

collected inside-the-facepiece samples at an airflow rate of 2 Lpm. The outside-the-facepiece sampling train also used 25 mm cassettes containing 0.8 micron pore size polycarbonate filters. The investigators collected outside samples as respirable dust using a MSA or Bendix cyclone operating at an airflow rate of 1.7 Lpm; however, they did not mention the location of the outside sample cassette. They collected area samples for particle size analysis using cellulose acetate filters and a personal sampling pump operating at 2 Lpm. They calibrated the sampling pumps at least three times a day, but did not mention specific calibration times.

The authors analyzed the samples for Fe and Si using proton induced x-ray emission (PIXE) analysis. Having detected Fe and Si on the field blanks, they used the mean blank value to correct inside- and outside-the-facepiece sample weights. They used optical microscopy to determine mean particle size range from 6 area samples. The investigators presented no data for individual inside- and outside-the-facepiece concentrations, and associated WPFs; however, they did provide the range of outside sampling measurements, and the overall average outside concentration, for both analytes. While they presented the range of inside-the-facepiece concentrations, they did not report the average inside concentrations. Outside samples averaged 1,500 $\mu\text{g}/\text{m}^3$ for iron dust, and ranged from less than 100 to 2,800 $\mu\text{g}/\text{m}^3$. Outside samples for silicon averaged about 1,000 $\mu\text{g}/\text{m}^3$, with a range from less than 100 to 1,500 $\mu\text{g}/\text{m}^3$. Inside concentrations were at or near the detection limits for both elements. For the 39 samples with values greater than 25 times the field blank, the authors reported a GM WPF of 273, a GSD of 5.7, and a fifth percentile of 39. For samples with outside filter weights greater than 750 times the field blank, they reported a GM WPF of 1,012, a GSD of 2.6, and a fifth percentile of 199. The investigators found a significant correlation between mean filter weights and WPFs; this correlation did not plateau at higher filter loadings. The authors stated that their measurements never reached a level at which the protection factors were independent of the outside filter weight. They concluded that the relatively low sample loadings resulted in WPFs that significantly underestimated the respirator's performance. They stated that, in the case of SARs, the researchers:

* * * should attempt to target outside loadings of at least 1000 times the anticipated

analytical detection limit. If we do not, the data we get is likely to reflect limitations of our sampling and analysis procedures, rather than the respirators we are testing.

Study 19. At the 1993 AIHCE, C.E. Colton, H.E. Mullins, and J.O. Bidwell of 3M presented a WPF study on the 3M Snapcap W-3256 airline respirator (TC 19C-70) with a loose-fitting hood, fitted with a W-3258 hard hat, W-5114 breathing tube, W-2862 vortex tube air regulating valve, and 50-100 feet of W-9435 compressed-air hose (Ex. 1-64-17). They measured exposure to silica (Si) for four workers involved in furnace teardown at a foundry. The respirators were operated at an air pressure of 75 psi, with the participants were permitted to regulate the airflow rate to a comfortable level. The authors later determined that this level was 8-9 cfm. The job task consisted of using pneumatic chippers to remove the furnace wall and bottom. Pieces of wall and bottom either fell into or were shoved into a barrel for removal. The employees then vacuumed of the furnace bottom. The job consumed most of the eight-hour shift. Since the furnace was warm and the work was physical, the employees worked in pairs for about one hour before switching with other employees; therefore, sampling times varied over the two separate days of the study. Participants normally wore airline respirators. The investigators informed them of the study's purpose, procedures, and their role, and provided them with instruction on the proper donning, fitting, and operation of the respirator; however, the authors did not mention fit testing the participants. The investigators observed the employees on a one-on-one basis during sampling. The employees donned and doffed the respirators and sampling trains in a clean area, and the investigators checked the integrity of the respirator and sampling train before the respirator was connected to the air supply. The authors started the sampling pump after connecting the respirator to the air line, and stopped the pump before disconnecting the respirator from the air supply. They used field blanks to evaluate the possibility of contamination from handling the samples.

Inside- and outside-the-facepiece samples were collected in 25 mm three-piece cassettes containing 0.8 micron pore size polycarbonate filters and porous plastic back-up pads. Inside-the-facepiece cassettes were attached to the inside of the hood, directly across from the employee's mouth, with the cassette pointed toward the employee. A nylon Liu probe was attached to the inside cassette, and a sample line ran through

the elasticized inner shroud and out to the sampling pump; the inside sampling flow rate was 2 Lpm. Outside-the-facepiece samples were collected as respirable dust through use of a 10 mm nylon cyclone; the outside sampling flow rate was 1.7 Lpm. The authors do not mention the location of the outside sampling cassettes, or what method they used to conduct particle size sampling.

The investigators used PIXE to analyze collected samples for Si; however, overloading of many of the outside-the-facepiece samples prevented PIXE analysis, requiring analysis of these samples by Inductively Coupled Plasma (ICP) spectroscopy. The authors made no field blank adjustments to the measured sample weights (*i.e.*, Si was not detected on the field blanks). The investigators intended to invalidate sample pairs with an outside filter weight less than 1,001 times the field blank value, or limit of detection if the field blank value was zero; all outside sample weights were more than 10,000 times the detection limit. In addition, they rejected sample pairs with inside sample weights that were less than the mean blank value. They did not mention correcting inside-the-facepiece values for pulmonary retention of particles, or how they managed sample results that were below the analytical detection limit. Particle size analysis showed the contaminant to be "a dust with over 50 percent of the mass greater than 10 μm ." The authors established a correlation between the PIXE and ICP analytical methods by analyzing 37 samples using both methods. They developed a linear regression equation that permitted PIXE equivalents to be predicted from the ICP results. They reviewed the WPF results using: The ICP results for the outside concentrations, and PIXE results for the inside concentrations; and the regression to predict PIXE equivalents for the outside concentrations, and PIXE results for the inside concentrations.

The authors calculated WPFs and checked the resulting values for outliers at the 99% confidence level. They did not provide individual inside- and outside-the-facepiece concentrations, but instead reported an overall range of inside and outside concentrations, along with the ranges' associated GM and GSD. In addition, the authors did not provide individual WPF values, but presented calculated WPFs as an overall fifth percentile WPF, GM, and GSD for each of the 2 days, based on both methods discussed above (*i.e.*, ICP and PIXE equivalent). They found that the two methods gave similar results. Using the equivalent PIXE values (*i.e.*, calculated from ICP values), and the