

equipped with organic vapor/high-efficiency particulate filters. Participants were qualitatively fit tested with isoamyl acetate. Prior to participation, employees were quantitatively fit tested with a Dynatec/Frontier FE250A portable unit while wearing the Survivair with high-efficiency filters and performing six ANSI-recommended exercises. In addition, paired (before and after) quantitative fit tests were performed for about half of the WPF determinations to ascertain if quantitative fit tests can predict WPFs. Participants were instructed not to break the face seal during sampling, and were observed throughout the sampling period.

Samples were collected on 25 mm 0.8 micron pore size polycarbonate filters, for 30 to 120 minutes (a complete job cycle) at a flow rate of 2 Lpm. Sampling trains were calibrated before and after each day's sampling, and respirators were disassembled, cleaned, and reassembled at the end of each day. The authors do not provide a more detailed discussion of the inside or outside sampling trains (e.g., type of respirator probe, placement of outside sampling apparatus). Particle size analysis was performed using light microscopy and scanning electron microscopy.

Proton induced x-ray emission analysis (PIXEA) was used to analyze the samples. This method's limit of detection was 2 nanograms per sample. The authors provide an approximate particle aerodynamic diameter based on the particle size analyses. Inside-the-facepiece results were corrected for losses caused by the sample probe but were not corrected for lung deposition (which the authors believed caused only a small bias). Thirty-seven WPFs were determined; however, the individual data sets (i.e., inside concentration, outside concentration, and associated WPF) were not provided. During the study, some participants were observed to break the face seal to talk. The authors provide an overall range of WPFs achieved, GM, and GSD, for undisturbed facepiece samples and pooled disturbed and undisturbed facepiece samples. The authors reported a GM WPF of 3,400, and a best estimate of the fifth percentile of 390 when the facepiece was not disturbed, and a GM WPF of 2,400, and a best estimate of the fifth percentile of 160 when the facepiece was disturbed. The authors also found no correlation (at the 5% level) between WPF and outside concentration, or the relationship between WPF and quantitative fit factors for predicting workplace protection. The authors also estimated the program protection factor based on historical measures of air lead

concentrations versus blood lead levels (a table and graph of this data was provided). They concluded that the half-mask respirator they tested provided WPFs that exceeded an APF of 10, and provided program protection factors (PPFs) that exceeded 10.

*Study 2.* Workplace protection against exposure to asbestos fibers (chrysotile and amosite) was reported at the 1985 AIHCE by T.J. Nelson and S.W. Dixon for 17 workers who removed asbestos-containing materials at two sites (Ex. 1–64–54). Six of these workers were removing asbestos fireproofing from a ceiling at the first site, while eleven workers at the second site were removing asbestos-containing pipe insulation. The participants' work rate was judged to be moderate, site temperatures ranged from 65–85 degrees Fahrenheit, and humidity was very high.

The following six brands of half-mask respirators were studied: 3M 8710 disposable dust/mist respirator; 3M 9910 disposable dust/mist respirator; American Optical R1050 disposable dust/mist respirator; Survivair 2000 elastomeric respirator with high-efficiency filters or DFM filters; MSA Comfo II elastomeric respirator with high-efficiency filters or DFM filters; and a North 7000 elastomeric respirator with high-efficiency filters. Participants were trained in respirator use by the investigators and were qualitatively fit tested using the saccharin fit test. Supplemental data indicate that participants wore one or more respirator brands. No mention is made of respirator donning and doffing procedures, or starting sampling trains in a clean area; however, the sampling procedures state pumps were stopped and cassettes removed in a dust-free area. Participants were observed by the researchers throughout the sampling period.

The inside-the-facepiece sampling train was a 25 mm closed-face three-piece cassette with a 1/2-inch extender, containing a 0.8 micron pore size mixed cellulose ester filter. The cassette was attached directly to a tapered probe inserted into the respirator midway between the nose and mouth. In-mask samples were collected at a flow rate of 2.0 Lpm. The outside-the-facepiece sampling cassettes and probes were identical to the inside-the-facepiece sampling train and were fastened to the lapel of the subject. Outside samples were gathered at 0.5 to 1.0 Lpm. Sampling times ranged from 30 to 120 minutes, and the pumps were calibrated before and after each sampling period. The authors investigated uniform deposition of asbestos fibers across the

filters; they noticed a slight trend for heavier deposition at the filter center using both methods. They also computed the precision of sample gathering using open- versus closed-face cassettes and found no difference between the methods.

Asbestos analysis was based on NIOSH method P&CAM 239 and NIOSH method 7400 (i.e., the filter mounting and "A" counting rules). To increase analytical sensitivity, the methodology was modified by counting fibers in a minimum of 500 fields per inside-the-facepiece filter when less than 100 fibers were counted. The actual number of fibers counted in each sample was used to compute the airborne concentration. In addition, one microscopist performed all fiber counting. The distributions of fiber length and diameter were determined by transmission electron microscopy using lapel sample filters. The GM and GSD values for the fiber length, fiber diameter, and equivalent aerodynamic diameter at each worksite and the combined data from both sites were reported, but the values for fiber density and the length-diameter correlation coefficient were not provided. A total of 84 pairs of inside and outside fiber concentrations, and corresponding WPFs, were provided by participant, respirator brand, and sampling period in supplemental data tables. However, the authors considered seven WPF values measured for the American Optical respirator as suspect because the inside-the-facepiece filter samples contained glass fibers, originating from the respirator's filter matrix. These glass fibers have the same appearance as asbestos fibers under light microscopy. The authors did not adjust measured values for field blank values (i.e., blanks were below the limit of quantification) or fiber retention in the respiratory tract (i.e., the authors believed that pulmonary fiber retention resulted in only a slight change in concentration inside the facepiece).

The 3M 8710 results showed a GM WPF of 310, a GSD of 5.3, and a best estimate of the fifth percentile of 20. The 3M 9910 had a GM WPF of 580, a GSD of 4.2, and a best estimate of the fifth percentile of 55. The AO R1050 had a GM WPF of 52, a GSD of 4.2, and a best estimate of the fifth percentile of 5. The Survivair 2000 or MSA Comfo II equipped with DFM filters had a GM WPF of 240, a GSD of 6.3, and a best estimate of the fifth percentile of 12. With high-efficiency filters, the GM WPF was 94, the GSD was 3, and the best estimate of the fifth percentile was 16. For the North 7700 equipped with high-efficiency filters, the GM WPF was