

prior to donning after each break and cleaned and sanitized after each shift. One WPF was measured for each employee. The ambient particle size distribution was determined using 19 Marple cascade impactor samples (11 in the sinter plant; 8 in the blast furnace area).

Lead analysis was by flame atomic absorption spectroscopy according to NIOSH Method S-341. Inside-the-facepiece samples that contained less than 10 µg of lead were reanalyzed by graphite furnace atomic absorption (limit of detection = 0.2 µg). The ranges for the mass median aerodynamic diameters (in micrometers) and for the GSD values were reported. A total of 25 pairs of inside and outside half-mask values, and the corresponding WPFs, were provided by employee, job title, and job location. An overall GM and GSD of the WPFs, and various percentile WPFs, were provided. When samples contained lead below the level of detection, the authors reported concentration values “* * * determined from the least amount of lead detectable by the analytical method and the sampled volume of air.”

In-mask values were not adjusted for particle retention in the respiratory tract (the authors imply retention probably had a non-significant effect on results, but could result in overestimated WPFs). No mention is made of the investigators using field blanks. They reported that approximately 98% of the WPFs would be expected to be at or above 10, 90% above 30, and 75% would be expected to be above 100. They concluded that an APF of 10 was appropriate for the half-mask negative pressure air-purifying respirator evaluated in this study. The authors also discussed two proportional methods of defining an APF.

Study 7. W.R. Meyers and Z. Zhuang conducted a 3-part workplace protection factor study in three different work environments. In addition to presenting the study findings, the authors also discuss their rationale for selecting exposure agents, study facilities, and workers; study procedures followed at the sites; and analytical methods. W.R. Meyers and Z. Zhuang in January, 1993 (Ex. 1-64-51) and W.R. Meyers, Z. Zhuang, and T.J. Nelson in 1996 (Ex. 3-12) reported on the first part of the study in which the authors determined protection against exposure to particulate lead (Pb), zinc (Zn), and total airborne mass (TAM) for 25 workers, on day and evening shifts, in three brass foundries (3, 9, and 13 participants, respectively). (**Note:** The reports mention 26 participants, but data were presented for only 25 participants.) Four

brands of half-mask devices were studied: 3M 9920 disposable DFM respirator; American Optical 5-Star elastomeric respirator with DFM filters (R56A); MSA Comfo II elastomeric respirator with DFM filters (Type S); and Scott Model 65 elastomeric respirator with DFM filters (642-F).

Participants were selected from volunteers who normally wore respirators, were clean-shaven, and passed a fit test. Their work rate was subjectively determined by observing their work activities. Respirators were worn for the usual period. For the elastomeric half-mask respirators, the participants were quantitatively fit tested using a TSI Portacount; a fit factor of 100 or more constituted a pass. Disposable respirators were fit tested using the saccharin qualitative fit test. The investigators trained the participants in the proper donning and adjustment of the respirators, and instructed them not to remove or lift the respirator from their face in the work area. Readjustment of the respirator had to be accomplished by sliding the facepiece on their face. Workers were observed throughout the sampling period. Each participant wore two or more respirator brands, and one WPF was measured per employee for each brand worn.

The inside-the-facepiece sampling train was a 25 mm closed-face cassette attached directly to a flared mouth probe, inserted into the respirator opposite the mouth. The cassette contained a 0.5 micron pore size polyethylene filter and polypropylene backup pad. A 4.5 mm ring under the filter restricted airflow to an 18 mm circle in the center of the filter to keep deposition in an area that could be entirely covered by the proton beam used for sample analysis. A heating bonnet was slid over the outside of the cassette to minimize condensation of moisture from exhaled breath. Sampled air was then drawn through a moisture trap using a personal sampling pump operating at 2 Lpm. The outside-the-facepiece sampling train was a 10 mm nylon cyclone attached to 25 mm closed-face cassette (the cassette was not connected to a flared mouth probe). The cassette contained a 0.5 micron pore size polyethylene filter and polypropylene backup pad. A 4.5 mm ring under the filter restricted airflow to an 18 mm circle in the center of the filter. This sampling train was attached in the lapel area and samples were collected at a flow rate of 1.7 Lpm.

Two separate samples were gathered during the shift, one during the first half and another during the second half. Individual WPFs were based on

monitoring times of approximately one to four hours. Respirators were donned and doffed, and sampling trains were started and stopped, in a clean area. Elastomeric facepieces were cleaned and inspected at the end of each shift, but were not wiped out during the shift unless such wiping was a standard practice before the study (the authors noted that most of the time workers did not wipe out facepieces). Air-purifying filters (cartridges) and disposable respirators were changed at the end of each shift unless the employer's policy dictated more frequent changing. In addition, the mouth of the in-mask probe was plugged whenever the respirator was not being worn. Working (field) blanks and manufacturer's (media) blanks were used to determine possible contamination of filters due to handling or manufacturing. The investigators also washed the interior of the sampling cassettes to ascertain retention of sample particles on the cassette wall. The ambient particle size distribution was determined by PIXE 8-stage cascade impactor samples at several work locations in each foundry. These area samples were collected at roughly mid-chest to shoulder level of workers for approximately 1 hour, to prevent impactor overloading.

All samples were analyzed by proton induced X-ray emission analysis (PIXEA). The mass distribution of Pb, Zn, and TAM by particle aerodynamic diameter was graphically presented for all cascade impactor samples. Across the three foundries, 66 pairs of inside-the-facepiece and outside-the-facepiece concentrations, and the corresponding WPFs, were provided by job task, employee, brand of respirator, and analyte (Pb, Zn, and TAM). The authors did not adjust measured values for particle retention on sampling cassette walls since these losses appeared to be random, independent of collected mass, and of a negligible amount. No mention is made of correcting measured in-mask values for pulmonary particle retention. A foundry-specific average of the field blank loadings was used as a correction factor for estimating background and handling contamination for each foundry. Outside-the-facepiece samples were collected as respirable particulate, thereby providing respirable mass levels, while in-mask samples were collected as total particulate mass. The authors initially assumed that particles larger than 10 microns did not penetrate respirator face seals; however, this was found to be incorrect after analyzing in-mask particle size. Therefore, to avoid comparison of dissimilar measurements, the investigators used particle size data