equipment rule costs per dieselized mine are about $59,000 a year). The proposed rule provides adequate time for equipment purchase, installation, and training. MSHA has calculated that the costs of the proposed rule amount to less than one-half of one percent of the revenues of the underground coal mining sector at this time. (The methodology for this calculation is discussed in part V of the Agency's PREA). After reviewing the economic profile of that sector, and taking into account the cost of implementing the related diesel equipment rule, MSHA has concluded that the proposed rule is economically feasible for this sector as a whole.

Conclusion: Underground Coal Mines

Based on the best evidence available to it at this time, the Agency has concluded that the proposed rule for the underground coal sector meets the statutory requirement that it 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 the 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.

Moreover, 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.

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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 Mine				
						Column A		Column B	
1. MEASURED OR ESTIMATED IN MINE DP EXPOSURE (ug/m3)						330	ug/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			Truck2	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					Truck2	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					Truck2	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	ug/m3	50	ug/m3
SECTION AIR QUANTITY						155000	cfm	155000	cfm
AIRFLOW PER HORSEPOWER						173	cfm/hp	173	cfm/hp
4. CALCULATED SWA DP CONCENTRATION WITHOUT CONTROLS						---		551	ug/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	ug/m3	184	ug/m3

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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

Spreadsheet section	Input/output	Mine information
SECTION 1	INPUT	MEASURED DP LEVEL, µg/m³.
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/m³.
SECTION 4	OUTPUT	CURRENT DP LEVEL, µg/m³.
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/m³.

Section 1. This is the place to enter data on baseline dpm concentrations if obtained by actual measurement or 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) x (Q(I) / 35200) / [Sum (Hp(I) x 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) x Hp(I) x 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, 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) x Hp(I) x To(I))] x 35,300 / Q(I)]+I} x [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 be either 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, reprinted as an Appendix to the end of this document. 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. But 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) x 1000 x [(E(a) / 60) x Hp(I) x (35300 /Q(I)) x (Q(I) / Q(f)) x (1-R(o)) x (1-R(f)) x (1-R(e))]} + I

Where:

DPM(c) = Diesel particulate concentration after control application/ μg/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, μg/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) x Hp(I) x To(I)) x (35,300 / Q(I)) x (1-R(o)) x (1-R(f)) x (1-R(e))] x [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,
(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 coal sector.

The key conclusions of the PREA are summarized, together with cost tables, in part I of this preamble (see Question and Answer 5). 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–AA74). 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

Introduction

Pursuant to the Regulatory Flexibility Act of 1980, MSHA has analyzed the impact of this rule upon small businesses. Further, MSHA has made a preliminary determination with respect to whether or not it can certify that this proposal will not have a significant economic impact on a substantial number of small entities. Under the Small Business Regulatory Enforcement Fairness Act (SBREFA) amendments to the RFA, MSHA must include in the proposal a factual basis for this certification. If the proposed rule does have a significant economic impact on a substantial number of small entities, then the Agency must develop an initial regulatory flexibility analysis.

Based upon MSHA's analysis, the Agency has determined that the proposed rule will not have a significant economic impact on a substantial number of small underground coal mine operators, and has so certified to the Small Business Administration (SBA). MSHA specifically solicits comments on the cost data and assumptions concerning the regulatory flexibility certification statement for underground coal 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 coal mine operator. In addition, the regulatory flexibility certification, including its factual basis, 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 coal 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''. In concluding that it can certify that the proposed rule has no significant economic impact on a substantial number of small entities in the underground coal sector, the Agency determined that this is the case both for underground coal mines with 500 or fewer miners and for underground coal mines with 20 or fewer miners.

The Underground Coal Mines: Factual Basis for Certification

The Agency's analysis of impacts on ''small entities'' and ''small mines'' begins with a ''screening'' analysis. The screening compares the estimated compliance costs of the proposed rule for small mine operators in each affected sector to the estimated revenues for that sector. When estimated compliance costs are less than 1 percent of estimated revenues, (at both of the size categories considered), the Agency believes it is generally appropriate to conclude that there is no significant economic impact on a substantial number of small entities. When estimated compliance costs approach or exceed 1 percent of revenues, it tends to indicate that further analysis may be warranted. The Agency welcomes comment on its approach in this regard.

Derivation of Costs and Revenues for Screening Analysis

In the case of this proposed rule, because the compliance costs must be absorbed by underground coal mines only, the agency focused its attention exclusively on the relationship between costs and revenues for underground coal mines, rather than looking at the coal sector as a whole.

The compliance costs for this analysis are presented earlier along with an explanation of how they were derived. In deriving compliance costs, there were areas where different assumptions had to be made for small mines in order to account for the fact that the mining operations of small mines are not the same as those of large mines. For example, assumptions used to derive compliance costs concerning: the number of production shifts per mine, and the number of days the mine operates on an annual basis were different depending on whether the mine was classified as either a large or small mining operation. In determining revenues for underground coal mines, MSHA multiplied underground coal production data (in tons) for underground coal mines in specific size categories (reported to MSHA quarterly) by $19 per ton (the average rounded price per ton). The Agency welcomes comment on alternative data sources that can help it more accurately estimate revenues for the final rule.

Results of Screening Analysis

With respect to underground coal mine operators, as can be seen in Table VI–1, when the definition of a small mine operator is fewer than 20 employees, then estimated average per year costs of the proposed rule are $8,000 per small mine operator and estimated costs as a percentage of revenues are 0.04 percent for small mine operators. When the definition of a small mine operator is fewer than 500 employees, then estimated average per year costs of the proposed rule are $57,650 per small mine operator and estimated costs as a percentage of revenues are 0.13 percent for small mine operators.

In both cases, the impact of the proposed costs is less than 1 percent of revenues, well below the level suggesting that the proposed rule might have a significant impact on a substantial number of small entities. Accordingly, MSHA has certified that there is no such impact for small entities that mine underground coal.

TABLE VI–1.—UNDERGROUND COAL MINES

	Estimated costs (thous.)	Estimated revenue (million)	Estimated cost per mine	Costs as % of revenue
Small <20	$120	$287	$8,000	0.04
Small <500	9,624	7,359	57,650	0.13

As required under the law, MSHA is complying with its obligation to consult with the Chief Counsel for Advocacy on this proposed rule, and on the Agency's certification of no significant economic impact in underground coal. 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 section 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 section 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 coal mining industry are about $10 million per year. Accordingly, there is no need for further analysis under section 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 coal mines, and MSHA is not aware of any state, local or tribal government ownership interest in underground coal 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–1 and VI–2 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 the 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 April 7, 1998.

The Agency's complete paperwork submission is contained in the PREA, 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 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 mine operators and diesel equipment manufacturers.

Description

The proposed rule would result in additional burden hours associated with: the additional training that will be required for diesel equipment operators under § 75.1915; the additional changes required to be included in the mine ventilation plans under §§ 75.370 and 75.371; the new training requirements in proposed § 72.510; and the additional burden hours for equipment manufacturers under part 36 in connection with the approval of filtration systems that would be required by this rule.

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

TABLE VI–2.—UNDERGROUND COAL MINES BURDEN HOURS

Detail	Large	Small	Total
75.370	93	9	102
75.371	158	8	166
75.1915	12	1	13
72.510	347	5	352
Total	610	23	633

TABLE VI–3.—DIESEL EQUIPMENT MANUFACTURERS BURDEN HOURS

Detail	Total
Part 36	520
Total	520

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List of Subjects

30 CFR Part 72

Coal, Health standards, Mine safety and health, Underground mines, Diesel particulate matter.

30 CFR Part 75

Mine safety and health, Underground coal mines, Ventilation.

Dated: March 31, 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 72—[AMENDED]

1. The authority citation for Part 72 continues to read as follows:

Authority: 30 U.S.C. 811, 813(h), 957, 961.

2. Part 72 is amended by adding Subpart D to read as follows:

Subpart D—Diesel Particulate Matter—Underground

Subpart D—Diesel Particulate Matter—Underground

§ 72.500 Diesel particulate filtration systems.

(a) As of [insert the date 18 months after the date of publication of the final rule], any piece of permissible diesel-powered equipment operated in an underground coal mine shall be equipped with a system capable of removing, on average, at least 95% of diesel particulate matter by mass.

(b) As of [insert the date 30 months after the date of publication of the final rule], any nonpermissible piece of heavy duty diesel-powered equipment (as defined by § 75.1908(a) of this title) operated in an underground coal mine shall be equipped with a system capable of removing, on average, at least 95% of diesel particulate matter by mass.

(c) The systems required by this section shall be maintained in accordance with manufacturer specifications.

(d) In determining, for the purposes of this section, whether a filtration system is capable of removing, on average, at least 95% of diesel particulate matter by mass, emission tests shall be performed to compare the mass of diesel particulate matter emitted from an engine with and without the filtration system in place. Such tests shall be performed using the test cycle specified in Table E–3 of § 7.89 of this title. The filtration system tested shall be representative of the system intended to be used in mining.

§ 72.510 Miner health training.

(a) All miners at a mine covered by this subpart 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)(1) 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. Such record may 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 such training record. Whenever an operator ceases to do business, that operator shall transfer such records, or a copy thereof, to any successor operator who shall receive these records and maintain them for the required period.

PART 75—[AMENDED]

3. The authority citation for part 75 continues to read as follows:

Authority: 30 U.S.C. 811.

4. Section 75.371 is amended by adding paragraph (qq) to read as follows:

75.371 Mine ventilation plans; contents.

* * * * *

(qq) A list of diesel-powered units used by the mine operator together with information about any unit's emission control or filtration system.

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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

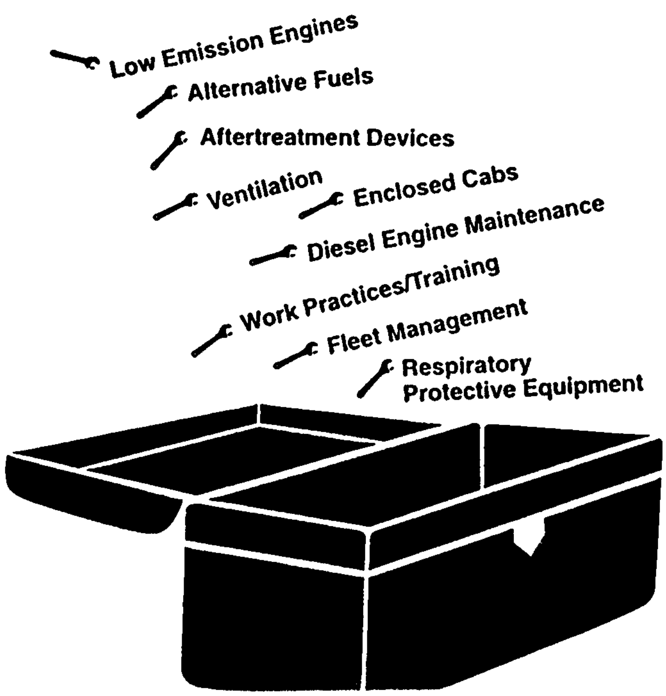

TABLE OF CONTENTS

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.

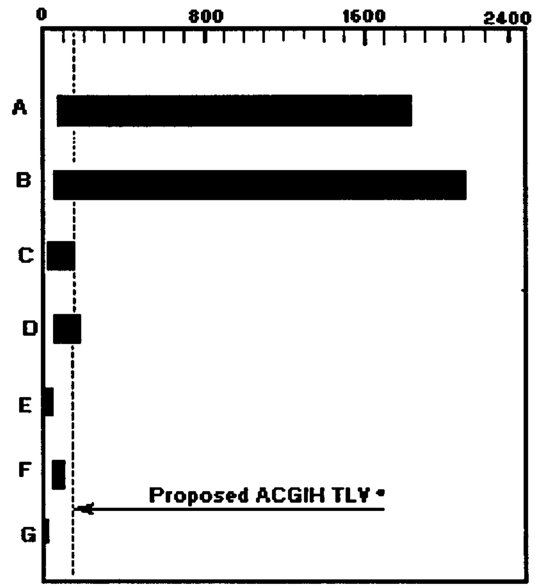
For example, 0.15 mg/m^3=150 $\mu g/m^3$.

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.