

calibrated before, and rechecked after, each sampling period. Respirators were donned and doffed, and the sampling trains started (and assumed stopped), in the clean area. Field blanks were used to identify possible contamination of filters due to handling. The number of sample pairs collected per subject was not specified. The ambient manganese particle size distribution was determined by 6-stage Marple Cascade impactor equipped with an inlet cowl to prevent debris from entering the impactor. Samples were collected for several hours at a flow rate of 2 Lpm, and flows were calibrated before and after each sampling interval. Four samples were gathered: One in the powder drop area (Plant A) and three at the bag slitting operations (one in Plant A, two in Plant B).

Samples were analyzed for Mn by atomic absorption (AA) spectroscopy according to NIOSH Method 7300. The mass distribution of Mn by particle aerodynamic diameter was tabulated for all cascade impactor samples. Less than 30% of the mass was associated with respirable particles. A total of 70 individual pairs of inside-the-facepiece and outside-the-facepiece concentrations, and the corresponding WPFs, were provided by job activity (but not by employee or plant). No mention is made of adjusting measured values for particle retention in the respiratory tract or results of field blank analysis. A GM of 50 and a GSD of 3.5 was reported for all the WPF values measured. A calculated fifth percentile protection factor of 7.5 was also reported. The authors reported that their data indicated a systematic dependence of WPF on the concentration outside the respirator. In their discussion of this observation, the investigators refer to three possible causes presented by authors of other studies: Program protection factors tend to be low in low exposure settings since the workers, aware of the low exposure, exercise less care; low outside concentrations result in inside-the-facepiece concentrations so small that reliable quantification is difficult; and filter efficiency increases with loading, and low concentrations do not adequately load the filter. The authors discuss these causes relative to their study results, and postulate that another cause may be particle size selectivity (*i.e.*, smaller particles have a higher probability of entering the respirator). They conclude that it is important to characterize respirator performance in the environment where the respirator will be used.

*Study 14.* At the 1990 AIHCE, C.E. Colton, A.R. Johnston, H.E. Mullins, C.R. Rhoe, and W.R. Meyers presented

a WPF study in which they measured protection against exposure to aluminum dust for five participants working as carbon changers in an aluminum smelter (Ex. 1–64–15). All participants wore the disposable 3M 9906 dust/mist respirator. The investigators trained the participants in donning the respirator and the participants were qualitatively fit tested, although the fit test method was not described. The total number of samples collected per employee was not specified, although it is stated that the five employees were sampled daily for five days. Participants were observed throughout the sampling period.

The inside-the-facepiece sampling train was a closed-face 25 mm cassette containing a 0.8 micron pore size polycarbonate filter. The cassette was connected to a tapered Liu probe, inserted into the facepiece in an unspecified location. In-mask samples were collected at an airflow rate of 2.0 Lpm. The outside-the-facepiece sampling train was a closed-face 25 mm cassette containing a 0.8 micron pore size polycarbonate filter. Outside samples were gathered as respirable dust samples with the cassette being connected downstream from a cyclone apparatus. Sampling airflow rate was 1.7 Lpm. Sampler airflow rates were calibrated before and after each sample period. No mention is made of donning and doffing procedures. Field blanks were used to identify possible filter contamination caused by handling. The ambient aluminum particle size distribution was determined through 12 area samples (unspecified locations) collected by Marple personal cascade impactors. In addition, particulates that passed a cyclone selector were sized by optical microscopy.

Aluminum was determined by proton induced x-ray emission analysis (PIXEA). The mass distribution of aluminum by particle diameter and percent penetration to the collector was graphically presented. Final calculations used only those outside filter weights that were greater than 11 times the detection limit. A total of 24 time-weighted-average (TWA) inside-the-facepiece and outside-the-facepiece concentrations, with corresponding TWA WPFs, are provided in supplemental data (Ex. 1–146). The sample pairs are not linked to specific participants. No mention is made of adjusting sample results for particle retention in the respiratory tract. The mean blank value was zero, so no adjustment to measured values was made. The authors reported a GM of 27, a GSD of 1.5, and a fifth percentile of 13 for the 23 sample sets used. The

report concluded that the respirator provided reliable WPFs of 10. Cumulative probability of achieving a particular WPF, and the effect of filter weight on WPF, were also graphically presented. The authors stated that the WPFs represented conservative estimates of protection since outside concentrations were measured as respirable dust. In the summary of this study (Ex. 1–146), submitted to OSHA along with the raw sampling data, the authors recommended that the study not be used to assess the ultimate APF for this class of respirator since they felt that the real WPF of the respirator was significantly underestimated.

*Study 15.* C.E. Colton, H.E. Mullins, and C.R. Rhoe presented a WPF study at the 1990 AIHCE in which they determined exposure to particulate Pb and Zn for 17 participants working in core making, mold making, pouring, and cleaning areas of a brass foundry (Ex. 1–64–16). All participants wore the disposable 3M 9970 high-efficiency respirator. The investigators trained the participants in the proper donning and fitting of the respirator, and participants were fit tested using the saccharin qualitative fit test method described in Appendix D of OSHA's Lead Standard (29 CFR 1910.1025). Sampling took place over five days.

The inside-the-facepiece sampling train was a 25 mm three-piece cassette containing a 0.8 micron pore size polycarbonate filter (open- versus closed-face was not specified). The cassette was directly connected to a tapered nylon Liu probe, inserted into the facepiece midway between the nose and mouth. The inside-the-facepiece samples were collected at a flow rate of 2.0 Lpm. The outside-the-facepiece sampling train was a 25 mm three-piece cassette containing a 0.8 micron pore size polycarbonate filter. Outside samples were gathered as respirable dust samples, with the cassette being connected downstream from a 10 mm nylon cyclone. Samples were collected at a flow rate of 1.7 Lpm, and sampling pumps were calibrated before and after each sample. The authors do not mention using of field or manufacturer's blanks, respirator donning and doffing procedures, or methods of starting and stopping sampling trains in a clean area. The ambient Pb and Zn particle size distributions were determined by an unspecified number of Marple personal cascade impactor (Model 2401) samples.

Pb and Zn were determined by proton-induced x-ray emission analysis (PIXEA). The particle size data were not presented; however, the report stated that the Pb and Zn aerosols were present as both dust and fume. The range of