

hour measurements using a sampling device known as the MRE instrument. Work shifts in U.S. coal mines now frequently exceed eight hours. According to a recent survey of MSHA District Offices conducted in August of 2002, approximately 48 percent of underground mines work 9-hour shifts or longer. Therefore, to provide the intended level of protection to miners working longer than eight hours, it is necessary to convert coal mine dust concentration measurements to equivalent 8-hour values as measured by the MRE instrument.

The first step in the conversion from "concentration" to "equivalent concentration" is intended to make the measurement equivalent to the concentration measured by an MRE instrument. This instrument was designed to selectively collect airborne dust in a way that would approximate the deposition of inhaled particles in

the lung. Because the MRE instrument was large and cumbersome, other, more portable samplers were developed for use in U.S. coal mines. Currently approved sampling devices use a 10-mm nylon cyclone to separate the respirable fraction of airborne dust, instead of the four horizontal plates used in the MRE sampler. Such differences in sampler design lead to systematic differences in the amount of dust collected. Since 1980, measurements made using the currently approved cyclone-based devices operating at a flow rate of 2.0 liters per minute (lpm) were multiplied by the constant factor of 1.38 prescribed by the Secretary for the approved sampling device used. Application of this factor compensates for the difference in dust collection characteristics and makes the measurements equivalent to what would be obtained using an MRE instrument.

Similarly, the second step in the conversion from "concentration" to "equivalent concentration" is intended to compensate for differences between current conditions and conditions under which the existing applicable dust standard was developed. Specifically, it is designed to ensure that miners working shifts longer than eight hours will be afforded the same level of protection as miners working an 8-hour shift. MSHA developed the existing standard from 8-hour shift exposure measurements. Therefore, MSHA will adjust the measured concentration to be equivalent, in its effect on cumulative exposure, to a concentration over an eight-hour exposure period. This is accomplished by multiplying the concentration measurement by $t/480$, where t is the sampling time (*i.e.*, length of the work shift) in minutes.

The formula for an equivalent concentration is:

$$\text{equivalent concentration (mg/m}^3\text{)} = 1.38 \times \left(\frac{\text{accumulated dust (mg)}}{t \times \text{airflow rate}} \right) \times \frac{t}{480 \text{ min}}$$

where t = sampling time in minutes (which will be the Part 90 miner's entire work shift) and airflow rate = $0.002 \text{ m}^3/\text{min}$). The product of t and the airflow rate is the total volume of air from which dust is accumulated on the filter.

The following example is meant to illustrate the effect of the second step in the conversion, multiplication by $t/480$, which adjusts for the full length of the work shift. In this example, it is assumed that the first step in the conversion, multiplication by 1.38 for equivalency with an MRE sampler, has already been performed.

Suppose a Part 90 miner sample is collected over a 9-hour work shift. Suppose that the amount of dust accumulated during the shift is 0.77 mg. If the concentration were not adjusted to an 8-hour equivalent concentration, the MRE-equivalent concentration would be calculated as 0.98 mg/m^3 . Under the definition of "equivalent concentration," this quantity is then multiplied by $540/480$, yielding an equivalent concentration measurement of 1.10 mg/m^3 .

This adjustment does not change the daily limit on the accumulated dose of respirable coal mine dust as intended by the existing exposure limit for coal mine dust. Since the current limit was based on an assumption that exposure occurs over an 8-hour shift, it corresponds to a daily cumulative dose of respirable coal mine dust of $8 \times 1.0 = 8 \text{ mg-hr/m}^3$ as measured by the MRE instrument. The

proposed definition of equivalent concentration will maintain this same MRE-equivalent 8 mg-hr/m^3 daily limit, regardless of the length of the working shift being sampled.

To continue the example, the exposure accumulated during the Part 90 miner's entire work shift is the same, whether over eight hours at an average of 1.10 mg/m^3 or over nine hours at an average of 0.98 mg/m^3 . In either case, the MRE-equivalent exposure accumulated during the entire work shift is 8.8 mg-hr/m^3 , which exceeds the intended limit of 8 mg-hr/m^3 . Under the proposed definition of "equivalent concentration" provided here, this will be reflected by the fact that, when more than 8 mg-hr/m^3 (MRE-equivalent exposure) is accumulated over the course of the particular shift sampled, the equivalent concentration will exceed 1.0 mg/m^3 , regardless of the shift's length.

MSHA originally proposed a different, but mathematically equivalent, method of adjusting concentrations to an 8-hour equivalent and solicited comments on the proposed method. The proposed method would have defined "concentration" to mean what is here defined as "equivalent concentration." Instead of making an explicit adjustment to the concentration, using the factor of $t/480$ as in the present definition, the earlier proposed rule would have substituted 480 for the actual sampling time in the definition of

respirable dust concentration. The proposed definition of "equivalent concentration" is meant to both preserve the ordinary definition of "concentration" and to clarify the adjustment to an 8-hour equivalent.

MSHA believes that the proposed adjustment to an "8-hour equivalent concentration" is necessary to protect Part 90 miners from excessive exposures who normally work nontraditional or extended shifts. For example, a Part 90 miner working for ten hours at an average concentration of 1.0 mg/m^3 will inhale and retain more respirable coal mine dust as a result of that specific shift than a miner working for eight hours at the same average concentration. By comparing the adjusted concentration to the concentration limit originally intended for Part 90 miners working an 8-hour shift, the same cumulative exposure limit is applied on individual shifts for all Part 90 miners.

It should be noted that the ACGIH approach of reducing the permissible concentration to compensate for the extension of a shift beyond eight hours is similar in its effect to the approach taken here of adjusting the equivalent concentration upwards and comparing it to a fixed limit. MSHA makes similar adjustments for extended work shifts in the enforcement of exposure limits in metal and nonmetal mines under 30 CFR 56.5001 and 57.5001. Taking into account the reduced recovery time that results from an extended work shift