

and pig caster. They selected two employees from each classification on two shifts. The PAPRs used in the study were the 3M W-344 and the Racal AH3; each employee wore both respirators twice. Pre-shift quantitative fit testing was performed each day. The investigators trained the participants, but did not describe the training; they monitored the employees continuously during sampling.

The authors referred to a companion paper for a description of the sampling protocol used in this study; therefore, they provided no information is provided on sampling or analytical methodologies in this report. Eight impactor samples were collected at each work activity to determine particle size distribution. Samples were collected for the full shift, but the investigators did not provide specific sampling times. The authors also provided the range of inside-the-facepiece concentrations, with associated GM and GSD, for both brands of respirator; they measured these concentrations with the PAPRs placed on manikins which were located at the worksites where employees in the three job classifications worked.

For each respirator, the study provided 24 individual inside- and outside-the-facepiece (front and rear) concentrations, along with associated WPFs and each employee's fit factor. It also provided the overall GM, GSD, and 95% confidence level on the mean for the inside-the-facepiece concentrations, WPFs, and fit factors. The authors tabulated the data by day, shift and work activity. For both respirators, two samples were discarded due to sampling pump failure, giving 22 usable measurements for each respirator. The WPFs measured on the Racal AH3 ranged from 42 to 2,323, with a GM of 205 and a GSD of 2.83. The 3M W-344 had WPFs that ranged from 28 to 5,500, with a GM of 165 and a GSD of 3.57. The two-sided 95% confidence limits around the mean of the WPFs were 128 and 325 for the Racal AH3, and 94 and 292 for the 3M W-344. The authors provided a detailed discussion of their statistical analyses of the data; they also discussed several potential sources of variation in the workplace performance of PAPRs, including: a possible relationship between fit factor and WPF; a possible relationship between fit factor and inside-the-facepiece concentration; day of the week; shift; leakage into the facepiece due to ambient air currents; and worker activity. The only sources found to be potentially significant were leakage into the facepiece due to ambient air currents and worker activity. The authors stated that " \* \* \* using the pooled 3M and Racal WPF

data and a probability of 0.95 the assigned protection factor calculated by this method for these PAPRs would be 26." They recommended a reduction in the RDL's APF of 1,000 for loose-fitting PAPRs with helmets and HEPA filters.

*Study 5.* W.H. Albrecht, G.R. Carter, D.W. Gosselink, H.E. Mullins, and D.P. Wilmes reported at the 1986 AIHCE on a study they conducted that evaluated protection against exposure to asbestos fibers for 12 workers who manufactured asbestos-containing brake shoes for trucks (Ex. 1-64-23). The employees performed six operations at the facility: mixing brake shoe components, weighing mixed formulation, pre-forming molding press charges, molding the shoe, grinding the brake shoe surface, and drilling shoe mounting holes. The investigators sampled at each operation. The PAPR studied was the 3M Airhat with high-efficiency (HEPA) filters. The participants and supervisory staff were shown an audio slide presentation explaining how to fit respirators and the procedures for saccharin fit testing; they then received the saccharin qualitative fit test (since the authors do not specifically mention fit testing the PAPR, it is assumed that only the half-mask respirators studied were fit tested). Fit testing was not conducted prior to each study test. The PAPR was fitted and worn according to the manufacturer's instructions. Each employee was observed on a one-on-one basis during testing to assure that they properly donned and used the respirator and that sampling train integrity was maintained.

The inside-the-facepiece sampling train was a closed-face filter cassette connected to a tapered Liu probe, inserted into the respirator between the nose and mouth. The outside-the-facepiece sampling train was a closed-face filter cassette connected to a Liu probe attached in the employee's lapel area; the authors do not mention cassette size. Samples were collected for 30 minutes, but other sampling times were occasionally used; sampling pump flow rates were 2 Lpm (inside-the-facepiece) and 0.5 Lpm (outside-the-facepiece). The report does not mention modifying the inside-the-facepiece probe location (midway between the nose and mouth) or the sampling flow rate for the PAPR versus that used for the half-mask respirators studied.

Sampling trains were calibrated before the shift, at lunch, and at the end of the shift; average airflow rate was used to calculate sampled air volume. The investigators did not mention determining the PAPR's airflow rate.

Asbestos analysis was based on NIOSH method 7400, with 500 fields

counted per inside sample filter and 100 fields counted per outside sample filter. The distributions of fiber length and fiber diameter were not characterized. The authors stated that blanks were submitted for fiber counting; however, no further mention is made of the blank results or how they were addressed. None of the PAPR samples were comparison counted by Phase Contrast Microscopy (PCM) and Scanning Electron Microscopy (SEM). A total of seven PAPR WPFs were reported (5 employees). Individual pairs of inside and outside concentration values were not provided. Individual WPFs were reported for each of the seven sampling intervals, but were not linked to specific participants or jobs. The authors provided an overall GM, GSD, and fifth percentile for the Airhat PAPR; a range of asbestos concentrations and the associated GM and GSD were also reported by job. An inside-the-facepiece fiber count of 1,000 was used in calculating the WPF when the sampling result was at or below the limit of detection (*i.e.*, 1,000 fibers per filter). The investigators did not mention adjusting inside-the-facepiece values for fiber retention in the respiratory tract. In addition, the authors determined that sampling results were not affected, at the 95% confidence level, by sampling flow rate or open-versus closed-face sampling cassette. The mean breathing zone concentration of asbestos for the Airhat PAPR was 4.14 fibers/cc, with a mean breathing zone concentration range of 1.23 to 8.05 fibers/cc. The authors reported a GM WPF for the PAPR of 199, with a GSD of 2.36 and a fifth percentile of 42. Five employees tested the PAPR, resulting in a total of nine sample sets, including two unusable sets of data. The authors noted that respirators that had the highest GM and fifth percentile WPFs (*i.e.*, the 3M Airhat and 3M 9920 DFM respirators) were also tested at higher breathing zone fiber concentrations. They believed that this factor probably led to these respirators' increased performance measurements.

*Study 22.* In 1986, W.R. Meyers, M.J. Peach, K. Cutright, and W. Iskander reported on a study in which they evaluated exposure to lead (Pb) dust and mist for 12 workers on two lead acid plate production lines of a battery manufacturer (Ex. 1-64-48). They sampled the pasting operator and two slitter operators on each line for two different shifts. The respirators studied were the Racal Airstream AH5 and the 3M W-3316, equipped with a helmet, visor enclosure, and dust/mist filters. Participants were clean-shaven, and