

each employee wore both types of respirator twice. The AH5 provided a seal between the employee's face and the face shield by using two flexible face seals; air was exhausted at the chin. The size of the faceseal (*i.e.*, large or small) was selected based on the appearance of best fit and wearer comfort. The 3M's soft flexible face seal gave a loose-fitting seal between the face and face shield, with air exhausted at the temples. Prior to field testing, randomly-selected filters underwent silica dust penetration testing. The investigators put on and removed the respirators from the employees in a clean area, except when the employees took personal breaks (in which case, the employees donned and doffed the respirator in the work area). Employees were not fit tested, but were instructed in the proper use of the PAPR and directed not to remove the helmet, lift the face shield, or tamper with the sampling equipment without notifying the investigators. The investigators continuously monitored donning and doffing and work activities. Respirator helmets and visors were cleaned between each use, and volumetric air output was periodically checked (usually at the beginning of the shift, lunch, and shift's end). The authors replaced the batteries according to manufacturer's instructions, and when low airflow occurred. They also installed new filters at the beginning of each shift. The investigators started the sampling pumps after the employees donned the respirators and the PAPR blower was functioning; they stopped the pumps before turning off the PAPR blower.

Sampling trains were identical and consisted of a closed-face 37 mm two-piece cassette, containing a 0.45 micron pore size cellulose ester filter and back-up pad. Inside-the-facepiece sample cassettes were attached directly to a modified Luer adapter sampling probe, inserted through the face shield about one to two inches in front of the employee's mouth. Outside-the-facepiece sample cassettes were located at the front lower right side of the facepiece, away from the PAPR's exhaust airflow; they located a second cassette located the employee near the PAPR's filter, to determine the filter's contaminant challenge. All samples were collected as total dust at a flow rate of approximately 2 Lpm over the full shift (The report did not provide actual sample times). Sampling pumps were calibrated in the laboratory, and the flow rates confirmed at the worksite. Performance of the PAPR filtration system was checked by placing operating respirators on manikins

(without simulated breathing), located about 4 feet from the subjects. Two filter blanks were used for each shift. Particle size distribution was determined through using a Marple cascade impactor operating at a flow rate of 3 Lpm.

Inside-the-facepiece samples were analyzed by graphite furnace using a modified NIOSH P&CAM 214 method, with perchloric acid in the wet ashing step. Outside-the-facepiece samples were analyzed by atomic absorption spectroscopy (NIOSH Method S-341 with the perchloric acid wet ashing step modification). Forty-seven individual inside- and outside-the-facepiece (*i.e.*, front and rear) time-weighted-average (TWA) measurements, with associated TWA WPFs, were provided (AH5 = 24; W-316 = 23). These results were tabulated by day, shift, and work activity. Overall GM and GSD were also given for the concentration measurements and WPFs. All blanks were below the analytical limit of detection; the authors did not mention adjustments for pulmonary retention. Particle size (large) and stationary manikin filter efficiency (98%–99.9%) were briefly discussed. The WPFs for the Racal AH 5 ranged from 23 to 1,063, with a GM of 120 and a GSD of 2.64. The WPFs for the 3M W-316 ranged from 31 to 392, with a GM of 135 and a GSD of 1.89. Since the authors found no statistical difference between the performance of the respirators, they pooled the data for both respirators; they then graphically plotted the percent of WPFs less than specific values. The pooled data for the two PAPRs resulted in a distribution with a GM of 127 and a GSD of 2.28. The authors stated that, at a 0.95 probability level, this class of PAPRs would receive an assigned protection factor of 25. The authors also stated that the results “* * * strongly suggest that the respirator user community not view current generation powered air-purifying respirators equipped with helmets as positive pressure respiratory devices.”

Study 3. A. Gaboury and D.H. Burd (Ex. 1–64–24) and A. Gaboury, D.H. Burd, and R.S. Friar (Ex. 1–64–348) reported in 1993 on the WPF study they performed in a primary aluminum smelter. Exposure to benzo(a)pyrene [B(a)P] on particles was measured for 22 employees who worked as rack raisers, stud pullers, and rod raisers on anode crews. The employees used a Racal Breathe-Easy 1 (BE1/AP3), a loose-fitting helmeted PAPR. The PAPR came equipped with one-piece non-woven flame-retardant face seals, visor locking clips, and combination organic vapor

and HEPA filters. (The authors also tested the performance of several negative-pressure, air-purifying half-mask respirators; see Study 7 above). The employees previously received training on this PAPR, and used it for more than six months prior to the study. Forty percent of the employees had beards (*i.e.*, more than two weeks growth), but the investigators did not find a significant difference between bearded and non-bearded participants. No fit testing was performed on the employees, but previous quantitative fit testing showed fit factors “greater than 1000 in all cases.” Industrial hygiene technologists assisted participants with donning and doffing respirators, cleaned and maintained the respirators at the end of each work cycle, and observed participants on a one-to-one basis throughout the sampling period. The investigators directed the employees not to tamper with the respirator or sampling equipment. Due to high heat levels in the work area, the employer required employees to rest in a cool environment for one-half hour during each work hour.

The inside-the-facepiece sampling train consisted of a closed-face three-piece cassette with a 25 mm organic-binder-free glass fiber filter, backed with a cellulose ester pad. Inside sampling cassettes were connected to a tapered Liu probe, which was inserted through the PAPR's visor and into the employee's breathing zone. The outside-the-facepiece sampling train was identical to the above; however, the investigators did not mention connecting the cassette to a Liu probe. The outside cassette was mounted on a bracket at the top of the visor. All filters were pre-calcined at 400 degrees Centigrade for 24 hours. Both inside and outside samples were collected at a flow rate of 2 Lpm for approximately 300 minutes, or one-half of the 10-hour work shift. Respirators and sampling trains were worn and operated until the employee entered the rest area; they donned and turned on the respirators prior to leaving the rest area for the next work cycle. The authors plugged the sampling cassettes when not in use, and cleaned the respirators after each work cycle. Field blanks were used to identify contamination due to handling. Sampling train airflow rates were checked at the beginning, middle (*i.e.*, after lunch), and end of the work day; upon changing cassettes; and when a problem was suspected. PAPR turbo-unit flow rate was checked every two hours to assure flow was greater than six cubic feet per minute (cfm). Sampling occurred over a five-day period.