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2009 DEC 14 P 2:27

December 14, 2009

Ms. Patricia Silvey
U.S. Department of Labor - Office of Standards
Mine Safety and Health Administration
1100 Wilson Boulevard, Room 2350
Arlington, VA 22309-3939

Dear Ms. Silvey:

Attached are the comments of the United Mine Workers of America for the Request for Information Regarding Use of the Continuous Personal Dust Monitor (CPDM), 74 (194) FR 52708-12 (October 14, 2009); RIN 1219-AB48.

The UMWA appreciates the opportunity to participate in this important rulemaking and asks that you forward our comments to the appropriate person(s) for consideration.

Sincerely,

Dennis O'Dell

Dennis O'Dell, Administrator
UMWA Department of Occupational
Health and Safety

AB48-COMM-4

Attachment 1

Reply to Request for Information Regarding Use of the Continuous Personal Dust Monitor (CPDM)

74 (197) FR 52708-12 (October 14, 2009)
RIN 1219-AB48

1. Please address conditions and circumstances under which CPDMs should be proposed for use in underground coal mines. In your response, include factors such as mine size, compliance history, type of mining, presence of quartz, and designated occupation. In addition, please address whether the CPDM could be integrated into the existing compliance strategy, and, if so, how. Please be specific in your response, and address any technological and economic feasibility issues associated with using CPDMs.

The CPDM should be used for two general purposes: compliance and for investigation and surveillance.

Compliance. Most aspects of compliance policy are independent of the technology used to monitor exposure. Some aspects arise that are unique to the PDM because of its unique capabilities. In particular, its ability to give real-time measurements of dust concentration and to project end-of-shift average concentrations creates a duty for mine operators to reduce dust concentration before the end of a shift. This duty did not exist before advent of the PDM. Failure to exercise this duty is an occasion of non-compliance. Another unique capability of the CPDM is the cost-effectiveness with which additional samples can be taken. If instances of over-exposure at a mine become chronic or if other circumstances warrant, it is possible with the CPDM to conductive intensive sampling at a mine in order to identify causes of over exposure.

In general, compliance policy should be guided by several principles stipulated in the Mine Act. These are, first,

> The Secretary, in promulgating mandatory standards dealing with toxic materials or harmful physical agents under this subsection, shall set standards which most adequately assure on the basis of the best available evidence that no miner will suffer material impairment of health or functional capacity even if such miner has regular exposure to the hazards dealt with by such standard for the period of his working life. Development of mandatory standards under this subsection shall be based upon research, 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. (Sec. 101 (a)(6)(A)). (emphasis added)

and second, The purpose of compliance is to protect the health of each and every miner and shall not exclude miners that happen to work in small mines. As the Mine Act says,

> " . . each operator shall continuously maintain the average concentration of respirable dust in the mine atmosphere during each shift to which each miner in the active workings of such mine is exposed at or below 2.0 milligrams of respirable dust per cubic meter of air. (Sec. 202 (b)(2)). (emphasis added)

That is, the purpose of ensuring compliance with the exposure limit is to prevent pneumoconiosis.[1]

Miners' exposure should not exceed the eight-hour time-weighted average PEL or its equivalent if miners work more than eight hours per shift or more than 40 hours per week.

Investigation and Surveillance. The CPDM should also be used as an investigative tool. That is, it should be used to find those circumstances under which exposure exceeds or is likely to exceed the exposure limit. With this knowledge, the operator should be able to control those circumstances and prevent excessive exposure.

The capability of the CPDM to provide real-time measurements of dust concentration in an electronic format is unique. It is a significant improvement in our ability to identify with precision those instances of exposure to excessive levels of dust and the conditions that cause them and therefore to reduce dust concentration to safe levels. These capabilities should be fully utilized to enable dust controls to be implemented in real time, i.e., at the time and place when exposure occurs.

The most pertinent characteristic of mines that should be used when deciding how to use the CPDM is miners' dust exposure. Factors such as mine size and type of mining should not be a consideration as they are related to dust exposure. They should play no role in deciding whether to use the CPDM or how to achieve compliance or control dust exposure.

Since the CPDM is technically incapable of making real time measurements of the concentration of quartz dust, enforcement of the concentration limit for quartz should follow the present practice: i.e., MSHA should determine the percent quartz, calculate a reduced standard for respirable dust, and the CPDM should measure the concentration of respirable dust and non-compliance determined if that concentration exceeds the reduced standard. Conceivably, the CPDM could be used to analyze full shift samples for quartz by removing dust accumulated on the detector and analyzing this dust for quartz content but to our knowledge, this capability does not yet exist, therefore quartz shall be sampled with gravimetrics as it is done today.

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[1] Throughout this document, the term "pneumoconiosis" means the full spectrum of conditions caused by exposure to excessive amounts of respirable mine dust. This is consistent with the definition provided in regulations designed to provide compensation for "black lung." These conditions include not only the medically defined entities, "coal workers pneumoconiosis" and "silicosis," which are parenchymal diseases of the lung evident on chest x-ray films, but also effects on airways, i.e., chronic bronchitis and emphysema.

In some circumstances, for purposes of determining non-compliance with the quartz standard, MSHA should take samples, analyze them for the concentration (not percent) of quartz and if it exceeds the exposure limit, to issue a citation for non-compliance. This approach is justified in part by knowledge of some conditions under which exposure to quartz is likely, i.e., whenever the operator cuts into roof or floor and into quartz bearing rock (such as sandstone or granite). Under those circumstances, an operator should know of the potential for exposure to quartz and should be expected to take reasonable steps to reduce exposure even in the absence of a reduced standard.

A significant constraint on current enforcement of the standard is the failure to take samples for a full shift in spite of miners working longer than eight hours per shift and more than forty per week. This constraint should be removed regardless of how concentration is measured because it prevents MSHA (or anybody else) from making an accurate measurement of miners' exposure. That constraint is in 30 CFR 201(b):

> Sampling devices shall be worn or carried directly to and from the mechanized mining unit or designated area to be sampled and shall be operated portal to portal. Sampling devices shall remain operational during the entire shift or for 8 hours, whichever time is less.

While it is implied that this regulation applies to operator samples, it is nonetheless applied by MSHA to its own samples. It should be applied to neither samples and should be removed.

In any event, the CPDM should be used to measure exposure for a full shift per day. The benchmark for determining compliance is the exposure equivalent either to an eight hour shift (because the current standard assumes an eight hour shift). This issue is discussed in more detail below.

2. Please address the advantages and disadvantages of the existing compliance strategy, which relies on a combination of occupational and area sampling, versus a personal exposure monitoring strategy only. Please be specific in your response, noting the safety and health benefits of each strategy.

There are three problems with this question. The first is that it assumes that the current sampling method (pump-and-filter) and the CPDM are interchangeable and that the additional capabilities of the CPDM do not create additional types of samples. (We discuss this in more detail below.) The second is that it assumes that there are only two alternative sampling schemes: occupational and area sampling on the one hand and personal sampling on the other. There are in fact seven logical schemes, as shown in the table below.

	Type of Sample		
Sampling Scheme	Occupational	Personal	Area
1	X		
2		X	
3			X
4	X	X	
5	X		X
6		X	X
7	X	X	X

The third problem is that it treats personal and occupational samples as mere technical variations devoid of context. They are, on the contrary, significantly entangled in forty years of fraudulent sampling methods. So we start with a discussion of the current sampling context, explain our reasons for favoring occupational rather than personal sampling and suggest uses for area sampling.

There are three fundamental defects in the current sampling strategy. The first defect is that sampling for compliance has been delegated to mine operators with only limited oversight by MSHA. The second defect is that the current sampling instrument is vulnerable to manipulation. The third defect is that sampling is limited to eight hours in spite of most miners working longer shifts.

The first two of these defects are manifest in the history of corruption of the current dust monitoring program. From the beginning of the program in the 1970s to the end of the century, whenever MSHA looked for fraudulent samples, it found them. Fraud was possible because the designated person was an employee of the operator; fraud was likely because the operator had strong incentives to submit samples that showed he was in compliance. The entire sampling cycle presented opportunities for fraud: assembling the apparatus, placing (or not) it on the miner, recording the time and conditions (creating an opportunity to "legally" void samples that were unsatisfactory for other reasons), and mailing it to MSHA for processing. Many if not most of these functions were performed without supervision. Thus delegating sampling to mine operators, failing to provide oversight, and using a sampling method with many opportunities to manipulate created the conditions that practically guaranteed fraud. At the very least, it significantly undermined the credibility of dust samples. The CPDM helps find a solution to the sampling technology problem but it does nothing to solve the organizational problem.

The solution to help solve the technological problem is to replace the current technology with the CPDM for all mines. We say more about this later and for now, focus attention on the organizational defect as the context for the mix of personal, occupational, and area samples.

The organizational defect in the current sampling strategy is best understood by examining the predicament of the certified person. His function is described in 30 CFR 103:

> (a) Approved sampling devices shall be maintained and calibrated by a certified person.

(b) To be certified, a person shall pass the MSHA examination on maintenance and calibration procedures for respirable dust sampling equipment.

(c) A person may be temporarily certified by MSHA to maintain and calibrate approved sampling devices if the person receives instruction from an authorized representative of the Secretary in the maintenance and calibration procedures for respirable dust sampling equipment under this rule. The temporary certification shall be withdrawn if the person does not successfully complete the examination conducted by MSHA on maintenance and calibration procedures within six months from the issue date of the temporary certification.

As many miners have put it, when it comes to dust sampling, operators are "the fox guarding the chicken coop." The certified person should be called the certified fox. One aim of a reorganized sampling program is to repair this defect. This can be done by eliminating or significantly changing operators' role altogether and by improving MSHA's oversight. The recommendation of the UMWA BCOA task force was to eliminate the operators role and have MSHA control sampling for compliance. This was the easiest consensus for the UMWA-BCOA task force to reach, but for different reasons. Mine operators were in a double bind – they were mistrusted if a sample was low and slandered as reckless dust mongers if it was high – and the Union simply did not trust the results of any sampling by mine operators. But removing operators from sampling is easier said than done. Mine operators are required to monitor miners' exposure to respirable dust by the Mine Act: "Each operator shall take accurate samples of the amount of respirable dust to which each miner is exposed." (Sec. 202(a)) This legislative mandate says nothing about how frequently samples are to be taken or how those samples are to be used, whether for compliance or not. But it does say that the operator shall (sic) use a device approved by the Secretary of Health and Human Services (i.e., by NIOSH).[2]

But partial removal is possible and some functions can and should be taken over by MSHA.

Let us assume that the certified person remains. One way to improve this person's situation is by limiting his role to taking samples that are not used for compliance and by strengthening that person's loyalty to MSHA and its mission. One of the reasons that the current system has been weakened by corruption over the past forty years is that these persons have been placed in a very difficult conflict of interest. Their first allegiance is, as it is for most of us, to their employer and MSHA seems to have done little or nothing to build loyalty to itself. Yet they are called upon to perform a function delegated by MSHA that could bring penalties to their employer. Whether consciously or not, this results in powerful incentives to, when the opportunity arises, give the benefit of doubt to the employer and to "look the other way" when conditions are unusual on the days that samples are taken. More perverse examples are abundant, as the history of felony convictions for fraud attests. This structural problem must be solved if dust monitoring is to regain credibility.

For the certified person to perform his function faithfully, there should be stronger bonds between that person and MSHA. It is not sufficient for MSHA merely to "train and certify" this

[2] Thus, NIOSH also has a mandate to approve a sampler for this use. Importantly, the choice of the sampler belongs to NIOSH, not anybody else, such as the mine operator.

person only once then to ignore them thereafter. MSHA should periodically audit the performance of certified persons and should build a relationship with these persons, intended to build loyalty, camaraderie, a sense of purpose, and MSHA should do more to hold them accountable. Specifically, we suggest MSHA hold quarterly meetings in each District for the purpose of keeping the certified persons up to date on MSHA policy and technological developments. During these meetings, the certified persons should be encouraged to raise questions and concerns about sampling methodology and to share solutions to common problems. They could learn from each other and MSHA could learn a lot from them. Expenses for this meeting should be covered by MSHA and income for the day should be provided by the mine operator.

Efforts like this would not "solve" the problem but it would create an environment that would support certified persons performing their tasks as intended. Neglecting them, as is the historical practice, is sowing the seeds for continued corruption.

Discussing the type of sample in the context described above can now have more meaning. One of the ways that fraud festered derived directly from the choice of whether to use personal or occupational samples as the basis for determining compliance. Such a decision was implemented and perhaps made by the certified person. If an operator wants to produce a sample that will demonstrate compliance (when in fact he might not be in compliance), a personal sample is the sample of choice. A "person," is easily manipulated, especially by his supervisor. That is what supervisors do. So in the name of making an ordinary operational decision, the person can be assigned work in an area known to have low dust levels. A personal sample, by the conventional practice of Industrial Hygiene, is also the preferred (over area samples) method of measuring workers' exposure. It samples the air that the person breathes and this is the air that can cause disease. Furthermore, the "occupational" sample is practically unheard of among industrial hygienists outside of the coal mining industry.

Whether an operator's choice to re-assign a worker to a less dusty area is intentional, of course, is difficult to say. This situation is like racial discrimination. The discriminatory act is rarely verbalized as such; one can only judge actions and their interpretation is informed by context and history. In the case of dust sampling, history is full of many examples of fraud. The context is one where the operator, via the certified person, has the opportunity and the incentive to avoid a citation. The certified person has the blessing of the agency, persons for whom a personal sample is being taken can be reassigned as ordinary operational decisions, industrial hygiene prefers the personal sample and barely recognizes the occupational sample. It is an overused metaphor, but it is a perfect storm for obscuring fraudulent samples. By opposing personal samples, critics can be discredited because they appear to oppose an employer's need to make ordinary operational decisions by assigning people to certain tasks and they appear to oppose professional conventions of industrial hygiene.

The Union's intention is, however, real assessment of exposure rather than fabrications. It is for these reasons that we oppose personal sampling and propose occupational sampling as the preferred means of determining compliance. It is a better and more credible method of measuring exposure and therefore, better for making determinations of non-compliance.

One factor that changes this environment is the specter of daily, as opposed to bi-monthly sampling. The fraudulent practice described above is possible, in part, because sampling is relatively infrequent. That being the case, it is a minor inconvenience to re-assign a miner with a personal sampler for one day (or five) every two months. If sampling is more frequent, moving him on sampling days becomes more inconvenient. If sampling is done every shift of every day, this particular loop-hole disappears altogether.

Such difficulties do not exist for area sampling. Area sampling is inherently useful, regardless of any other type of sampling, as a means of evaluating dust controls at a mine. But this utility depends on the selection of areas and analysis of the data. Clearly, area sampling is not a suitable surrogate for personal sampling but that is not its intent. Selection of the area for sampling should depend on at least three factors: potential sources of dust, air flow rate (cfm), and whether inby or outby the face. Implied in these factors is consideration of ventilation controls such as regulators, point-feeds, cross-cuts, curtains, auxiliary ventilation, and the like. Compliance with arbitrary dust concentration standards should not be a consideration. Rather, mine workers, MSHA and the mine operators should use data from area samples for the purpose of evaluating dust controls and thereby achieving the intention of the Mine Act which states, in Sec. 303 (b):

> [T]he Secretary shall prescribe the minimum velocity and quantity of air reaching each working face of each coal mine in order to render harmless and carry away methane and other explosive gases and to reduce the level of respirable dust to the lowest attainable level. (Emphasis added.)

Mine operators can achieve this goal if, for example, an area sample indicates a higher concentration than usual and it occurs in an air course that feeds a working face. He could identify the cause (e.g., failure of a water spray on a coal transfer location or closure of a regulator) and take appropriate steps to reduce the dust concentration in air feeding a working face.

Area sampling is also useful if an established gradient in dust concentration exists and that can be used to advantage in reducing dust control. "Designated occupation" (DO) sampling is based on the assumption that a dust concentration gradient exists from the DO to other occupations on a working face. If the dust concentration to which the DO is exposed is consistently the highest concentration to which other occupations are exposed, then if that concentration is reduced to an acceptable level, then the concentration to which other occupations would be acceptable also.

This same concept can be used in other circumstances also, provided a concentration gradient can be established. For example, if a miner is working on a remote control mining machine, area samples could be used to establish a concentration gradient in relation to the mining machine (a dust source) thereby creating a strategy for that miner to position himself to achieve an acceptable concentration.

And, in general, short term and long term area samples are very useful as a means of identifying dust sources and successful dust strategies.

However, the boundary between area, occupational, and personal samples, although they are clear conceptually, they are not clear in practice. Under current rules, the mine operator may place a dust sampler on a miner in the DO ". . or 36 inches inby the normal work position." (30 CFR 70.207 (e)) The latter practice – 36 inches inby – is in practice an area sample although it is classified as equivalent to the DO sample. Since the MSHA database does not distinguish between samples placed on the miner or 36 " inby, we cannot evaluate how many DO samples are such area samples. Furthermore, if a miner stays in his occupation for an entire shift, the personal sample and the occupational samples are identical.

Finally, area samples can be used to audit a sampling program. For example, dust concentration in intake airways is typically less than 0.2 mg/m^3 and often less than 0.1 mg/m^3. If an operator submits samples that show dust concentration less than about 0.2 mg/m^3 as a DO sample, those samples lacks credibility. It is very unlikely that dust generated by mining would add little or nothing to the concentration of dust in intake air. Sampling practices at such a mine should be investigated.

<u>For all these reasons, we support occupational and area sampling only.</u>

3. If CPDMs were to be required, how should a compliance strategy based on CPDMs be structured? Please be specific as to miners and occupations covered and include the rationale for your response. Include suggestions for the role of the mine operator, miner, miners' representatives, and MSHA under such a strategy.

Strategy for Monitoring Miners' Exposure to Respirable Dust and Quartz Dust

A program for monitoring miners' exposure to dust has two principal objectives:

1. To reduce miners' exposure to respirable dust and quartz dust to a level that is sufficient to prevent the occurrence and progression of pneumoconiosis. This level is to be set by MSHA under Sec. 101 (a)(6)(A) of the Mine Act (i.e., evaluating individual dust measurements to determine compliance, and
2. To measure progress in achieving the goal of reducing dust exposure to that level. As in any surveillance program, analysis of dust exposure data would identify trends in dust exposure and would identify clusters of excess exposure and would base its intervention efforts on these and other findings (i.e., measuring dust collectively over time periods).

To achieve these objectives, the dust monitoring program would operate at two levels: at mines and within the agency, as follows.

1. The intent of dust monitoring at mines would be
   a. to ensure compliance with the exposure limit
   b. to provide miners, MSHA and operators with the means to identify sources of excess exposure and thereby to design, implement, and maintain dust control parameters.
2. The intent of dust monitoring within the agency would be
   a. To issue citations for non-compliance,

b. To follow-up on each citation to assess whether the operator came into compliance,
c. To analyze data for the purpose of improving miners' exposure, and
d. To investigate dust monitoring practices to ensure samples are properly taken.

This is a holistic approach to dust monitoring, independent of the specific sampling technology. Rather than focus attention only on compliance, we suggest designing a dust monitoring program in its entirety and focus on the objective of preventing pneumoconiosis by controlling miners' exposure below the exposure limit over each miners' entire career. Each inspection is but part of a larger effort of disease prevention. Below we discuss each separate aspect of this effort and show how it fits into this larger framework.

We recognize that mines differ from one another in how well they control dust exposure, their coal mining methods, size, etc. Some of these differences should be considered in designing policy and some should not. All mine operators, regardless of differences, should be held to the same standard of performance (i.e., compliance with exposure limits) and, to ensure that all miners receive the benefits of monitoring by the CPDM, this instrument should be the principal means of monitoring exposure, implementing the Dust Control Plan, and determining non-compliance. This is a question of elementary fairness. Miners' health should not be sacrificed to accommodate differences that mine operators must accommodate on a daily basis – such as the conditions at a mine, the mine's size, its location, mining methods, etc. The important differences between mines and mine operators is their performance in reducing miners' exposure to respirable dust.

Use of other instruments (e.g., the current pump-and-filter device) should be limited to taking samples to determine the quartz content and eventually for setting a reduced standard if there is more than 5% quartz in the sample. (Incidentally, "more than 5% quartz" does not mean "5% plus an error factor.")

Exposure and Exposure Limits.

The criteria for establishing an exposure limit is described well in the Mine Act at Sec. 101 (a)(6)(A), above.

As described in detail below, "exposure" is measured with two parameters: dust concentration (mg/m^3) and duration of exposure for shift length greater than 8 hours and exposure limits should use the same metric. To emphasize this point, an exposure limit should be expressed using the metric "mg-hours/m^3" so that, for example, a 2.0 mg/m^3 standard for an 8 hour work shift should be expressed as 16.0 mg-hours/m^3. This would be the constant exposure limit for any shift, for 8 hours or greater than 8 hours. The purpose of using this convention is not only conceptual accuracy but also to avoid the misconception that an exposure limit expressed only by its dust concentration is a reduction in the exposure limit if the shift is greater than 8 hours. For example, a dust concentration limit of 1.6 mg/m^3 for 10 hours limits a miner's exposure to the same amount of dust as does a dust concentration limit of 2.0 mg/m^3 for 8 hours. <u>Both</u> are 16.0 mg-hours/m^3.

Dust Control Plan.

As presently conceived, the ventilation and dust control plan are linked with measurements of dust concentration only at the most general level. If the operator can maintain exposure below the exposure limit with a given ventilation and dust control plan then those parameters are the parameters for the dust control plan. No further linkage is described or anticipated. This serves the interests of neither dust control nor effective function of the ventilation and dust control plan. Therefore, we propose that dust monitoring, both for compliance and for surveillance, both occupational and area samples, be incorporated as essential measures of how well the ventilation and dust control plan is functioning. Dust control measurements should be tabulated as the same time and in the same log book as are measurements of ventilation, water sprays, and other dust control measures.

Types of Samples

Samples taken for the purpose of determining non-compliance with the respirable dust exposure limit or the quartz exposure limit are all full shift samples and can be designated occupation (DO), designated work place (DWP), or Part 90 samples.

Designated occupation (DO) samples are attractive because of their efficiency. Although it is an individual occupation that receives attention, it is the MMU that is the regulated entity. Properly conceived, a sample for one occupation can be taken with logical inferences to other occupations on a specific MMU. The logic has been that if dust concentration is below the limit for the DO then it is reasonable to assume it is below the limit for other occupations on the same mining section or MMU. The intent of a DO sampling strategy is not simply to control dust exposure for the DO but to control it for every miner on that MMU. Thus, its efficiency depends on the simultaneous existence of at least three conditions:

1. There must be an exposure gradient so that one, perhaps more, occupation should experience higher concentration of dust than other occupations on that MMU.
2. Within each mine, this exposure gradient must be consistent and exist from shift to shift.
3. The dust concentration that the DO experiences should be linked to the concentration for other occupations on that MMU so that if it is reduced for the DO it would be reduced for the other occupations also.

When this sampling strategy was first developed (in 1970?), perhaps these conditions existed. But over the past forty years, there have been many changes in mining practices that could make the DO strategy invalid. Longwall faces are longer, continuous miners are operated remotely, auxiliary fans and scrubbers are used, etc. Consequently, before MSHA adopts a DO sampling strategy, it is essential to investigate conditions to determine if the three conditions noted above actually exist. Depending on conditions, this

DWP samples should be taken for those occupations that, because of the nature of the work, could subject the miner to excessive amounts of respirable dust or quartz dust. Roof bolters or workers constructing an overcast, for example, could be exposed to excessive amounts of silica. Some workers in preparation plants may also be exposed to excessive amounts of respirable dust.

Occupations can be identified and selected as possible DWP samples for sampling purposes based on the judgment of that worker, his supervisor, or an MSHA inspector.

Measuring the exposure of Part 90 miners is the only circumstance for which a personal sample is both necessary and appropriate.

Sampling for quartz exposure should be done similar to the manner in which it is currently taken. A sample taken by MSHA with a pump-and-filter sampling device should be used to determine the percent quartz and this percent used in the current formula to determine a reduced sample. DO, DWP, and Part 90 samples would then be compared with the reduced standard. We suggest two changes, however. First, operators should not have the opportunity of taking additional samples. The only effect of taking additional samples is to lower the measurement of the percent quartz. Consequently, only single MSHA samples should be used to determine the percent quartz.

Second, in some circumstances, it is reasonable to conclude, in the absence of sampling, that there is a high potential for exposure to quartz. For example, if the rock in the roof is sandstone and the operator is cutting into that rock – to make more room, to construct an overpass, to install roof bolts – then it is reasonable to assume that there is a high potential for exposure to quartz. In those circumstances, a measured concentration of quartz greater than100 □g/m^3 x 8 hours would be sufficient to issue a citation for non-compliance. In those circumstances, it would not be necessary to take a sample, calculate a reduced standard, then expect the operator to maintain dust below the reduced standard. If there is more than 5% silica under those conditions, this procedure would expose miners to elevated levels of silica for the time between the sample to determine the percent silica and imposition of a reduced standard. This time can be in excess of two weeks. The conditions under which exposure to silica is likely is no mystery to anyone experienced in mining and MSHA should not act as if it is.

Criteria for Determining Non-compliance

The two critical issues affecting non compliance determinations are the number of samples on which to base the determination and the exact level which would result in a citation for non-compliance.

MSHA's current practice of issuing a citation for non-compliance – requiring a "high degree of confidence" that the true value is above the exposure limit which means, in practice, that a measurement should exceed the exposure limit plus the 95% confidence interval in order to issue a citation for non-compliance – is unacceptable. It requires an inappropriate standard of proof, it gives the benefit of doubt to mine operators, and it shifts the burden of uncertainty entirely onto miners at the expense of their health. Two advisory committees have recommended against this policy.

We recommend, as an alternative, that any full shift sample that exceeds the exposure limit by 0.1 mg/m^3 or more should be subject to a citation for non compliance. Sampling and analytical error inherent in any measurement should not be considered when making this determination although it should be considered as part of its rationale. A citation for non-compliance is, as stated in the Act, a civil penalty. The standard of proof required for a civil penalty is "more likely than not." The corresponding numerical value is "more than 50% likely." In this case, a numerical assessment is, in fact possible. Sampling and analytical error creates a distribution of likely values above and below the actual measurement. If a measurement is near but above the exposure limit then more that 50% of the area under the frequency distribution curve, i.e., more than 50% of the likely values are above the exposure limit. The true value then is more than 50% likely to be above the exposure limit. This is sufficient for a determination of a civil penalty of non-compliance. (The rationale for this issue is described in more detail in a peer reviewed publication attached: (Weeks, 2006)

The existing policy gives the benefit of doubt to mine operators at miners' expense. Sampling and analytical error exists both above and below the measured value. There is a range of uncertainty associated with this as with any measurement. In the interests of simple fairness, the burden of this uncertainty should be equally shared by miners and operators alike. This is especially true when what is at stake for miners is their health; for operators it is a citation and a fine. One could make the case, moreover, that because of this disparity in effect, the benefit of doubt should go to miners and MSHA would have to show, with a high degree of confidence, that the true concentration of dust was below the lower 95% confidence limit in order to avoid a citation for non-compliance. This is standard reasoning in health science practice.

NIOSH has already stated that the existing exposure limit – 2.0 mg/m^3 for an eight hour shift – is inadequate and recommended a lower limit of 1.0 mg/m^3 for a ten hour shift. If MSHA is not going to reduce the exposure limit, this NIOSH recommendation is sufficient for a change in MSHA policy.

Two authoritative bodies have recommended against this policy: MSHA's advisory committee and the NIOSH Criteria Document on preventing pneumoconiosis both reject prevailing MSHA policy.

But MSHA enforcement policy should not end with criteria for either taking samples or determining criteria for non-compliance. Doing so limits attention only to isolated individual samples. It is exposure to dust over an extended time period that causes pneumoconiosis. Individual isolated exposures are important but so is a consistent pattern of exposure important. Therefore, we recommend that if an operator is issued more than three citations for violation of the exposure limit in any 12 month period, he would be subject to a pattern of violations order under Sec. 103(d) of the Act. It seems fitting that the pattern of exposure that causes disease should cause a pattern of violation citation.

Who takes samples.

MSHA inspectors would take all samples for the purpose of determining non-compliance with the exposure limit. This means that MSHA would own, maintain, and calibrate the CPDM and would visit each mine according to the schedule described below, select which occupations to sample, monitor sampling t, retrieve the samplers at the end of the shift, and download the data.

The Operator's Certified Person, selected, trained, and supervised in the manner described above, would be responsible for designing and implementing a Dust Control Program at each mine. This plan would be approved by the MSHA District Manager and would be reviewed and revised, if necessary, annually. Its purpose would be to monitor and control exposure for the whole mine. Among other tasks, the Certified Person would take samples with the aim of monitoring implementation and function of the dust control plan, identifying sources of high exposure, and identifying circumstances that result in low exposure. This information would be used to modify parameters of the Dust Control Plan. None of the samples taken by the Certified Person would be used for determining non-compliance. His failure to implement this plan would be subject to citations for non-compliance. If parameters of the approved Dust Control Plan are changed, these would not automatically result in changes in the plan but would be reviewed by the District Manager.

Interpretation of Data Displays by Individual Miners is encouraged. Each miner who carries or wears a CPDM would be entitled to observe data as it displayed by the CPDM. If any miner is concerned about how to interpret displays, he should consult with the Designated Person for assistance in interpreting the display and determining what he should do, if anything. After consulting with the Designated Person, such miner would retain the right to take whatever corrective action he considers appropriate, including the right to refuse dangerous work.

Sampling Frequency.

DOs should be sampled every shift, 24/7. There are several reasons. First, such sampling will generate data that can be used to evaluate the feasibility of reducing exposure to an exposure limit less than the current standard of 2.0 mg/m^3 for eight hours. Second, sampling every shift will reduce opportunities to submit fraudulent samples, as discussed above. Third, if samples are taken every shift, it will come closer to complying with the provisions of the Mine Act which requires exposure to be controlled for each miner on each shift. Finally, sampling every shift is feasible with the CPDM. We should take advantage of this instrument's capabilities and use them to protect miners health.

Data Acquisition, Storage, Retrieval, Applications, and Analysis.

Acquisition. Data are acquired by the CPDM in the course of sampling. Since these data are in electronic format, they are far more easily managed than data acquired using the pump-and-filter method of sampling. Data should be downloaded at the end of each shift, transmitted to the MSHA district office, and made available to any interested party, i.e., miners, miners' representatives, contractors, state agencies, and others.

Storage and Retrieval. Data should be stored by MSHA. Since it is in an electronic format, it will require minimal space and can be indexed by mine ID number and date for easy retrieval.

Applications. We see two general applications. The first is to determine whether a particular mine is or has been in compliance with the exposure limit. This can be used, for example, to assess the performance exposure . The second general application is to evaluate the effectiveness of dust controls at a mine. Successful and unsuccessful controls can be shared throughout the industry to aid other operators in controlling exposure. And of course there are the unknown applications that will appear as we gain experience with this system.

Data Analysis. In addition to analyzing data for purposes of determining non-compliance and for evaluating dust control measures, these data can also be used in epidemiologic investigations of the associations between dust exposure and disease outcomes, such as pneumoconiosis, emphysema, chronic bronchitis, and gastric and lung cancer (associated with exposure to coal mine dust, silica, and diesel particulate matter).

4. How would the use of CPDMs impact the frequency of sampling? Please be specific and address how the concentration and exposure levels impact the frequency of sampling.

This issue was discussed in the previous question. Since the CPDM can be used for every shift, it should be used for this purpose. Compared to pump-and-filter sampling, the cost per sample is significantly less and feedback is nearly instantaneous. Exploitation of both of these features will help prevent black lung.

5. What examinations should be performed to assure the validity of exposure measurements, and how frequently should these examinations be made?

The frequency of examinations to assure validity depends on the rate of errors and the desired level of performance. Once these are determined, conventional quality control methods can be applied. This would require occasional return of instruments to the manufacturer for purposes of calibration and maintenance.

6. Since the current exposure limits were developed from 8-hour shift exposure measurements, how should the miner's end-of-shift exposure be reported when the work shift is longer than 8 hours?

"Exposure" of an inhalation hazard is measured with two parameters: *dust concentration and duration of the time* the dust (or other hazard) was inhaled. Since this concept is important and misunderstood, we feel that it is necessary to explain it in some detail.[3]

The common short-hand way of describing exposure is by mentioning only dust concentration. Time of exposure is important too but is often ignored because historically, the time of exposure was equivalent to the time of a shift and until recently, this has been a constant 8 hours. Time as a parameter of exposure is embodied in all exposure limits for inhalation hazards. Both threshold limit values (TLVs) and Permissible Exposure Limits (PELs) distinguish between time-weighted average limits which apply to eight-hour shifts, short term exposure limits (STEL), which apply to fifteen minute intervals, and ceiling (C) limits which apply to concentration for any time period less than fifteen minutes. If time were not an important parameter, there would be no need for these distinctions.

[3] Throughout these comments, we use "exposure" with both these parameters: concentration and duration.

Duration of exposure is also inherent in the 2 mg/m^3 standard in another way as is stated in the Mine Act (Sec. 101 a 6 A). Whenever MSHA sets an exposure limit under this section, one of its requirements is that the miner exposed to a concentration below the standard should be able to be exposed for his *entire working life* without suffering material impairment of health. Epidemiologic studies of the effects of dust usually measure exposure by measuring both concentration and duration as expressed in the metric, gram-hours/m^3 or its equivalent. This measure is typically estimated by obtaining data about concentration, including trends, then assuming a working year of 2,000 hours (8 hours per shift *x* 5 shifts per week *x* 50 weeks). As with the TWA limit, 8 hours per shift is assumed usually without acknowledgement.

Because of the universality of the 8 hour per shift convention, exposure limits are usually expressed in terms of the concentration of the substance in question and reference to eight-hours is omitted. The more precise and informative but clumsy measure would be to express exposure limits as, in the case of the respirable dust standard, mg-hours/m^3. Thus, the respirable dust exposure limit should be expressed as 2 mg/m^3 *x* 8 hours = *16 mg-hours/*m^3 *per day.*

The physiological basis of exposure being dependent on concentration *and* duration is straight-forward. The occurrence and severity of disease depends on the mass of dust accumulated in the lungs. With every breath, dust is inhaled. The amount of dust inhaled depends on its concentration and how much air is inhaled. Some of the inhaled dust is deposited and retained and it is this portion that leads to disease. With every breath, more dust is inhaled and more is deposited and retained. The total amount of dust deposited and retained thus depends on how many times a worker inhales, i.e., it depends on *how long* the worker inhales dust.

Expressed as a simple formula, the total mass of dust inhaled, *and thus the magnitude of risk*, can be expressed in the following formula:

$$M = C \, x \, D \, x \, B \, x \, Pct$$

M = mass of dust retrained (mg)
C = dust concentration (mg/m^3)
D = duration of exposure (hours)
B = breathing rate (m^3/hour)[4]
Pct = percent of dust that is deposited and retained (unitless)

Stripped to its essentials and assuming the breathing rate and the percent of dust retained is approximately the same from one person to the next, "exposure" that leads to risk of disease is expressed as C *x* D, concentration times duration, with the units mg-hours/m^3. It has been assumed in the 2 mg/m^3 standard that D = 8 hours. It did in the past; it does not now. Thus, in order to maintain a *constant* exposure limit, for shifts longer than 8 hours, an adjustment must be made to provide *the same* level of protection as does the 2 mg/m^3 limit for eight hours. This problem has been addressed and a conventional solution has been available since early in the 20th century as Haber's rule. (Armstrong et al, 2005)

[4] Ordinarily, the breathing rate is expressed as liters per minute but is measured here by m^3/hour, its conceptual equivalent (i.e., volume/time), so that the units come our correctly.

In order to ensure the same level of protection for work shifts of different lengths, Haber proposed an intuitively appealing rule:

$C \, x \, D$ = constant for all shifts.

For example, for shift 1 which has concentration limit C_1 and is D_1 hours long, and shift 2 which has concentration C_2 and is D_2 hours long, $C_1 \times D_1 = K = C_2 \times D_2$. The concentration limit for shift 2 is then

$C_2 = C_1 (D_1/D_2)$.

If exposure is limited to C_2 for shift 2, then the miner faces the *same* risk of disease – measured by the mass of dust inhaled, deposited, and retained – as he does if exposed to C_1 for shift 1.

A numerical example illustrates the application of Haber's rule. If a miner works for ten hours then the concentration limit should be 2.0 mg/m^3 (8/10) = 1.6 mg/m^3 in order to get the same level of protection as he does for working eight hours under a 2.0 mg/m^3 concentration limit. The total amount of dust deposited is the *same* (16 mg-hours/m^3) under either circumstance.

What Haber's rule does not account for is a reduction in recovery time. Recovery is that process that enables the lung to remove or to clear dust particles while not exposed to dust.[5] Clearance occurs continuously but in the absence of dust in inhaled air in between shifts, it is possible for clearance mechanisms to reduce the accumulated mass. Larger particles are removed from the large airways relatively rapidly by cilia that cause a wave-like motion beneath a layer of mucus. Dust particles stick to the mucus and waves propel them up and out to be coughed out or swallowed. Smaller particles are removed from the alveolar region of the lung in a slower process that involves alveolar macrophages (specialized immune cells) that engulf particles (macrophage means "big mouth") and carry them to the large airways. Macrophages also clear dust particles from alveoli and deposit them in interstitial spaces and when this occurs, the dust particles are retained and add to the risk of disease. It is the smaller particles, so-called respirable dust particles, that are of greatest concern for causing pneumoconiosis, in large part because they are more likely to be retained in the part of the lung where gas transfer occurs.

Because alveolar clearance is slow, it is important to provide for adequate recovery time between shifts when these particles can be removed. If they are not removed, today's retained dust is added to yesterdays and so on. When workers work longer shifts, not only does this result in more dust retention it also reduces recovery time and thus creates the potential for greater dust accumulation than when workers work shorter shifts. With an eight hour shift, recovery time is sixteen hours; with a ten hour shift, recovery time is fourteen hours. Whether this creates significant additional risk of disease is, at this time, not known. Alveolar clearance can also be overwhelmed or overloaded if dust is excessive. When this occurs, clearance is significantly reduced and even more time is needed to remove the dust particles.

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[5] Technically speaking, there is no such time when a miner or anybody is "not exposed" to dust because particulate matter is ubiquitous. It is a relative estimate of exposure but for our purposes, it is sufficient to refer to the recovery time as time away from dust.

There is also the problem of dust overload. This is when dust exposure is sufficient to overwhelm clearance mechanisms and dust would accumulate rapidly in the lungs. When this occurs (the exact dust concentration that results in overload is unknown.), a longer recovery time is needed to remove deposited dust particles.

As a consequence, *Haber's rule is only minimally acceptable as a standard of performance, especially when miners work very long shifts. Long shifts result not only in deposition of more dust, they also result in decreased time to remove dust.*

In sum, we recommend the use of Haber's rule for shifts longer than eight hours. We also suggest research to estimate the health effects of reducing recovery time inherent in longer shifts.

7. Since the CPDM cannot be used to monitor for quartz, how should the applicable dust standard, including reduced standards established when the quartz content of the respirable dust exceeds 5 percent, be addressed when using a CPDM?

8. Please address the use of CPDMs for sampling in outby areas, including specific areas, occupations, and frequency of sampling.

Sampling in outby areas are principally area samples taken from a fixed and strategically important locations. The principal purpose of outby samples is to aid in monitoring the entire dust control system. For example, these samples would monitor intake air, exhaust air, and outby locations where dust could be generated (such as transfers from one belt to another, loading or unloading points, or heavily traveled roadways). They could be placed in order to measure the effect of ventilation changes (such as point feeds, closing or opening regulators or doors). They could also be used indirectly to monitor inby dust measurements. For example, if the dust concentration on intake air was 0.2 mg/m^3 and dust concentration on a working section was also 0.2 mg/m^3, then it would be reasonable to suspect that there was something wrong with the sample on the section.

Some outby samples could be designated work-place samples. These would be selected based on dust measurements that suggest the possibility of over exposure. These occupations could include, for example, motormen who drive on dusty roadways, preparation plant workers exposed to dust, or construction workers exposed to dust (such as quartz) in the course of their work. Sampling for these occupations would have the same frequency as that for other DWP. Ordinarily, however, most outby samples would be area samples.

9. Please address the use of engineering and administrative controls including how such controls should be applied to the CPDM's real-time exposure readings.

We take engineering controls to mean methods used to reduce ambient dust concentration or to remove air contaminated with dust in work areas of a mine. These methods include ventilation, water, methods of coal cutting, and maintenance of coal cutting or handling machines. Feasibly and effective methods arewell described in several publications by NIOSH (e.g., Colinet and Thimons, 2009; Colinet et al, 2008; Kissell 2003) and are otherwise common practice.

Administrative controls can reduce exposure of individual workers by changing their occupation or workplace. These are logical means of reducing exposure but are impractical in practice. Workers specific duties are changed often in the course of work and are changed for many reasons: to fill in for an absent worker, to assist in solving some problem, to increase production, and so on. Changing their occupation or location to reduce dust exposure is simply one more reason to change a worker's duties and it must compete with all other reasons. Moreover it has been used by some operators merely as a means to avoid compliance even while exposure may remain excessive. In any case, its effectiveness has not been evaluated systematically. To our knowledge, neither NIOSH, the Bureau of Mines, nor anybody else has evaluated whether administrative controls are effective or practical and we therefore reject them as a means to control miner's exposure to dust.

This question seems to have the issues backwards. Instead of asking ". . how [engineering and administrative] controls should be applied to the CPDM's real-time exposure readings" it makes more sense to ask how CPDM real-time exposure readings could be applied to engineering and administrative controls. Our primary interest is in controlling dust exposure and the CPDM should serve that end, not the other way around.

On this issue, the CPDM should be a very useful tool. Whatever adjustments are made can be promptly evaluated enabling prompt decisions about either form of control or any fine-tuning.

10. What action should be taken by the mine operator when a miner's exposure during a working shift reaches the dust standard limit?

It is important in replying to this question to have clear operational definitions of what "exposure" means and what the "dust standard limit" means. As we have said, both dust concentration and duration of exposure must be measured for both "exposure" and the "dust standard limit." Saying that the dust standard limit is 2.0 mg/m^3, for example, is inadequate. It would be more to the point to express the limit in terms of its *concentration limit* is 2.0 mg/m^3 *for an eight hour shift* or 16.0 mg-hours/m^3 per day. Expressing the limit in this way allows it to be applied to a shift of any length without having to explain why and how a concentration limit by itself had to be adjusted. This measure can be displayed as such – as so many mg-hours/m^3 -- on the CPDM screen.

Now it makes sense to answer the question. If a miner's exposure approaches this limit (i.e., 16.0 mg-hours/m^3) the CPDM should also display the average dust concentration he would have to achieve for the remainder of the shift in order to have an exposure less than the limit by the end of his shift. (This presumes that shift length is entered before the shift begins.) This can be calculated and displayed continuously throughout a work shift. The closer the miner's exposure is to this limit, the lower the dust concentration would have to be in order to finish the shift under the limit. If he reaches this limit, there is no dust concentration (other than zero) that would allow the miner to finish the shift with a concentration that is under the limit.

If a miner's exposure reaches this limit at any time before the end of a work shift, any additional exposure would put him over the limit and would subject the operator to a citation for non-compliance. At this point, the miner should cease work and, to avoid adding financial insult to injury, should be paid for the remainder of the shift for which he was scheduled.

11. Please address the use of CPDMs at surface mines, including sampling of areas, occupations and miners.

The same basic approach used at underground mines would be used at surface mines, with two important differences. First, without an exposure gradient (and the other conditions necessary to regulate exposure for all miners on a working section), having a designated occupation for sampling purposes is not appropriate. Rather, it would be appropriate to sample exposure for occupations at which exposure is known to be elevated. These occupations would be sampled in order to protect workers in those jobs with no expectation that any surrounding workers would benefit from sampling or dust controls for that job.

The second important difference arises from the principal exposure of surface miners is to quartz dust and not respirable dust. That being the case, one should presume, in the absence of any evidence to the contrary, that any dust to which surface miners is exposed contains some quartz. And if any sample contains more than 100 □g/m^3 for an eight hour shift (or 800 □g-hours/m^3), that operator should be issued a citation for non-compliance. In other words, there would be no reduced standard. The reduced standard implicitly assumes that there is less than 5% quartz in a sample until it is analyzed. This is not a valid assumption at surface mines. The reduced standard policy permits miners to be exposed to elevated levels of quartz while the mine operator is not considered for citation for non-compliance regardless of the actual level of quartz in a sample. At surface mines, the benefit of doubt should go to miners and not to mine operators. This more stringent approach is partially responsive to the NIOSH recommended exposure limit of quartz dust at 50□g/m^3 for a ten hour shift or 500 □g-hours/m^3.

B. Dust Control Plan Requirements

Providing and maintaining a work environment free of excessive levels of respirable dust is essential for long-term health protection. Monitoring the work environment provides an indication of the effectiveness of existing dust controls; however, monitoring alone does not control concentrations of respirable dust in the mine atmosphere. Accordingly, consistent with MSHA's regulatory strategy, engineering or environmental controls are the principal methods that have been relied on over the past 35 years to prevent or minimize miners' exposures to both primary and secondary sources of respirable dust in the workplace. These controls are required in an operator's approved mine ventilation plan to provide assurance that miners are not being exposed to excessive dust levels. Since the CPDM provides real-time information on concentration levels, MSHA is exploring alternatives to limiting miners' exposures. MSHA is therefore requesting comments on the following dust control plan issues:

1. Please address the advantages and disadvantages of using engineering controls to

maintain the mine atmosphere in the area where miners work or travel. Please be specific in your response and include the technological and economic feasibility of such controls. In addition, please address the advantages and disadvantages of using administrative controls as part of an effective exposure control program.

It is a well established standard of practice in industrial hygiene that engineering controls are superior to all other forms. There is good reason for this standard. Think of occupational hazards having a source, a path or medium that conveys them to workers, and a destination (i.e., the workers themselves). Conceivably, controls can be implemented at any of these places – the source, the path, or the worker. Controls at the source prevent the hazard from contaminating the workplace; controls on the path can redirect hazards or remove them from workers' environment; controls on workers (i.e., personal protective equipment [PPE]) can protect workers individually.

PPE (respirators, in this case) are the least effective. They leak, they are uncomfortable, they are burdensome, they interfere with communication, and the protection they provide is highly variable. Workers often do not wear them. Because of these and related problems, respirator manufacturers, OSHA, and the American National Standards Institute, in the form of a consensus standard (ANSI, Z-88. Standards for Respiratory Protection) strongly recommend that employers use respirators only in the context of a respiratory protection program. ANSI developed such a program in 1969 as a consensus standard and it has gone through several revisions. OSHA has such a standard which it requires employers under its jurisdiction to use (29 CFR 1910.134). While MSHA incorporates the ANSI standard (ca 1969) by reference, it remains obscure and is rarely enforced.

Miners, therefore, are in the worst possible situation with regard to the use of respirators. They are routinely exposed to high amounts of dust; a higher proportion of miners use respirators than do workers in any other industry (NIOSH Respirator Usage in Private Sector Firms, 2001 [2003]); yet they are not protected by any regulation that would ensure their proper use. The section of the Mine Act that rejects respirator use as a substitute for engineering controls is well supported.

It is important to clarify the meaning of "engineering controls." In principle, engineering controls at the source implies that the hazard does not enter the workplace at all. In other industries, this can be accomplished by using less toxic materials or by conducting the work in using intrinsically safe methods. Engineering controls in mining are significantly different from these conventional methods because mining is a fundamentally different type of activity. There can be no substitution of a less toxic material because the toxic material is what is being mined. Ventilation is altogether different because miners work inside what serves as ventilation ducts (i.e., mine entries that are also airways).

Engineering controls in mining must take account of these unique features. The conventional dogma, however, is still valid. It is better to reduce exposure to dust by using inherently less dusty methods than it is to use personal protective equipment. These methods are by now well known (Kissell,) an should be standard practice in all mines. (They should also be taught in mining schools.)

2. If CPDMs are used, please address the information that would need to be included in the dust control portion of the mine ventilation plan, including information related to addressing silica.

Present practice for the mine operator's dust control plan is to establish and monitor ventilation (cfm at based on the assumption that if these are maintained at the level the mine operator submits to MSHA, dust concentration will be controlled to an acceptable level.

This is inadequate for several reasons. There are additional parameters that are correlates of dust concentration and the outcome parameter – dust concentration – is not included in this monitoring plan. Specifically, production level, usually expressed as the rate of production, should be monitored as well. Since shift length varies, it would be appropriate to express it as tons per hour rather than tons per shift. And, as a crude indicator of quartz exposure, the rate of production should include a measure of what percent of production was coal and what was rock. (This assumes that a higher proportion of rock would be associated with a higher level of quartz.) Whenever picks are changed, this should be so indicated in the log book. In addition, since the purpose of the dust control plan is to control the concentration of dust, the dust concentration itself should be monitored as well. A log book should contain all these parameters.

The purpose of monitoring in this manner is to gain some real data about the correlates of dust concentration. If there is an overexposure, operators would have real knowledge about the causes and what to do to reduce exposure. Such information would also provide insight into conditions that result in low concentrations of dust thereby leading to successful dust control strategies.

C. Recordkeeping

To promote miners' awareness of the air quality in the work environment and the integrity of the sampling process, existing regulations require mine operators to send all collected samples to MSHA for processing within 24 hours after the end of the sampling shift. Once processed, the operator is provided with a respirable dust sample data report, which contains the results of every sample submitted. With few exceptions, the operator must post this report on the mine bulletin board for a period of 31 days to provide miners access to current information on respirable dust conditions in the mine. The results of all samples taken by mine operators and With exposure information available at the completion of the work shift when a CPDM is used, existing recordkeeping requirements and responsibilities would need to be addressed. MSHA requests comment on how recordkeeping requirements based on the use of CPDMs should be structured. Please be specific in your response.

1. Who should be responsible for maintaining the CPDM data files and why? How long should exposure records be maintained? How should information be used?
This question is silent on the question of what these data files should include. Information in existing data files includes information about the mine, the date of the sample, the mine section (or mechanized mining unit), the type of mining, the workers' occupation, and the

type of sample (e.g., DO, DWP, DA, Part 90). It does not contain, nor does it provide a link to, information about dust control parameters, production rate, the seam identity, the seam height, the and the ceiling height. (The difference between the seam height and the ceiling height could serve as an indicator of silica exposure [from cutting into the roof] and would have an effect on air velocity if the flow rate is constant.) It also does not include information about the shift length which is, as we have indicated, an essential parameter for measuring exposure.

Since records are in electronic format and require only a fraction of space required for paper or microfiche, there should be no limit on the length they should be retained. They should be retained by MSHA. Any person who has access to these records could keep them as long as they want to. These records could be used for a variety of purposes, some of which cannot be anticipated. Possible uses include epidemiologic research on the occurrence of pneumoconiosis or other diseases, identifying trends and clusters in the distribution of exposure, and evaluating various methods of controlling dust exposure.

These records should not be used in workers' compensation cases. The reason is two-fold. First, workers' compensation statutes require merely that a claimant show that any compensable condition "arise out of and in the course of" employment. There is no requirement, expressed or implied, that the Dust concentration, even concentration that is below an exposure limit, that results in no disease for one miner could result in disability for another. The link between dust and disease applies to a population of miners and the link for any individual miner is significantly weaker. Workers compensation claims are evaluated for individual miners.

2. How should the data from operator monitoring using the CPDM be transmitted to MSHA? What data should be transmitted? How often should the data be transmitted (e.g., daily, weekly, or some other frequency)? What steps should be monitoring results on the mine bulletin board for a period of 31 days. How practicable would it be for operators to continue this practice if the monitoring is conducted with the CPDM, which results in the collection of significantly more data than with the current MRE instrument? Would it be appropriate for operators to only provide miners with a portion of the data captured by the CPDM or to post the data for a period less than 31 days? Please be specific with your response, including your rationale.

Data should be transmitted electronically at the conclusion of the shift for which dust samples were taken. Such communication is nowadays routine, secure, and efficient. It should be built into the sampling routine. All information should be available to any interested party. It should be posted for 31 days and available thereafter on request.

This information is important for miners' health. This is sufficient rationale and because of it, it is incumbent on others to explain why such information should not be made available.

Imagine an epidemic of hepatitis A (food borne hepatitis). The public health department of a city investigates and discovers a restaurant as the source but, in order not to affect that restaurant's business, keeps this information confidential. Then imagine that public health official saying to the city, "We know the source but we cannot tell you." The public's right to know seems a matter of common sense.

D. Education and Training

It is vital that persons designated by the mine operator to perform dust sampling functions and miners be properly educated and trained to assure the integrity and credibility of the sampling process. To be effective, these persons must be fully cognizant of the nature of the health hazards in the working environment and possess a level of competence in the proper use, operation and maintenance of sampling equipment, and an awareness of the limitations of available protective measures. The required level of competence would be dictated by the complexity inherent in the operation of the particular CPDM and the degree to which oversight of sampling integrity is to be assumed by mine operators using the CPDMs. MSHA requests comments on suggested elements for a training program on using and maintaining a CPDM. Please be specific in your response, addressing the quality, quantity, and types of training, and the qualifications and certifications that should be required.

1. What training should miners receive if required to wear a CPDM? What type of training would be necessary to assure that the miner understands how the device works, what information it provides, and how that information should be used to reduce miners' exposure to respirable dust? How often should miners be required to receive this training?

The CPDM is new, unfamiliar, and apparently complex technology. Consequently, training is critical to its successful deployment. CPDM training should not be included into Part 48 training. Since, in practice, miners will be the first persons to see information displayed by the PDM, and since any miner who works underground or who is otherwise exposed to dust (such as in preparation plants or surface mines) may be called upon to wear this device, all such miners and their supervisors should be trained in the basic structure and function of this device. An eight hour session, with miners and supervisors together, with training provided by MSHA (or a contractor to MSHA), hands on, and in small groups (N < 8, approximately). It would be useful for miners to use a CPDM (with little or no training except for showing them the on/off switch) for a few days before training occurs so that they could come prepared with questions. Among other topics, trainers should explain the following:

- What is an average?
- How does CWP occur? (by accumulating dust in the lung)
- How does one measure "exposure," (by dust concentration and duration of exposure)
- Quartz is important and usually comes from drilling or cutting into mine roof or floor.
- High and low exposures will occur but it is the average that is important.
- When a high concentration occurs, note the circumstances and opportunities to reduce concentration.
- When a low concentration occurs, note the circumstances and see if they (and dust concentration) can be maintained on a regular basis.

The reason for including miners and their supervisors together (for example, everybody from the same section) is so that they will all hear the same message from the trainer at the same time and they will also hear others' questions. There should be opportunity for trainees to ask questions of their trainer after the training because additional questions will come up with additional experience. Questions and replies should be posted on the mine bulletin board. Training should be provided with these instruments are first deployed with four hour refresher training provided annually.

Training should not be thought of as having been accomplished with training sessions, regardless of how frequent they are. Miners should be encouraged to raise questions to whoever they like – such as their trainer, the employer's safety supervisor, the chairman of the mine safety committee, or MSHA -- at any time.

2. What qualifications should be required before an individual is permitted to operate and maintain a CPDM? How should an individual be required to demonstrate proficiency before being permitted to operate and maintain a CPDM?

Any miner exposed to dust should be permitted to operate a CPDM. Only persons specifically trained to do so should conduct maintenance on a CPDM. Training to operate a CPDM would cover matters of turning it on or off and reading and comprehending the numerical displays that the CPDM produces. Demonstrating proficiency could be accomplished by presenting a variety of displays and having the trainee explain what the displays mean. This could be done by examination or other interactive means..

3. Which mine personnel should oversee CPDM usage, download exposure information, and interpret data? What type of qualifications/ certifications should these personnel be required to have?

If there is a certified dust monitoring person, as under the current monitoring plan, that person would be the logical choice to oversee CPDM usage and to download exposure. That person should have the appropriate training in order to become certified and the status of the certified person should be significantly changed, as we discuss elsewhere in these comments. If there is not a certified dust monitoring person, the MSHA District Manager, or whoever he selects, would be the person.

Since information is in electronic format, it can be downloaded directly to the MSHA District office electronically. Whatever information that is downloaded, should also be kept at the mine and anybody that works at the mine should have access to this information. We suggest that after the information is downloaded to the MSHA District office, it should also be transmitted to the miners' representative, such as the UMWA local union or to the appropriate Regional office of the Union.

Whoever has access to this information would "interpret" it. Access and interpretation are inseparable, as a matter of common sense. Clearly, when these instruments are first deployed, there will be mistakes and disagreements about how to interpret the data. These are to be encouraged because the way people learn how to interpret data is to do it and discuss the interpretation with others. But if what you mean by asking this question is whose interpretation is authoritative, inevitably, it has to be MSHA. They are the ones, after all, with the authority to act, to issue citations.

E. Benefits and Costs

Because of the changing mining environment, more timely feedback on current respirable dust conditions in the workplace should significantly enhance miner health protection. Benefits would include the ability to immediately identify hazardous dust conditions that cause debilitating and potentially fatal coal workers' pneumoconiosis or ``black lung'' disease, and to reduce or eliminate the risk of overexposure and the potential for illness and premature death, thereby avoiding the attendant costs to employers, miners and their families, and society.

The difficulty with evaluating the principal benefits of using this device, i.e., preventing pneumoconiosis, and of considering costs is multi-faceted. Issues can be expressed as a series of contrasts:

- The substantial costs come in the present but the benefits do not appear until years later.
- The costs are measured in dollars but the benefits are measured in longer lives and improved quality of life.
- Costs are measured by what happens (initial payment, operating and maintenance costs and training) but benefits are measured by what does not happen (i.e., cases of pneumoconiosis).
- And finally, the costs and benefits accrue to different people, operators or MSHA on the one hand, and miners on the other.

Because of these mis-matches, any comparison of costs and benefits depends on making many assumptions about matters such as how much a life is worth, the value of a dollar in twenty years v. its value now, how the price of the CPDM might change as the volume of sales changes, what the demand of the CPDM will be, whether demand for coal will increase or decrease, whether carbon-capture technology will make coal a viable fuel, etc. The results of a cost-benefit analysis are highly dependent on the assumptions about these issues which, of necessity, must be made prior to the analysis.

A cost-effectiveness analysis would be better. That is, given certain resources, how much can miners' exposure to dust be reduced using the CPDM. This focuses on the more limited and more measurable question of how effective this device is at reducing exposure.

MSHA requests comment on the following questions concerning the benefits and costs of the CPDM:

1. What would be the benefits of using CPDMs in a comprehensive and effective compliance strategy? Note that benefits might differ depending upon which compliance strategy is selected.

The benefits are a reduction in the incidence of pneumoconiosis. Furthermore, benefits do not depend on the compliance strategy. Perhaps the magnitude of benefits would change, but the benefits themselves do not. These benefits seem so plainly obvious that this question is puzzling. What are you asking? What conceivably, would depend on a compliance strategy is the magnitude of exposure. But this is not a question of balancing costs and benefits; it is a matter of cost effectiveness. Assuming that everybody has limitations on their budgets, the question is how effective can a compliance strategy be (i.e., how much can exposure be reduced) for a given amount of resources.

2. What costs would be associated with using CPDMs? Please be specific as to every component, such as, initial outlay, maintenance, and training.

Initial outlay for the CPDM is high, in the neighborhood of $10,000. But as demand increases, this cost should decline. According to NIOSH analysis, however, the cost per sample compares favorably with the existing system. (NIOSH, 2008) Until the commercial unit is put into practice, costs of maintenance and training are unknown. Since it is a significant departure from the existing device, initial training is likely to be costly. Consequently, it would be useful for MSHA, NIOSH, and the manufacturer to devote time and resources to the task of training miners, operators, MSHA inspectors, and others. There is considerable skill available for conducting such training and these agencies should find it and use it.

3. What would be the advantages, disadvantages, and relative costs of different methods of using CPDMs?

As we have said above, there should be two principal uses of the CPDM: for determining compliance and for conducting surveillance. It can be used for determining compliance because, if used properly, it makes accurate determination of exposure. And since it measures both concentration and duration of exposure, it can by itself measure true exposure in terms of mg-hours/m^3. No additional instrument, like a clock, is needed.

Its use for surveillance comes as a natural consequence of it giving a real time (and place) measurement of dust concentration and in so doing, identifies potential sources of excess exposure. Indeed, as many who have taken this device into mines have noted, it tells you when and where (and perhaps why) dust concentration varies. This is useful not only for identifying sources but also for identifying practices that are useful at reducing exposure.

With this capability comes also a potential duty. Just as mine operators are required to conduct surveillance for exposure to methane – and to take corrective action – so should they be required to conduct surveillance for exposure to respirable dust – and to take corrective action. Granted, exposure to methane poses a risk of acute and immediate danger while exposure to respirable dust poses a risk of chronic disease. However, if dust exposure is to be reduced at all, it can only be reduced at the time and place where it occurs. This may be remote from the risk of disease actually becoming manifest but if one waits, it will be too late. As the Administrative Law Judge said when deciding whether violations of the dust standard should be "significant and substantial," "every drop in the bucket counts." (Weeks & Jordan, 1985; MSHA v. National Gypsum,) One cannot prevent the drop from falling if it already has.

Thus, mine operators should be required to conduct surveillance on a regular basis, to record the results in a log, to take corrective action if necessary, to record what action they took, and the results.

4. Would the use of CPDMs affect small mines differently than large mines, and if so, how?

In our society, we have the fundamental principle of "equal protection under the law." The plain implication is that small mines and large mines should receive the same benefits and the same penalties. If costs are a significant obstacle to any mine, purchase, operation, and maintenance should be subsidized in some manner. (The joint UMWA-BCOA task force recommends that MSHA purchase all CPDMs. We agree.)

The PCDM is such a fundamental departure from the old system that to treat miners at small mines any different from other miners would be to deny them the substantial benefits of this device.

5. What incentives, if any, should MSHA consider to promote effective use of CPDMs in coal mines?

CPDMs should be required as the only acceptable means of monitoring dust exposure just as the current system was introduced in 1970. That is sufficient incentive.

6. What actions, if any, should MSHA take to encourage coal mining industry acceptance of the CPDM technology, stimulate economic market forces for more competitive pricing of CPDM devices, and promote innovation in respirable dust monitoring technology?

The first part of this question, i.e., what should MSHA do to encourage … acceptance of CPDM, evaporates when MSHA makes them required. This question was not asked in 1970, it should not be asked now. We should not invest millions of dollars and thirty years into developing this instrument only to ask the industry if they want to use it.

As for stimulating market forces and promoting innovation, this device can be promoted just as it has been developed: identify a need, meet it technologically, and find a way to sell it, either as an exceptionally useful device or one that is mandatory. Underground coal miners are not the only workers exposed to dusts and that could benefit from this instrument. Others include metal and non-metal miners, foundry workers, construction workers, and dozens of others. Many dust exposed workers are under OSHA's jurisdiction. And workers in the U.S. are not the only workers exposed to dusts. There are six million coal miners in China (though perhaps the Chinese would be more interested in replicating this device than purchasing it – another matter), thousands in India, Russia, Ukraine, etc. And the EPA has a long standing interest in airborne particulate matter. This device is not wanting for customers. MSHA, OSHA, NIOSH, and EPA all are in touch with potential customers.

Advantages and Disadvantages of the CPDM

Advantages

1. It provides real-time measurements. This makes it possible to link concentration with determinants of concentration at the time the measurement was made. With this linkage, it is possible to better identify and evaluate both conditions that facilitate low concentrations and thus to maintain them and conditions that result in high concentration and thus to control them.
2. It can project end-of-shift concentration if conditions up to the measurement persist to the end of measurement but also to measure average concentration from the beginning of a shift projected to the end of the shift.
3. The wearer knows his own exposure both at the moment the measurement is taken, the average from the beginning of the shift, and the projected average at the end of the shift.
4. It provides for electronic storage and transmittal of information. This facilitates surveillance and monitoring which can lead to rapid and well targeted intervention. It also facilitates storage, retrieval, and data analysis.
5. Per-sample cost is significantly less than it is with the pump-and-filter method thus facilitating frequent, even daily sampling.

Disadvantages

1. Initial cost of the sampling unit is high.
2. Significant amount of training is required to effectively operate the unit.
3. Its durability with repetitive use over an extended period of time is unknown.
4. The mass collected for each sample is relatively small thus inhibiting quartz analysis.

Advantages and Disadvantages of the Pump-and-Filter

Advantages

1. This sampling apparatus is familiar throughout the industry, having been used for over forty years.
2. Mine operators and MSHA have investment in equipment and skill.
3. The concept of "respirable mass' is readily apparent from the sampling apparatus and is clearly derived from the sampling method: the pump takes of sample of air, non-respirable dust particles are removed by the cyclone, and respirable particles are collected on a filter. The mass of collected respirable dust particles divided by the volume of air sampled gives the concentration of respirable mass.
4. It collects sufficient mass to facilitate analysis of quartz content.

Disadvantages

1. Results cannot be reported to the mine in a timely manner.
2. The process of taking the sample is labor-intensive and cumbersome.

3. The method is vulnerable to fraud and abuse and thus lacks credibility even in the absence of manifest fraud.

Should compliance depend on results of a single sample (i.e., a sample for a single shift) or on the average of samples taken over multiple shifts? The Act provides guidance, confusion, and a remedy on this issue. Taking samples over a single shift is a necessity to meet the requirements of the Act. First, the guidance:

> ". . each operator shall continuously maintain the average concentration of respirable dust in the mine atmosphere during <u>each</u> shift to which each miner in the active workings of such mine is exposed at or below 2.0 milligrams of respirable dust per cubic meter of air. (Sec. 202 (b)(2)).

This is an unambiguous mandate to maintain the concentration of dust below the exposure limit for every single shift. The only way to measure compliance with this mandate is to take air samples on single shifts. Operators shall *continuously* maintain (that is, "without interruption" or "forming a series with no exceptions or reversals" [New Oxford American Dictionary]) the average concentration of respirable dust . . during *each* (that is, "used to refer to every one of two or more people or things," [New Oxford American Dictionary]) shift.

The confusion arises from the following section which is at odds with the above paragraph and is a hopelessly garbled attempt to define "average."

> "For the purpose of this title, the term "average concentration" means a determination which accurately represents the atmospheric conditions with regard to respirable dust to which each miner in the active workings of a mine is exposed (1) as measured, during the 18 month period following the date of enactment of this Act, over a number of continuous production shifts to be determined by the Secretary and the Secretary of Health, Education, and Welfare, and (2) as measured thereafter, over a single shift only, unless the Secretary and the Secretary of Health, Education, and Welfare find, in accordance with the provisions of section 101 of this Act, that such single shift measurement will not, after applying valid statistical techniques to such measurement, accurately represent such atmospheric conditions during such shift. (Sec. 202 (f))

The principal implied aim of this section is, as it should be, to make an accurate measurement of the concentration of respirable dust. An "accurate" measurement is one that represents the truth. In the absence of a clear standard of measurement, a gold standard, "accuracy" is difficult to assess in any absolute sense but what can be assessed is whether measurements are consistent with one another, a problem implicitly recognized in this section. Thus for 18 months after the Act (the Federal Coal Mine Health and Safety Act of 1969) was passed, samples were to be taken over a number of continuous production shifts, and after that, over a single shift unless the Secretary of Health and Human Services (i.e., NIOSH) determined that a single shift did not accurately represent true conditions.

This condition assumes that the clear standard of measuring an "average" was achieved by taking samples over a number of continuous production shifts and it was this standard against which a sample taken over a single shift was to be compared. The average of samples taken over a number of shifts was taken as the gold standard. But it was Midas's gold. This assumption is valid in theory but not in practice. It is valid in theory because if one is to determine accurately the average concentration of dust in a mine, the larger the number of samples, the more accurate is the estimate of the average – by the Law of Large Numbers. [Oxford Dictionary of Statistics]. *But this is valid only if those measurements are unbiased.* NIOSH's determination is practically a foregone conclusion and this statistical rationale supports taking multiple samples. In practice, it is a false rationale.

Bias in samples taken over a number of shifts is evident in an analysis by MSHA of a series of samples taken by MSHA inspectors for compliance determination. This analysis shows that samples taken towards the end of such a series are systematically lower than those taken at the beginning (Kogut 1994). A reasonable interpretation of these findings is that when a mine operator knows that samples are going to be taken, he takes whatever steps are necessary to reduce concentration and thereby avoid a citation.

It is this behavior that common sense provisions in both the Mine Act and the Occupational Safety and Health Act that inspections are required by the Act to be without advance notice.

> In carrying out the requirements of this subsection, no advance notice of an inspection shall be provided to any person (Sec. 103(a))

Advance notice can be avoided for the first of a series of inspections but for none of the others. Thus samples taken when there is no advance notice are lower. When mine operators are taking their own samples, this requirement cannot be satisfied at all. The only sample that is not biased is the first of a series of MSHA samples, i.e., the single sample. Ironically, NIOSH was asked to compare the single sample to the average of several samples when it was the average of several samples that should have been compared to the single sample. Congress had the issue backwards. Experienced gained under this Act shows the single sample, taken during an unannounced inspection, to be the most accurate measure of dust concentration.

There is good news in this bias, however. It suggests the mine operators know how to reduce the concentration of respirable dust and can implement this knowledge promptly. If they can reduce dust concentration to avoid a citation, they can reduce concentration to prevent black lung.

MSHA's hands are not tied by the language of Sec. 202. These are *interim* mandatory standards and MSHA has the authority to remedy this situation with the mandate to set permanent standards under Sec. 101.

> The Secretary, in promulgating mandatory standards dealing with toxic materials or harmful physical agents under this subsection, shall set standards which most adequately assure on the basis of the best available evidence that no miner will suffer material impairment of health or functional capacity even if such miner has regular exposure to the hazards dealt with by such standard for the period of his working life. Development

of mandatory standards under this subsection shall be based upon research, 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. (Sec. 101 (a)(6)(A))

By this section, the Secretary is required to, among other criteria, base a permanent standard on experience gained under this Act and may express the standard in terms of ". . objective criteria and of the performance desired," i.e., the Secretary may require, as she should, that compliance be based on single samples.

Needless to say, the Secretary may promulgate such a permanent rule regardless of whether samples are taken by the CPDM or any other device.

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Attachment 2

AMERICAN JOURNAL OF INDUSTRIAL MEDICINE 49:492–498 (2006)

Commentary

The Mine Safety and Health Administration's Criterion Threshold Value Policy Increases Miners' Risk of Pneumoconiosis

James L. Weeks, SCD, CIH*

Background *The Mine Safety and Health Administration (MSHA) proposes to issue citations for non-compliance with the exposure limit for respirable coal mine dust when measured exposure exceeds the exposure limit with a "high degree of confidence." This criterion threshold value (CTV) is derived from the sampling and analytical error of the measurement method.*
Conceptual Framework *This policy is based on a combination of statistical and legal reasoning: the one-tailed 95% confidence limit of the sampling method, the apparent principle of due process and a standard of proof analogous to "beyond a reasonable doubt."*
Critique *This policy raises the effective exposure limit, it is contrary to the precautionary principle, it is not a fair sharing of the burden of uncertainty, and it employs an inappropriate standard of proof. Its own advisory committee and NIOSH have advised against this policy. For longwall mining sections, it results in a failure to issue citations for approximately 36% of the measured values that exceed the statutory exposure limit.*
Discussion *Citations for non-compliance with the respirable dust standard should be issued for any measure exposure that exceeds the exposure limit.* Am. J. Ind. Med. 49:492–498, 2006. © *2006 Wiley-Liss, Inc.*

KEY WORDS: ***compliance; coal mining; pneumoconiosis***

"Congress declares that—there is an urgent need to provide more effective means and measures for improving the working conditions and practices in the Nation's coal or other mines in order to prevent... occupational diseases originating in such mines." (Sec. 2(c), Federal Coal Mine Health and Safety Act [1969], Mine Safety and Health Act [1977])

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Accepted 6 March 2006
DOI 10.1002/ajim.20318. Published online in Wiley InterScience (www.interscience.wiley.com)

INTRODUCTION

First in 1994, again in 2000 [MSHA, CDC, 2000] and more recently in March, 2003, [MSHA, 2003a] the mine safety and health administration (MSHA) proposed several changes in regulations for monitoring coal miners' exposure to respirable dust. These changes were prompted in part by a long history of complaints, from miners and mine operators, about dust monitoring in coal mines. [Weeks, 2003] Among the changes, MSHA introduced the concept of the criterion threshold value (CTV). This is the value above the exposure limit at which MSHA would issue citations for non-compliance. It is derived from the sampling and analytical error of the sampling method and is its upper 95% confidence limit (one-tailed). The agency explained that the CTV was developed in order to provide a "high degree of confidence" that the true value of dust concentration exceeds the exposure

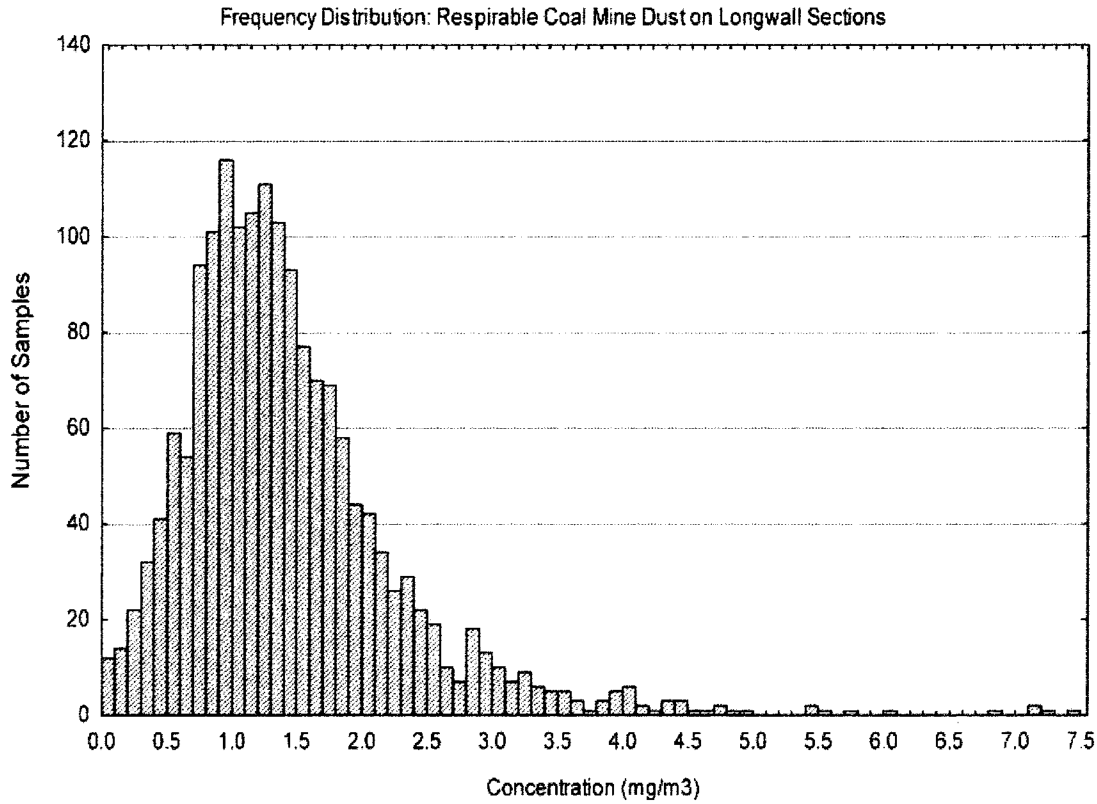

FIGURE 1. Frequency distribution respirable dust, longwall mining sections.

limit. When the applicable standard is 2.0 mg/m^3 (the statutory limit) and compliance is evaluated based on a single sample, the CTV is 2.33 mg/m^3.

This policy is not limited to respirable dust, is not unique to MSHA, and is not a recent development. Similar policies apply to other hazards and a similar policy is used by the Occupational Safety and Health Administration (OSHA). This policy does not appear in any regulation and until MSHA's current rule-making, it has not appeared in any preamble to any regulation.

To our knowledge, this policy has never been adjudicated and it is unlikely to be heard before any court using means available under the Mine Act. Employers are unlikely to contest the failure to issue a citation and employees under the Mine Act (Sec. 105) and the Occupational Safety and Health Act (Sec. 10(c)) are barred from contesting the failure to issue a citation. In its present form, it is not a part of the proposed dust monitoring rule per se but will appear only in MSHA's Coal Mine Health Inspection Procedures Handbook [MSHA, 2003b].

This is not a trivial concern. For example, based on samples taken at longwall sections in 2003, 36% of all valid measurements above the exposure limit of 2.0 mg/m^3 are between 2.0 and 2.33 mg/m^3 and under this policy, would not be subject to citation (Fig. 1, Table I). In addition, NIOSH has recommended a reduced exposure limit, suggesting that in the absence of MSHA promulgating a lower limit, if any consideration at all is given to sampling error, it should be err on the side of lower, not higher exposure [NIOSH, 1995].

MSHA describes how the numerical value for the CTV for respirable dust was derived, not only for evaluating compliance with the 2.0 mg/m^3 based on a single sample but also based on multiple samples with and without quartz.[1] For each situation, MSHA identified sources of variation, identified those associated with the sampling and analytical method, evaluated each, estimated the effects of their interaction, and calculated CTVs. For each situation, the logic is the same. It does not, however, describe why a "high degree of confidence" is needed.

The purpose of this discussion is to focus on the logic of this policy. We argue against it because it permits excessive exposure. The CTV policy is faulty in several respects.

- It raises the effective exposure limit for respirable dust.
- It is not fair.
- It is based on an inappropriate standard of proof.

[1] If there is more than 5% quartz, MSHA calculates a so-called reduced standard based on the formula, $L = 10/pQ$ with L in mg/m^3 and pQ, percent quartz.

TABLE I. Value of Respirable Dust Samples on Longwall Sections

Value of samples	Number of samples
$0 < V \leq 2.00$	1,203
$2.00 < V < 2.33$	104
$2.33 \leq V$	184
Total	1,491

In addition to these generic criticisms, applicable to the policy as implemented by MSHA and by OSHA, there are also some issues specific to mining and the Mine Act.

- At several places in The Mine Act, there is an implied preference for an affirmative need to maintain exposure below the exposure limit rather than an obligation not to exceed the limit.
- MSHA's Advisory Committee on dust monitoring and control and NIOSH both recommended that MSHA not adopt the CTV policy.

CONCEPTUAL FRAMEWORK

Before discussing these criticisms, we must first describe the conceptual and ideological framework of this policy. This discussion is not one that MSHA has articulated but is evident from the policy itself.

This policy combines concepts from statistics (hypothesis testing) and law (due process and standards of proof) and misapplies both. The principal purpose of guaranteeing due process is to protect accused persons from arbitrary abuse of power by the state. Following this principle, when MSHA considers whether to issue a citation for non-compliance, it presumes compliance and accepts the burden to prove non-compliance. This adherence to the principle of due process is combined with the rhetoric and logic of statistical hypothesis testing. By presuming compliance, the agency in effect creates a null hypothesis that it must disprove and it does so by adopting the conventional statistical criterion of showing that it is 95% confident that the measured exposure is above the exposure limit. This is analogous to the "beyond a reasonable doubt" standard of proof, appropriate for criminal violations. Citations for non-compliance, however, are civil violations requiring a "preponderance of evidence." By borrowing from and combining these two traditions, it acquires the appearance of fairness under the law and of rationality from science but to the detriment of miners' health.

When applied to the problem of decision-making in general or determining non-compliance in particular, statistical reasoning and legal reasoning are similar. The law begins with a presumption of innocence, which one has to disprove and statistics begins with a hypothesis, which one must reject. There are criteria for what is required to disprove or to reject either. Under the law, there are burdens of proof and in statistics, there are tests of significance. In apparent adherence to the principle of due process, MSHA has chosen 95% confidence limit as its statistical criteria for achieving a high degree of confidence.

Before these decision-making criteria are applied, MSHA formulates a presumption or a hypothesis that lays the foundation for its policy. As noted below, it is the presumption that exposure is below the exposure limit; ironically, this presumption allows it to rationalize a policy that permits exposure above the limit.

This logic is inherently contrary to the precautionary principle [Kriebel et al., 2001]. According to the precautionary principle, one presumes or hypothesizes that a hazard exists and the burden of proof is to show that it does not exist. Under conditions of uncertainty, the public health need is to demonstrate that exposure to some hazard is inherently safe. MSHA employs the reverse of this logic. This is not merely a matter of focusing attention on Type IV vs. Type II errors but of testing different hypotheses. This difference is described schematically in Figure 2.

CRITIQUE OF THE MSHA LOGIC

We do not question the propriety of the fundamentals of hypothesis testing or of due process. But we do question their application in formulating the CTV policy. It is the propriety of these concepts that lends the veneer of rationality and fairness but their misuse increases miners' risk of disease. The assumptions in the lightly shaded area in Figure 2 are the issues that we question. Because they are surrounded by well-established and reasonable principles, they appear proper. But in practice, MSHA is more concerned with protecting mine operators' rights than with preventing disease; the law should be a tool of disease prevention, not its master.

The defects with the CTV policy are as follows.

Outcome	Hypothesis Testing	CTV Policy	Legal Reasoning
Best estimate	sample mean	single sample	evidence
Variability	sample standard deviation	sampling & analytical error	
Policy, given variability	Avoid type I error	MSHA must show non-compliance with "high degree of confidence"	rules of evidence
Presumption	null hypothesis (H_0: E is below the exposure limit	presumption of compliance	presumption of innocence
Criterion; Standard of proof	95% confidence to reject H_0	criterion threshold value	Beyond a reasonable doubt
			Preponderance of evidence
Determination	rejection of null hypothesis	determination of non-compliance	guilt

FIGURE 2. Combining law and statistics to rationalize the CTV.

The CTV Raises the Effective Exposure Limit

The CTV in effect raises the exposure limit. In its simplest formulation, 2.33 mg/m^3 is greater than 2.0 mg/m^3. There is no dispute that the value measured by current sampling methodology is the best estimate of true exposure. If MSHA permits exposure to the CTV, it is inherently incapable of ensuring long-term compliance with the requirements of the Act. If measured exposure is 2.32 mg/m^3 the true value could in fact be $2.32+0.33=2.65$ mg/m^3 yet MSHA would not issue a citation for non-compliance. The CTV moves the benchmark for determining compliance but it does not (because it cannot) eliminate sampling and analytical error. It is as present at the CTV as it is at the exposure limit.

Over time, there would be a few occasions (fewer than 5%) when MSHA would issue a citation but, in fact, exposure was below the limit; there would be many occasions, however, when MSHA would *not* issue a citation but in fact, exposure would be above the limit. Since the mandate of the Act is to "continuously maintain exposure at or below the exposure limit," (Sec. 202 (b)(2)) this would not meet the requirements of the Act.

The CTV is not Fair and Requires Miners to Bear Most of the Burden of Uncertainty

Assume that the sampling and analytical error is normally distributed with a symmetrical bell-shaped curve. The area under this curve represents the distribution of uncertainty. The one-tailed CTV is selected so that 95% of the area under the curve is to its left, reducing the uncertainty of (Type I) error. In other words, reducing the burden of uncertainty on mine operators shifts most of this burden (95%) to miners. On the face of it, this is not fair. The CTV gives the benefit of doubt to the mine operators.

For measurements that fall between the exposure limit and the CTV, MSHA is proposing not to issue citations but is proposing to return and take more samples, essentially treating the CTV as an action level. The action level, as interpreted by OSHA, is the level at which there is a substantial probability that exposure is above the exposure limit. The "action" that follows is usually to take more samples. If MSHA measures exposure below the exposure limit, even above the lower confidence limit, MSHA proposes no action. The stark difference between the proposed MSHA practice and OSHA's action level is that in all of OSHA's applications of the action level, it is *below* the exposure limit, not above it.

There are alternative policies. For instance, if the measured exposure is above the exposure limit by any measurable amount, MSHA could issue a citation and, in effect, require the mine operator and miners to share uncertainty equally. In this way, the probability of not issuing a citation when exposure was above the limit would be equal to the probability of issuing a citation when exposure was below the limit.

MSHA replied to this option as follows:

> "Some commenters proposed that miners would be even more protected if non-compliance was cited whenever any single, full-shift measurement exceeded the applicable standard by any amount. That is, it was recommended that MSHA not make any allowance for potential measurement errors. MSHA has considered this recommendation but has not adopted it in the final policy because it could result in citations being issued where compliance with the applicable standard is more likely than not. If the mine environment is sufficiently well controlled, it is more likely that a particular measurement exceeds the applicable standard, but not the CTV, due to measurement error rather than due to excessive dust concentrations." [MSHA, 1997]

This reply is unconvincing. As a matter of common sense, miners would be more protected if exposure were enforced at a lower level. It is true that if the policy we recommend were adopted, it "... could result in citations being issued when compliance with the applicable standard is more likely than not." But the issue that MSHA ignores is that the CTV policy not only could but would result in citations *not* being issued when *non*-compliance with the applicable standard is more likely than not. Issuing citations if exposure is merely over the exposure limit by any amount would result in approximately equal number of citations not being issued when non-compliance was likely as the number of citations being issued when compliance was likely. On the face of it, this would be "fair."

Part of MSHA's rationale is based on two assumptions. The first of these is the assumption of the "well controlled" mine environment, roughly equivalent to the presumption of innocence. If the mine environment is "well controlled," that is, if exposure is below the exposure limit, it is in fact likely that measurements only slightly above the exposure limit are more likely to be the result of random error than overexposure. But there is no reason to make this assumption, a priori, and, in any event, MSHA fails to define, in any way, what a "well controlled" environment is. It is an arbitrary and abstract assumption.

Still another alternative, more consistent with the literal mandate of the Mine Act and with the precautionary principle, is to issue citations if the measured value is above the *lower* 95% confidence limit, that is, above 1.67 mg/m^3. Below this level, there is a high degree of confidence that exposure is below the limit, which is what the Mine Act requires. This policy is based on a different null-hypothesis, that is, that the environment is not in compliance, and imposes a different burden of proof, that is, that the mine operator must show compliance. In analogous situations, health professions strive for concentrations of hazardous substances that are known to be "safe," that is, below a critical level. Should we not, in public health, have the same generic standard of practice?

These three options—cite if above the upper confidence limit, cite if above the exposure limit, or cite if above the lower confidence limit—correspond to those outlined by Leidel et al. [1977] in their occupational exposure sampling strategy manual. Of these three options, MSHA has chosen the one that favors mine operators the most and provides the least protection for miners health.

The Risk That Miners Face is not Equivalent to the Risk That Mine Operators Face

Fairness is not a mathematical abstraction. If the bell-shaped curve centered at the exposure limit represents the distribution of uncertainty and the effects of uncertainty were equal, a commitment to fairness implies that risk should be shared equally, that is, that the area under the curve be divided evenly. The second option above (cite if over the exposure limit) achieves this balance and appears to be fair—when treated merely as a matter of sharing uncertainty conceived of as the area under the curve. This is, however, only the illusion of fairness. Uncertainty for miners means risk of acquiring an irreversible and disabling disease; for mine operators it is a civil penalty and a nominal fine.

MSHA is Applying an Inappropriate Standard of Proof

The Mine Act states unequivocally that citations for violations of MSHA standards are civil penalties. To gain a conviction in cases of civil penalties, one must show "with a preponderance of the evidence" that the accused committed the offense. A preponderance means more likely than not. In statistical jargon, this means a probability greater than 0.50. The CTV policy, by requiring a "high degree of confidence," and in practice, requiring a probability greater than 0.95, requires a higher standard of proof than is appropriate for civil penalties.

MSHA employs conventional statistical logic to obscure this legal misinterpretation. The concept and terminology, "high degree of confidence" is taken directly from the confidence interval used in hypothesis testing. Translated into legal terms, this is analogous to the standard of proof, "beyond a reasonable doubt" which is characteristic of criminal and not civil charges.

None of this reasoning is appropriate to this situation. Not only are citations for non-compliance civil penalties, there are no a priori reasons to presume compliance. Presuming compliance runs contrary to the purpose of the Mine Act and contrary to standard means of disease prevention. The purpose of the Mine Act is "...to prevent...occupational diseases originating in such mines..." and to do so, miners' exposure has to be controlled "...at or below..." the exposure limit for "...the miner's entire working life." (Secs. 2(c), 202(b)(1), and 101 (a)(6)(A), respectively). The principal incentive on mine operators for controlling exposure created by the Mine Act is enforcing compliance. If one is going to presume anything, it would be to presume non-compliance.

There are, in fact, many reasons *not* to presume compliance. There is a long history of mine operators submitting fraudulent samples in order to avoid citations for non-compliance [Boden and Gold, 1984; Weeks, 2003]. Further, an investigation by MSHA's statistician, demonstrated that when MSHA took dust samples over several consecutive days, the results on the first day, when the inspection was unannounced, was on average, higher than it was on subsequent days [Kogut, 1994]. This difference was not a result of trends nor was it a regression to the mean phenomenon. A reasonable conclusion from these findings is that when mine operators knew that an inspection was imminent, conditions changed. This phenomenon is assumed by common sense and by a provision in the Mine Act (with a similar provision in the Occupational Safety and Health Act) prohibiting advance notice of inspections (Sec. 103 (a)). Whenever MSHA measures exposure, it is taken over an entire shift and MSHA has the advantage of no advance notice only at the start of that shift. The mine operator can do many things during that shift to reduce dust levels and create the appearance of compliance. For example, the operator may adjust ventilation, water sprays, or production levels. That operators do make adjustments is evident not only from their own sampling but also from the phenomenon that Kogut observed.

The Mine Act Implies That MSHA Err on the Side of Caution

The Mine Act requires that exposure to respirable dust be "*...kept continuously at or below the exposure limit for each miner on each shift.*" (Sec. 202 (b)(2)). It does not say that exposure shall not exceed the exposure limit. This subtle difference focuses attention on the affirmative duty of mine operators to keep exposure to respirable dust below the exposure limit rather than a prohibition against exceeding that limit. The exposure limit is not, in other words, an upper limit so that any performance below that limit is acceptable. Rather it is an upper limit not to be exceeded and the lower the concentration the better.

When the Federal Coal Mine Health and Safety Act of 1969 was passed, it created interim standards to which mine operators would have to comply. These provisions were carried over to the Mine Safety and Health Act of 1977. Anticipating that the agency would eventually pass its own standards it requires that no subsequent standard would reduce the protection afforded miners (Sec. 101 (a)(9), and (b)). Concerning exposure to respirable dust, this meant that no exposure limit could exceed 2.0 mg/m^3. The CTV is contrary to the spirit, if not the letter of this provision.

The spirit of these provisions is reinforced in a section of the Act concerned with mine ventilation. Ventilation is one of the principal means of reducing exposure to respirable dust and mine operators are required to maintain ventilation "*... sufficient to reduce the concentration of respirable dust to the lowest attainable level.*" (Sec. 303(b)) (emphasis added.)

MSHA has Been Advised Against Adopting the CTV Policy

An advisory committee, convened for the purpose of advising MSHA on reforms of the dust monitoring program, characterized this policy as raising the standard and explicitly recommended against adopting it [Mine Safety and Health Administration, 1996]. And NIOSH, while recommending a lower exposure limit (from 2.0 to 1.0 mg/m^3) also recommended that "MSHA make no upward adjustment of the exposure limit to account for measurement uncertainties." [NIOSH, 1995]

DISCUSSION/CONCLUSION

The CTV policy is an instance where an exposure limit is subverted by the way in which it is enforced. Set at 2.0 mg/m^3, MSHA in effect raises the limit to 2.33 mg/m^3 by failing to issue citations for non-compliance at exposure measured above 2.0 mg/m^3 but less than 2.33 mg/m^3. They do so by imposing an inappropriate standard of proof—the requirement for a high degree of confidence—rather than the standard of proof appropriate for civil violations. This policy has the appearance of due process and statistical rationality but in fact is not protective and unfair.

Published discussions of exposure variability are often limited to analysis of its sources, with sampling and analysis being one source among many. Nicas et al. [1991] for example, note that environmental variability is a far greater source of measurement variability than is sampling and analytical error and that preoccupation with sampling and analytical error is misplaced. Tornero-Velez et al. [1997] conclude that compliance testing can significantly underestimate health risk especially with small sample sizes. These authors conclude that assessment practices which focus upon either compliance or exceedance (i.e., the likelihood that any measurement would exceed an occupational exposure limit) are problematic and recommend that employers evaluate exposures relative to the probabilities of overexposure. While this recommendation is not directly related to MSHA's CTV policy, it nevertheless focuses attention on the aim of preventing disease.

An earlier paper by some of the same authors cited above notes that employers can maximize compliance (or rather, the appearance of compliance) by minimizing exposure monitoring [Rock, 1982; Rappaport, 1984]. One solution is for the regulatory agency to define compliance in relation to cumulative exposure, implying the use of several measurements. Buringh and Lanting [1991], discussing this problem from the Netherlands, also suggest taking serial samples in order to obtain an accurate estimate of the geometric standard deviation then comparing the geometric mean with the relevant exposure limit (without explaining why one should compare the geometric rather than the arithmetic mean with the exposure limit). None of these authors discuss the potential for measurement bias associated with serial measurements or the propriety of basing compliance on serial measurements.

Evaluating cumulative exposure with serial measurements focuses attention on exposure measurements associated with risk of disease. Even without accounting for bias inherent in serial measurements noted above [Kogut, 1994], in order to accumulate sufficient information about cumulative exposure to make a reliable estimate of risk, one runs the risk of tolerating the very exposure that the agency is committed to preventing. [Weeks and Jordan, 1985]. In any event, enforcement activities are more problems of risk management than of risk assessment [Hewett, 2001].

The most thorough discussion of sampling variability in relation to compliance is by Leidel et al. [1977]. These authors describe four different regions: less than the lower 95% confidence limit, between this limit and the exposure limit, greater than the exposure limit but less than the upper 95% confidence limit, and greater than the upper 95% confidence limit. In general, MSHA (and OSHA) issue citations only if measured exposure is greater than the upper 95% confidence limit. Like others, these authors do not discuss the implications for determining non-compliance in any of these regions (perhaps because it is elementary that higher exposure results in higher risk of disease).

A case could be made (employing the precautionary principle) for issuing citations for exposure measured above the lower 95% confidence limit. However, we suggest treating the lower 95% confidence limit as an action level and issuing citations if measured exposure is greater than the exposure limit. This is an appropriate standard of proof for civil violations, it is consistent with the plain language of the Mine Act, it shares risk of error equally between miners and mine operators, and is more likely to meet the aim of disease prevention than does the CTV.

Lawyers and statisticians are two professions commonly slandered because of their allegiance to base causes. There is little in MSHA's policy to rescue them from this fate. However, this collaboration has succeeded in part because "public health professionals have dropped the ball," to use Eula Bingham's memorable comment when she left OSHA.

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