MSHA's Revised Quartz Enforcement Program

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To control the health hazard associated with quartz in the U.S. coal mining industry, Federal regulations require that whenever the quartz content of the respirable dust in the coal mine environment exceeds five percent, the applicable respirable dust standard is reduced. This regulation, which is applicable for both surface and underground mining operations, has been in force since the promulgation of the Coal Mine Safety and Health Act in 1969. On December 1, 1985, the Mine Safety and Health Administration (MSHA) instituted a revised quartz policy relative to the enforcement of this regulatory requirement.

Under the previous enforcement policy, reduced dust standards were set based upon results of quartz analyses performed only on MSHA inspection samples and were determined from the results obtained from a single sample. The new (or revised) policy allows coal mine operators the opportunity to voluntarily submit samples for use in the standard setting process. The system also provides a mechanism for the reevaluation at approximate six month intervals of mining operations which are on a reduced standard.

This paper presents the background behind the development of the new program and discusses its operating mechanics. Information describing the mining community's participation in the program is also given.

Introduction

It has long been recognized that exposure to coal mine dust can lead to the development of the disease known as coal worker's pneumoconiosis (CWP); defined by Morgan and Seaton as "the accumulation of coal dust in the lungs and the tissues' reaction to its presence."[1]

In 1948 the Bureau of Mines recommended limits of dustiness for mining operations. The limit for dust containing more than five percent quartz was to be determined by multiplying the particle concentration by the percent quartz; the number determined was not to exceed five million particles per cubic foot of air. In setting this limit, recognition was given to the fact that the toxicity of coal mine dust is dependent on the quantity of quartz contained in the dust.

The increased hazard associated with exposure to coal mine dust containing quartz was further recognized by the U.S. Congress, when, as part of the Federal Coal Mine Health and Safety Act of 1969, it required that a formula be developed for determining the applicable respirable dust standard whenever the quartz content of the respirable dust was greater than five percent. Such a formula was developed and is included in Parts 70.101, 71.101, and 90.101 of Title 30, Code of Federal Regulations (CFR). These regulations state that: "When the respirable dust in the mine atmosphere of the active workings contains more than five percent quartz, the operator shall continuously maintain the average concentration of respirable dust... at or below a concentration of respirable dust... computed by dividing the percent of quartz into the number 10."

In 1978 a review of MSHA's quartz analysis data showed that approximately 40 percent of the underground respirable dust samples analyzed contained greater than five percent quartz; however, because of the analytical techniques used at that time, only 25 percent of the dust samples submitted for analysis were being analyzed. In 1981 a revised analytical technique was implemented.[2] The new technique provided the capability of analyzing nearly all samples submitted for quartz analysis. In December of 1984 there were approximately 1800 underground and 800 surface coal mining entities that were on a reduced standard because the quartz content of the respirable dust exceeded five percent. Figure 1 shows the percentage of samples, by type of underground mining operation, that had a quartz content greater than five percent. Also shown on this figure is the percentage of samples analyzed whose dust concentration exceeded the applicable dust standard established from the quartz percentage determined. One significant point that should be noted from these data is that 60 percent of the samples representative of the continuous mining and roof bolting operations are above the applicable standard established from the quartz content of those samples.

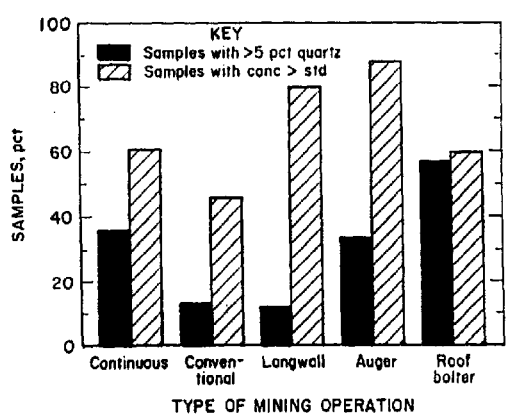

FIGURE 1. Analysis of quartz data from samples containing more than five percent quartz, 1984.

Because of the large number of mining entities on a reduced standard, the fact that many of the entities (more than half) are not sampled after the standard is reduced and mine operators were questioning adjustment of the standard based on the analysis of a single respirable dust sample, MSHA established a program to develop improved enforcement procedures that would enhance the health protection of the miner and the integrity of the protocol used to adjust the respirable dust standard when the quartz content of the dust exceeds five percent.

Quartz Enforcement Program Prior to December 1985

The main thrust of MSHA's respirable dust enforcement program is aimed at approving a mine operator's dust control plan. Selected respirable dust samples collected during the plan approval process are analyzed for quartz and, when necessary, the applicable respirable dust standard is adjusted. MSHA's policy calls for approving or reviewing a mine operator's dust control plan twice a year for underground mining operations and once a year for surface mining operations.

Those samples collected in underground coal mines during a plan approval that are typically analyzed for quartz content are the designated occupation (DO) samples (samples collected on the occupation on a mining operation that has the highest respirable dust exposure), all roof bolter (RB) samples and samples collected from areas of a mine where excessive respirable dust and/or quartz levels are suspected. Designated work position (DWP) samples collected at surface mining operations are the samples typically analyzed for quartz content; however, samples may be collected on other occupations or operations suspected of having excessive quartz and/or respirable dust levels.

TABLE I

Comparison of Occupational Quartz Determinations by Type of Mining

Type of Mining	DO* > All Occupations (%)	DO > All Occupations Except RB** (%)	RB > DO (%)
Continuous	41	68	61
Conventional	43	69	66
Longwall	57	NA	NA
Auger	50	50	100

* CO = Designated Occupation
** RB = Roof Bolter

Underground mine environments on a reduced standard based on the analysis of DO samples are sampled bimonthly by mine operators in accordance with the requirements of Title 30, CFR Part 70. Normally, 30 samples per year are collected in these environments. However, environments with standards which were adjusted based on the analysis of samples collected on the roof bolter or from some other non-designated area of the mine were not sampled again until the dust control plan was reevaluated. In practice, the time span for resampling of these environments ranged from six months to two years. Consequently, the environments of the roof bolting operation, the underground mining operation that had the highest incidence of exposure to quartz and typically the lowest respirable dust standard, were never monitored for conformance with the reduced dust standard. A similar situation existed for surface coal mine environments. Only those occupations assigned as DWP's are required to be sampled by the mine operator (Title 30, CFR Part 71). Unless those occupations placed on a reduced dust standard are made DWP's by MSHA en- forcement personnel, no further sampling is conducted until the dust control plan is reevaluated. DWP's are sampled bimonthly by the mine operator. A minimum of six samples are collected per year.

Development of Revised Program

To achieve the goals of enhancing miner health protection through improved enforcement procedures and improving the integrity of adjusting the respirable dust standard when the quartz content of the dust exceeds five percent, two investigations were conducted. The first investigation evaluated MSHAs policy of adjusting the respirable dust standard for a mining operation based on the quartz percentage of the designated occupation, and the second centered on quantifying the day-to-day variability associated with the quartz percentage in the environments of underground mining operations.

The first investigation consisted of analyzing all samples collected by enforcement personnel during the approval of a mine operator's dust control plan, for quartz content. This consisted of samples collected on the DO, RB and three or more other occupations working on the mining operation whose dust control plan was being evaluated.

The percentage of quartz determined for the DO sample was then compared to the percentage of quartz determined for: all the other occupation samples on the mining operation, all occupations except the roof bolter. A comparison of these three determinations is shown on Table I. As the comparison shows, the quartz percentage of the DO sample is equal to or greater than the quartz percentage of all occupations approximately 45 percent of the time, is equal to or greater than all occupations except the roof bolter approximately 70 percent of the time and is less than that of the roof bolter sample approximately 63 percent of the time.

It was concluded from this investigation that: 1) adjusting the respirable dust standard based on the quartz determination of a sample collected on the DO would provide protection for the majority of the personnel on a mining operation, except for the roof bolter, and 2) that a separate standard needed to be established for the environment of the roof bolter occupation.

The second investigation consisted of analyzing mine operator dust samples, submitted in fulfillment of regulatory requirements (Title 30, CFR Part 70), for quartz content. The samples analyzed were designated occupation samples from mining operations that were on a reduced dust standard as of April 1983. Data were accumulated on 86 mining operations, which represented approximately ten percent of the operations on a reduced dust standard at that time. For each operation there were five or more samples which rep-

resented three or more bimonthly sampling periods. The number of analyses necessary to estimate the long-term average quartz percentage for a given operation was determined by calculating the average quartz percentage using the most recent groups of five, three, and two samples and then comparing these respective averages to the averages determined from all the samples obtained on a given operation. In addition, the last sample analyzed was compared to the overall average.

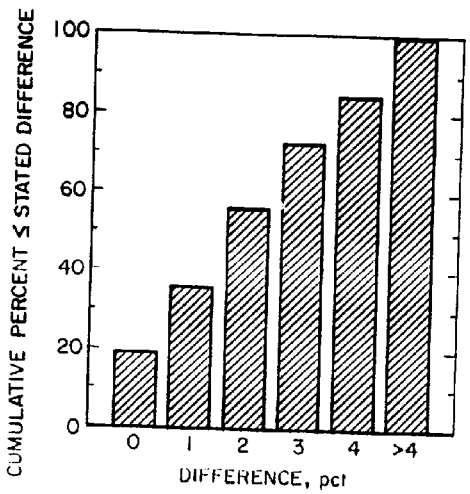

FIGURE 2. Difference between six-month average percentage and percentage of last sample.

Figure 2 shows the cumulative frequency distribution of the differences between the quartz percentage determined over the three bimonthly sampling periods and the quartz percentage of the last sample analyzed. As the data show, a quartz determination based on a single sample is equivalent to the long-term average approximately 20 percent of the time, and is only within three percent approximately 72 percent of the time, indicating that a quartz determination from a single sample is not a good estimator of the long-term average quartz level of an operation.

Figure 3 shows the cumulative frequency distribution obtained when the average of the last five samples is compared to the long-term average. As these data show, the average determined from the most recent five samples agrees closely with the long-term average, i.e., the five sample average is within one percent of the long term average 87 percent of the time and within two percent 92 percent of the time.

Figure 4 shows the distribution obtained using the average of the last three samples. As the data show, at a difference of two percent, the average of three samples provides nearly as good an estimator of the long-term average as using the average of five samples.

A comparison of the average of the last two samples to the average of the last three samples is shown in Figure 5. This comparison shows that these two averages are within two percent 96 percent of the time. Based on these data, it was concluded that a reasonable estimate of the long term (six months) average quartz percentage of an operation could be obtained from the average of three samples and that a high percentage of the time the average of the two most recent samples reasonably agreed with the average of the most recent three. These data were used to develop the sampling scheme used in the revised quartz program to adjust the dust standard of an operation.

Revised Quartz Program

In developing the revised quartz program, the following objectives were given primary consideration:

1. Accounting for the day-to-day variability associated with environmental quartz percentages.
2. Using samples collected by mine operators to establish the dust standard when the percent quartz in the mine environment exceeds five percent.
3. Providing for subsequent environmental monitoring of occupations, or environments placed on a reduced dust standard.
4. Reevaluating operations on a reduced dust standard biannually.

All of these objectives were met in the program developed and implementation of the program did not require the promulgation of new regulations or changes to existing regulations.

In the revised quartz program, samples collected during the approval of a mine operator's dust control plan are similarly submitted for quartz analysis, i.e., samples collected on the DO, RB, DWP as well as those collected from

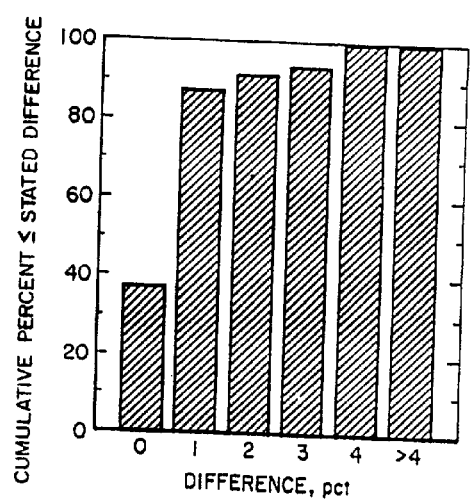

FIGURE 3. Difference between six-month average percentage and average percentage of last five samples.

areas where excessive respirable dust and/or quartz level are suspected. If any of the samples submitted for quartz analysis are found to contain more than five percent quartz, the mine operator is notified that he has the option of collecting a sample on the entity represented by that sample and submitting it to MSHA for analysis. If the analysis of the sample shows the quartz percentage to be within two percent (difference) of the MSHA sample, the quartz determinations from the two samples are averaged. If the average is greater than five percent, a new environmental dust standard is established based on the average quartz value. However, if the quartz determination of the operator's optional sample differs from the MSHA sample by more than two percent (difference), the operator is given the option of collecting another sample on the entity and submitting it for analysis. The quartz determinations from all three samples are then used to establish an average quartz percentage for the entity. If the average quartz percentage is greater than five percent, the standard for the entity is accordingly adjusted. In any instance where the mine operator does not elect to submit a sample for analysis or the samples submitted do not contain sufficient dust (greater than 0.5 milligrams) for analysis, the standard established for the entity is based on the quartz percentage determined from the MSHA sample or, if a first optional sample had been submitted, on the greater of the two (MSHA or operator). In the revised program, any entity, other than the DO, that is placed on a reduced dust standard can be required to be assigned "designated area" (DA)

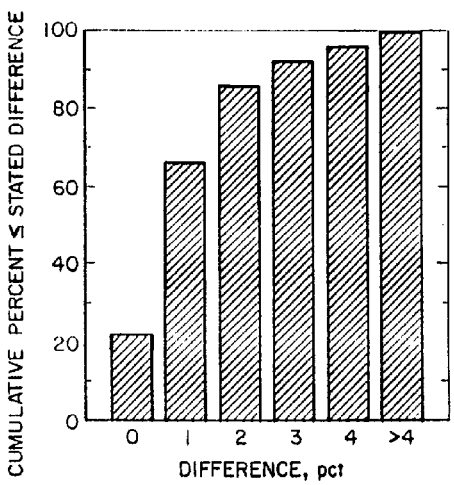

FIGURE 4. Difference between six-month average percentage average and average percentage of last three samples.

status. This requires the entity to be identified in the operator's Ventilation System and Methane and Dust Control Plan and to be sampled bimonthly by the mine operator. The mine operator is required to collect five samples bimonthly on the DO whether the dust standard has been adjusted or not. The samples may be collected on consecutive production shifts or on production shifts on consecutive days. Requiring all entities on a reduced standard (other than the DO) to be made designated areas is considered a major thrust at enhancing miner health protection because subsequent monitoring of the entity is then required by the mine operator.

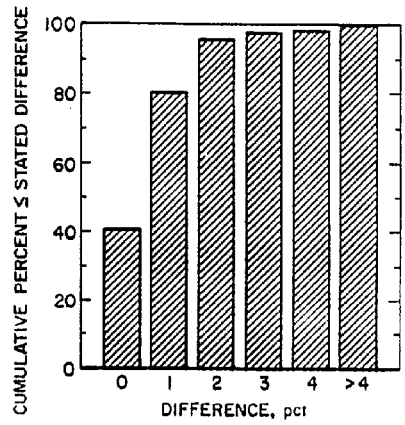

FIGURE 5. Difference between average percentage of last two samples and average percentage of last three samples.

Six months after an entity has been placed on a reduced dust standard, the data of samples submitted by mine operators in accordance with regulatory requirements (Title 30, CFR) are screened by a computer. Provided that the entity is in compliance with its applicable dust standard, the computer identifies the first sample submitted with sufficient dust for analysis. This sample is then analyzed for quartz content. If the quartz percentage determined from that sample is within two percent of the quartz percentage used to adjust the standard, the quartz percentage used to adjust the standard and the quartz percentage determined from the operator's sample are averaged and the standard revised accordingly. If the quartz percentage from the operator's sample is not within two percent, the operator is given the option of collecting and submitting a sample for analysis. The environmental dust standard for the operation is then determined by averaging the quartz percentage used to establish the existing standard, the quartz percentage determined from the computer selected sample and the quartz percentage of the optional sample submitted by the operator. If the operator does not elect to submit the optional sample or the sample is voided because of insufficient weight, the preestablished environmental standard remains in effect. The standard is not automatically reevaluated again until another six month period has lapsed.

Revised Quartz Program Status

Initiation of the revised quartz program commenced on December 1, 1985. At the time of commencement approximately 360 samples were being analyzed per month; 38 percent of these were DO samples, 10 percent DWP samples, 6 percent DA samples, 33 percent roof bolters, and the remainder nondesignated entities or work positions. Of

the samples analyzed, approximately 30 percent of the DO samples, 50 percent of the roof bolter samples, and 50 percent of the DWP samples contained greater than five percent quartz. Based on these figures and the assumption that 100 percent of the mine operators would elect to submit a sample for analysis when given the option and that 45 percent of the time a third optional sample would be submitted by the operator, it was estimated that approximately 18,000 quartz analyses would be performed a year.

At the present time, approximately 500 samples per month are being analyzed. The percentage of samples being analyzed in the respective categories previously discussed is approximately the same, and the percentage of samples in each of the categories that have a quartz percentage greater than five percent is also approximately the same. However, mine operators are not electing to participate in the standard setting process at the level assumed (100%). Only 35 percent of the operators who have been notified that they have the option of submitting a sample for analysis have elected to submit one. Of the optional samples submitted by mine operators, approximately 25 percent could not be analyzed because of insufficient weight gain (< 0.5 milligrams).

Prior to commencement of the revised program, it was estimated that quartz determinations on two consecutive samples would be within two percent (difference) 55 percent of the time and the option to submit a third sample would occur approximately 45 percent of the time. However, at the present time only 31 percent of the operators' first optional samples are within two percent of the MSHA sample, permitting the option to submit a third sample 69 percent of the time.

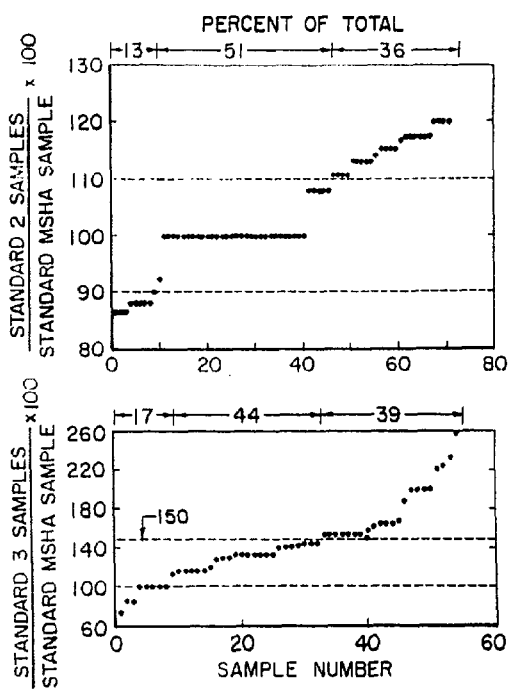

FIGURE 6. Comparison of dust standards established using an average quartz value and the quartz value from a single MSHA sample (data from revised quartz program.)

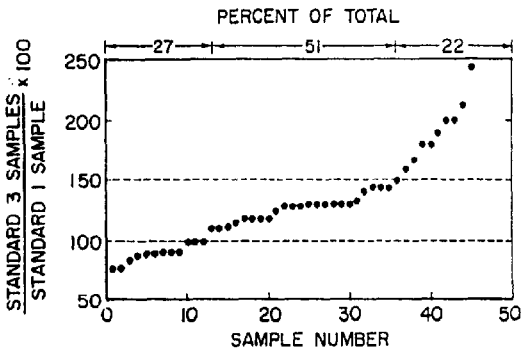

FIGURE 7. Comparison of dust standards established using an average quartz value from three samples and the quartz value from one sample (data from analyzing operator samples).

The effect of the revised program on the standard established for a given operation was also assessed. Figure 6 shows a comparison of dust standards established using the average quartz value determined from the analysis of two or three samples and the quartz value determined from the MSHA sample that was greater than five percent. As these data show, dust standards established from the average of two samples (one MSHA and one operator) are equal to or within ten percent of the standard determined from the MSHA sample alone 51 percent of the time and are 10 to 20 percent higher 36 percent of the time. When three samples are used (one MSHA and two operators) the standards established exceed those established using the one MSHA sample 83 percent of the time. Approximately one-half of these standards are more than 1.5 times those established from the one MSHA sample. Standards derived from the single MSHA sample exceeded the standard derived from using the average from three samples only 7.5 percent of the time. This percentage is not significantly different from that obtained from a similar analysis of operator data where standards based on quartz determinations from a single sample, with greater than five percent quartz, were compared to the average determined from three samples (the single sample determination being one of the three). A plot of these data is shown in Figure 7. As the data show, approximately 73 percent of the time the standard derived from the average quartz percentage is greater than that derived from the single sample; with approximately 27 percent of these exceeding 1.5 times those established from the single sample.

As previously discussed, one of the major objectives of the revised quartz program was to enhance miner health protection through subsequent monitoring of occupations or environments placed on a reduced dust standard, the oc-

cupation of primary concern being the roof bolter. To date, there have been 482 roof bolting operations placed on a reduced dust standard (approximately 45% of all roof bolter samples analyzed have greater than 5% quartz). At the present time 243, or 50 percent, of these operations have been established as a DA, thus requiring subsequent monitoring by the operator.

In May of 1986, computer screening of operator respirable dust samples from operations on a reduced dust standard commenced. Nine samples had been identified and analyzed by August. To date insufficient data have been gathered to comment on this aspect of the program.

Epilogue

MSHA's revised quartz enforcement program inherently contains the elements necessary to achieve the objectives of:

1. Taking into consideration the day-to-day variability associated with quartz percentages when establishing the respirable dust standard for a mine environment.
2. Using the analysis of operators' samples to establish the respirable dust standard of an environment.
3. Subsequent monitoring of personnel or operations placed on a reduced dust standard.
4. Reevaluation of operations on a reduced dust standard biannually.

However, a review of the revised program seven months after its implementation indicates that several of these objectives have not been fully realized. Mine operators have elected to submit optional dust samples for use in establishing an environmental dust standard only 35 percent of the time, and the percentage of roof bolting operations that have been placed on a reduced dust standard and assigned "designated area" status, is less than originally projected. Failure of mine operators to participate in establishing the standard has had no impact on individual health protection because standards established based on the analysis of a single sample are typically lower than those established from averaging the results from several samples. However, not assigning roof bolting operations on a reduced dust standard "designated area" status eliminates any requirement of the operator to subsequently sample the operation to confirm that the dust concentration is being maintained at the applicable standard.

References

1. **Morgan, W.K. and A. Seaton:** *Occupational Lung Diseases.*. W.B. Sanders Company, Philadelphia, Pennsylvania (1975).
2. **Goldberg, S.A., T.F. Tomb, P.M. Kaesmar et al:** MSHA's Procedure for Determining Quartz Content of Respirable Coal Mine Dust. Mine Safety and Health Administration, *IR 1152* (1984).