beginning of averaging period, including the two latest measurements).

There are several advantages to such a strategy: (1) all the measurements are utilized, (2) both the mean exposure (a parameter of some recognized importance) and excursions above the mean are monitored, (3) the strategy recognizes that exposures tend to be highly variable and that excursions occur even for processes under control, (4) upward trends due to changes in production levels or ventilation controls are identified, and (5) decision errors can be estimated by using menu-driven Monte Carlo simulation program written specifically for this strategy.

91

APPLICATIONS OF INDOOR EMISSION FACTORS FOR WORKER EXPOSURE MODELLING. C.B. Keil, Environmental Health Program, Bowling Green State University, Bowling Green, OH 43403-0280; R.A. Wadden, J.E. Franke, P.A. Scheff, L.M. Conroy, Environmental and Occupational Health Sciences, University of Illinois at Chicago, 2121 W. Taylor, Chicago, IL 60612.

There is a growing library of indoor emission factors that can be used to estimate worker exposure to airborne chemicals. Emission factors have the advantage of being a generalizable tool. By using mass balance models an emission factor for a process can be used to predict chemical concentrations in a variety of ventilation and production conditions. The applications of emission factors need to be communicated in a meaningful way to more industrial hygienists in order for this approach to be fully validated, developed and integrated into hygiene practice. Two examples of emission factor use are illustrated. An emission factor for chrome plating has been published as 26.8 g chromium emitted per rack of parts plated. At a separate facility this emission factor along with process and ventilation measurements were used to predict chromium concentrations. the predicted values ranged from 1.7 $\mu g/m^3$ to 18 $\mu g/m^3$. Actual measured values ranged from 0.19 to 4.72 $\mu g/m^3$. This agreement is reasonable considering potential differences in rack types, part sizes, and plating current. As another example, an admission factor developed for offset printing volatile organic compound (VOC) emissions at one print shop was used to predict concentrations at a separate shop. VOC emissions at offset printing are most closely associated with the solvent cleaning activities at the presses. An emission factor was developed as 48.5 g VOC emitted during each solvent cleaning event. This emission factor along with appropriate process and ventilation measurements were used to estimate VOC concentrations at the second shop. Predicted VOC concentrations for the shop ranged from 35 to 109 mg/m^3. Measured concentrations at the shop ranged from 8.0 to 24 mg/m^3 and were highly correlated with predicted values (r^2=0.85). In both examples concentrations were overpredicted by about a factor of four. This agreement is reasonable given the number of assumptions that had to be made in both cases. emission factors tied to more detailed process variables such as surface area plated or cleaned will improve the models. These examples illustrate how emission factors can be effectively used to predict indoor chemical concentrations for use in epidemiological studies, developing exposure assessment strategies, and defining pollution control priorities.

92

AREA CONCENTRATIONS OF TOLUENE AND PERSONAL EXPOSURES IN A ROTOGRAVURE PRINT SHOP. R.A. Wadden, P.A. Scheff, L.M. Conroy, J.E. Franke, Environmental & Occupational Health Sciences, University of Illinois at Chicago (M/C 922), 2121 W. Taylor, Chicago, IL 60612.

Rotogravure printing requires an ink solvent which is typically >97% toluene. Because of the high rate of ink usage (typically 150 gal/press hour), significant quantities of toluene can escape from the local exhaust control systems into the workplace. A two-day test was carried out in a rotogravure press room during press operation. Web speeds were ~ 1800 fpm with 25,000 impressions/min. The purpose of the test was to collect concentration and ventilation data in a form suitable for expressing room release of ink solvent vapors as emission rates. personal exposures and source activities were also determined.

One-hour air samples were simultaneously collected on charcoal tubes at 16 different locations in the space for 12 separate hours. The sample sites included all identified entry and exit point. Bulk solvent samples were collected for four inks, three press cleaning materials, two extenders, and a web adhesive. The air and bulk solvent samples were analyzed by gas chromatography for toluene, benzene, total non-methane hydrocarbon expressed as hexane, and 18 other organics. Airflow into and out of the room was determined through doors and ventilations ducts using a combination of pilot tube and hotwire anemometer measurements. personal exposure samples, using 3-M passive dosimeter disks, were collected on each of the two days from nine persons working in the area. we also recorded each person's proximity to the press on a two minute basis.

Area concentrations of toluen were between 11 and 132 ppm. the measurements on the second day were only 10-30% of first day concentrations. This change was consistent with source activity as production was much lower on the second day. Personal exposures showed this same trend over the two days and varied between 17-85 ppm on the first day. Three persons incurred exposures which were above the TLV of 50 ppm. In addition to supporting emission rate and LEV collection efficiency determinations, the data provide a reasonable basis for comparing predictions from various exposure models.

93

MONTE CARLO SIMULATION OF A DIFFUSION MODEL USED IN THE PRELIMINARY ASSESSMENT OF POTENTIAL EXPOSURE TO HALOGEN GAS DURING DOSING OF A LARGE OUTDOOR BROMINATOR. W.D. Shade, M.A. Jayjock, Rohm and Haas Company, Toxicology Department, 727 Norristown Road, Spring House, PA 19477.

Monte Carlo Simulation was incorporated into a diffusion-based exposure assessment model used to estimate the potential worker exposure to halogen gases resulting from the dosing of 500-lb sacks of bromine-based biocides into brominators used outdoors. The diffusion model used in this assessment describes a concentration gradient of halogen as a function of distance and time from the source. Instead of ascribing single point values to all of the variables used in the diffusion model, Monte Carlo simulation analysis allows for a distribution of values to be used for each model variable. Distributions input into the diffusion model included the time to empty the biocide sack, the distance of the worker's breathing some from the source during emptying, the concentrations of halogens in the headspace and void volume of the biocide, and the prevailing windspeed at the time of brominator dosing. Using a personal computer and Monte Carlo Simulation software, 10,000 iterations of the diffusion model were performed utilizing random and independent "samples" from the distributions entered into the model. The corresponding output distribution of predicted exposures was then calculated and displayed graphically.

This preliminary Monte Carlo Simulation predicts that outdoor dosing of the brominators with the biocide is unlikely to result in an exceedance of the halogen exposure limit. In the presence of most ambient windspeed conditions, diffusion of the material is such to prevent appreciable airborne exposure to workers in the immediate vicinity of the brominator. After 10,000 simulations of the diffusion model, the Monte Carlo distribution of airborne concentrations was below the halogen exposure limit greater than 97% of the time.

94

THE EFFECTS OF FIVE POTENTIAL EXPOSURE DETERMINANTS ON MEAN LEAD EXPOSURES ESTIMATED FROM OSHA COMPLIANCE DATA IN THE LEAD BATTERY INDUSTRY. M.R. Gomez, Science Advisory Board, 401 M St., SW (1400F), Washington, DC 20460.

An investigation was conducted of a portion of the exposure data collected during compliance inspections of the Occupational Safety and Health Administration (OSHA) in the lead battery industry in the period 1979-1989. Five linear regression models (including one linear logistic regression) were used to examine the association of five potential exposure determinants to mean and high-end (upper quartile) exposures to lead in exposure groups in the industry. The five variables studied were *union status* and *size* of the establishment in which the measurements were collected. The study found strong evidence of a secular decline in mean exposures in the time period studied (about 9% per year) as well as strong evidence that mean exposures in large- and medium-size firms were only 40% of those in small-size firms. Type, scope and union status, however, were not found to be associated with mean exposures. The presentation will briefly discuss how findings of this study help to characterize the strengths and weaknesses of the OSHA data for use in a wide range of potential exposure assessment applications.

95

CHARACTERIZATION OF SOURCE ACTIVITY AND EMISSION FACTORS FOR WAVE SOLDERING. S.A. Milz, Naval Hospital, Occupational Health/Preventive Medicine Department, NH-064, Great Lakes, Il 60088; R.A. Wadden, J.E. Franke, P.A. Scheff, L.M. Conroy, University of Illinois at Chicago, Environmental and Occupational health Sciences, 2121 West Taylor, M/C 922, Chicago, IL 60612.

Emission rates and emission factors for lead particles were developed based on data collected during production in a space containing three wave soldering lines at a semi-conductor manufacturing plant. Twelve one-hour air samples for particulate matter were collected on polycarbonate filters over a two-day period at ten sampling locations around the lines. The particulate matter on the filters was analyzed for elemental composition using Proton Induced X-Ray Emission Spectroscopy. source activity data were recorded during the entire twelve hours for each of the three lines. The observations included board type, number of boards, number and duration of hood cover openings, and number of scrapings and dedrossings.

The collected hourly concentration data and ventilation rates were used with a box model describing a lead mass balance on the space to calculate the combined hourly emission rate from all three lines. The average lead emission rate was 50 mg/hr. Emission factors were calculated using the emission rate estimates. The resulting relationships indicated that total board count and total pot scrapings and dedrossings best described the overall lead emissions from all three lines. These emission factors can then be used to estimate emissions for other wave soldering lines in the semi-conductor industry.

In addition, chemical mass balance (CMB) receptor modeling was carried out on the area samples to determine the fraction of the measured lead concentration at each sampling site which was emitted from each of the three wave lines. In a space containing multiple sources, the CMB approach has the potential to provide a quantitative estimate of the fraction of each workplace sample which is due to emissions from each specific source. In this study, the allocation procedure resulted in individual line concentrations which were in good agreement with scraping and dedrossing activities for the specific line most likely to affect the area concentrations. This agreement suggests that the CMB can serve as a useful evaluating tool for discriminating the contribution of individual sources to area and personal concentrations.

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ABSTRACTS

Abstract Index by Session Topics