

shifts, including those that were not sampled, at these same 716 MMUs. With 99-percent confidence, the overall percentage of production shifts on which the DO sample exceeded the standard was between 18.6 percent and 20.0 percent for 2001. At the same confidence level, again assuming representative operating conditions, the overall mean excess on noncompliant shifts at these MMUs was between 0.96 mg/m<sup>3</sup> and 1.11 mg/m<sup>3</sup>. If, as some commenters on the earlier single sample proposed rule and the Dust Advisory Committee proceedings have alleged, operators tend to reduce production and/or increase dust controls on sampled shifts, then the true values could be higher than even the upper endpoints of these 99-percent confidence intervals.

The available data suggest that, unless changes are made to enforce the applicable dust standard on every shift, the same general pattern of overexposures observed in 2001 will persist into the future.<sup>18</sup> Therefore, MSHA concludes that without the proposed changes:

- More than half of all MMUs would continue to have a pattern of recurrent overexposures on individual shifts;
- At those MMUs with recurrent overexposures, full-shift average respirable dust concentrations for the DO would continue to exceed the applicable dust standards on about 20 percent of all production shifts;
- Among those shifts on which DO exposure exceeds the applicable dust standards, the mean excess for the DO would continue to be approximately 1 mg/m<sup>3</sup>.

If all overexposures on individual shifts are eliminated, the reduction in total respirable coal mine dust inhaled by a miner over a working lifetime will depend on three factors: (1) The average volume of air inhaled on each shift that would otherwise have exceeded the applicable dust standard, (2) the degree of reduction in respirable dust concentration in the air inhaled on such shifts, and (3) the number of such shifts per working lifetime. While the inhaled dose (mg) could not be measured directly, it is biologically and quantitatively related to the accumulated exposure (*i.e.*, airborne concentration multiplied by duration, summed across jobs for each miner) used to predict CWP and PMF prevalences in the Attfield-Seixas models. If a miner inhales ten cubic meters of air on a shift (U.S. EPA, 1980), reducing the respirable coal mine dust

concentration in that air by 1.04 mg/m<sup>3</sup> will result in 10.4 mg less dust inhaled on that shift alone. Assuming the miner works 240 shifts per year, then reducing inhaled respirable dust by an average of 10.4 mg on 19.3 percent of the shifts will reduce the total respirable coal mine dust inhaled by 482 mg per year, or nearly 22,000 mg over a 45-year working lifetime:

1.04 mg less respirable coal mine dust per m<sup>3</sup> of inhaled air  
 × 10 m<sup>3</sup> inhaled air per shift  
 × 46.32 affected shifts (*i.e.*, 19.3% of 240) per work year  
 × 45 work years per working lifetime  
 = 21,678 mg less respirable coal mine dust inhaled per working lifetime.

In Section V, the strengths and weaknesses of various epidemiological studies were presented, supporting the selection of Attfield and Seixas (1995) as the study that provides the best available estimate of material health impairment with respect to CWP. Two strengths of this study are its quantitative description of exposure-response among both miners and ex-miners (who had worked as miners for approximately 13–40 years) and the fact that it reflects recent conditions experienced by coal miners in the U.S. Using the exposure-response relationship it is possible to estimate the health impact of bringing dust concentrations down to or below the applicable dust standard on every shift. This is the only contemporary epidemiological study of CWP in U.S. miners providing such a relationship.

Attfield and Seixas (*op cit*) used two or three B readers to identify the profusion of opacities based on the ILO classification scheme.<sup>19</sup> The most inclusive category defined in their paper was CWP 1+, which include simple CWP categories 1, 2, and 3, as well as PMF. The second category CWP 2+, does not include simple CWP, category 1, but does include the more severe simple CWP categories, 2 and 3, as well as PMF. The third category used in their report was PMF, denoting any category (A, B, or C) of large opacities. The authors applied logistic regression models to the prevalence of CWP 1+, CWP 2+, and PMF as a function of accumulated coal mine dust exposure calculated for each miner included in the study. In the absence of data differentiating the inhalation rates of individual miners, the accumulated

exposures in these models were expressed in units of mg-yr/m<sup>3</sup>.

At the MMUs being considered (those exhibiting a pattern of recurrent overexposures), bringing dust concentrations down to no more than the applicable dust standard on each and every production shift would reduce DO exposures on the affected shifts by an average of 1.04 mg/m<sup>3</sup>. Assuming this average reduction applies to only 19.3 percent of the shifts, the effect would be to reduce cumulative exposure, for each miner exposed at or above the DO level, by 0.20 mg-yr/m<sup>3</sup> over the course of a working year (*i.e.*, 19.3 percent of shifts in one year, times 1.04 mg/m<sup>3</sup> per shift). Therefore, over a 45-year working lifetime, the benefit to each affected miner would, on average, amount to a reduction in accumulated exposure of approximately 9.0 mg-yr/m<sup>3</sup> (*i.e.*, 45 years times 0.20 mg-yr/m<sup>3</sup> per year). If, as some miners have testified, operator dust samples submitted to MSHA tend to under-represent the frequency or magnitude (or both) of individual full-shift excursions above the applicable dust standard, then eliminating such excursions would provide a lifetime reduction of even greater than 9.0 mg-yr/m<sup>3</sup> for each affected miner.

The Attfield-Seixas models predict the prevalence of CWP 1+, CWP 2+, and PMF for miners who have accumulated a given amount of exposure, expressed in units of mg-yr/m<sup>3</sup>, by the time they attain a specified age. Benefits of reducing cumulative exposure can be estimated by calculating the difference between predictions with and without the reduction. For example, suppose a miner at one of the MMUs under consideration begins work at age 20 and retires at age 65. At these MMUs, the mean DO concentration reported in 2001 was 1.15 mg/m<sup>3</sup>; so, after 45 years, a miner exposed at this level can be expected to have accumulated a total exposure of nearly 52 mg-yr/m<sup>3</sup> (*i.e.*, 45 yr × 1.15 mg/m<sup>3</sup>). By the year of retirement, such a miner is expected to accumulate, on average, 9.0 mg-yr/m<sup>3</sup> less exposure if individual shift excursions are eliminated. For 65-year-old miners, reducing an accumulated total dust exposure of 52 mg-yr/m<sup>3</sup> by 9.0 mg-yr/m<sup>3</sup> reduces the predicted prevalence of “CWP 1+” by more than 16 per thousand (see the entry for affected DO miners in Table VI–1).<sup>20</sup>

<sup>20</sup> The Attfield-Seixas model predicts a higher prevalence of CWP, and consequently a greater risk reduction (35 per thousand DO miners at age 65), after 45 years of occupational exposure to coal mine dust in central Pennsylvania or southeastern West Virginia. (Attfield and Seixas attribute this effect to

Continued

<sup>18</sup> Appendix VI.1 compares the pattern observed in 2001 to that in earlier years.

<sup>19</sup> If three readings were available, the median value was used. If two readings were available, the higher of the two ILO categories was recorded. Eighty radiographs were eliminated because only one reading was available.