

and outside-the-facepiece concentrations and WPFs. They presented results in two tables showing respirable dust samples with values 25 times the mean blank level, and total dust samples with values 100 times the mean blank level. The investigators provided tables reporting sample size and overall GM, GSD, and fifth percentile WPF by type of filter (*i.e.*, dust/mist, HEPA) and the presence or absence of a shroud (*i.e.*, dust/mist with shroud, dust/mist without shroud). Using the respirable dust samples that were 25 times the mean blank value, the authors combined the sampling results of the PAPR with dust/mist filters (*i.e.*, with and without a shroud) and found an overall GM WPF of 2,480 and a fifth percentile of 95. The combined respirable dust results of the HEPA-filtered PAPR gave an overall GM WPF of 5,730 and a fifth percentile of 762.

Atmosphere-Supplying (Supplied-Air) Respirators

Atmosphere-supplying respirators, also referred to as supplied-air respirators (SARs) or airline respirators, operate in one of three modes: Demand, continuous flow, and pressure demand. Demand and pressure demand respirators can be equipped with half or full facepieces. Continuous flow respirators can also be equipped with a helmet, hood, or loose-fitting facepiece.

7. WPF Studies—Loose-Fitting Atmosphere-Supplying Respirators With Hood or Helmet

Study 28. A.R. Johnston, *et al.* in 1987 conducted a WPF study evaluating exposure to silica (Si) among four shipyard workers who wore a 3M Whitecap II loose-fitting, continuous flow SAR with hood/helmet while sandblasting paint from the flat top of a barge (Ex. 1–64–36). The respirator was comprised of a W–8100 abrasive blasting helmet, a W–5114 breathing tube, a W–2862 air / temperature control valve, 50 feet of W–9435 air hose, and a W–8054 extended length shroud. To permit evaluation of the respirator at its low and high range of airflow rates, air pressure was maintained at 60 or 80 psi, resulting in an in-helmet airflow rate of either 6.4 or 14.4 cfm. The investigators informed the employees of the purpose and protocols of the study, and instructed them in the proper donning and use of the respirator. They also directed the employees not to adjust or remove the respirator after sampling began. Sampling trains were connected and disconnected in a clean area when possible. Sampling pumps were started after confirming proper operation and donning of the respirator, as well as

airflow rate into the helmet. Pumps were stopped before the helmet was disconnected from the air supply and removed. The authors maintained continuous one-on-one observation of the employees during sampling, and used several field blanks during each day of sampling.

The authors collected inside-the-facepiece samples on 25 mm cassettes containing 0.8 micron pore size polycarbonate membrane filters. They attached the cassettes directly to a Liu probe inserted through the center of the faceshield, about midway between the nose and mouth; the probe extended about 3 mm into the helmet. The flowrate for the inside samples was approximately 2 Lpm. The authors collected outside-the-facepiece samples as both total and respirable dust, using a 37 mm cassette with a 0.8 micron pore size polycarbonate membrane filter. They used a Bendix or SKC cyclone, operating at 1.7 Lpm airflow rate, to gather the respirable dust samples and obtained total dust samples at flow rates ranging between 0.5 and 2 Lpm. Both outside-the-facepiece sample cassettes were located on the employee's lapel. The investigators calibrated the sampling pumps at least three times a day, and sampling periods ranged from 10 to 60 minutes to prevent filter overloading.

The authors analyzed all samples using PIXE. They found Si on all 18 blanks. Of 68 initial sample sets, they discarded 16 (11 due to test malfunctions and 5 due to outside loadings less than 10 times the mean blank level and inside loadings at or below the blank level). They corrected the remaining 52 sample sets for blank value, and then tabulated by inside and outside filter weights, inside and outside sample volume, and associated WPFs. Since nearly all of the dust was of respirable size, the authors did not report results for the total dust samples. Comparing the sampling results with the mean blank levels, the investigators stated that the analytical confidence limits of the data were poor, with only 11 samples being better than plus or minus 25%. The authors considered samples with inside concentrations greater than 1,000 times the mean field blank to be an accurate indicator of the respirator's performance capability; seventeen sample sets met this criteria, but they removed two samples WPF calculation database as outliers. For the remaining 15 samples, the GM WPF was 4,076, the GSD was 2.3, and the fifth percentile WPF was 1,038.

The authors concluded that WPFs generated from sample sets with light outside dust loadings significantly

underestimated respirator performance; higher outside sample loadings appeared to be less influenced by non-respirator variables. The investigators judged WPF estimates derived from data subsets with higher outside filter loadings as providing a better indication of respirator performance capability. The authors also discussed an apparent correlation between WPFs and outside filter loadings (*i.e.*, a higher loading equaled higher a WPF until reaching a plateau about 600 times the mean blank value); however, the correlation between WPFs and outside concentrations was not statistically significant. In addition, the effect of higher versus lower helmet airflow rate on sample results and WPFs was not significant. They also discussed the daily and overall WPFs achieved when using time-weighted-averages for the calculations. They concluded that their data supported the ANSI Z88.2 proposed APF of 1,000 for loose-fitting SARs with hoods or helmets.

Study 20. At the 1989 AIHCE, A.R. Johnston, C.E. Colton, D.W. Stokes, H.E. Mullins, and C.R. Rhoe presented a WPF study on a 3M W–8000 Whitecap II SAR with a helmet, and equipped with a breathing tube (W–5114), a compressed air hose (W–9435), and either a vortex cooling assembly (W–2862) or air regulating valve (W–2907) (Ex. 1–64–37). They evaluated exposure to iron (Fe) dust and silicon (Si) dust for six workers involved in grinding iron parts at a foundry. Air supply pressure was 60 psi with the vortex cooler or 25 psi with the regulating valve, thereby maintaining a helmet airflow rate of 6.7 cfm throughout the test. They did not mention employee selection procedures, previous use of respiratory protection, provision of training, or respirator donning and doffing procedures. They verified air supply pressure; valve settings; and integrity of the respirator, connections, and sampling train before starting the sampling pumps. They stopped the samplers before disconnecting the respirator from the air supply; they then took the participants to a clean area to remove the sampling cassette. The investigators observed the employees on a one-on-one basis during sampling, and used field blanks to evaluate possible contamination due to sample handling.

The inside-the-facepiece sampling train consisted of a 25 mm cassette containing a 0.8 micron pore size polycarbonate filter. The authors attached the cassette to a Liu probe installed into the faceshield approximately midway between the nose and mouth; it extended a few millimeters into the helmet. They