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Comparison Between Personal and Stationary Sampling Results: A Field Survey in a Printing Factory

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Due to the current regulations (WORK SAFETY AND HEALTH LAW 1972; WORK ENVIRONMENT MEASUREMENT LAW 1975; GUIDELINE FOR WORK ENVIRONMENT MEASUREMENT 1976), the concentrations of air-borne chemicals in work environments in Japan are required to be monitored by means of stationary sampling after a grid sampling strategy. The question inevitably raised, is, that if there is a quantitative relationship between the environmental concentrations measured as required by the regulation (GUIDELINE FOR WORK ENVIRONMENT MEASUREMENT 1976) and exposure concentrations in the breathing zone of the workers. This study was initiated to investigate the relationship between these two parameters in a printing factory.

MATERIALS AND METHODS

The printing factory surveyed had 8 workplaces manned by 2-8 printers in each or 35 persons total. Carbon felt dosimeters were employed for the measurements of solvent concentrations (HIRAYAMA & IKEDA 1979; KOIZUMI et al. 1980). For the personal sampling of breathing zone air, each worker was equipped with one carbon felt dosimeter on the chest from the beginning of the morning work till lunch break at noon (for ca. 4 hours) and another one from the beginning of the lunch break till the end of the afternoon work (for ca. 5 hours). The two results were combined to calculate the average exposure of the day. Stationary sampling of the workroom air after the grid strategy (GUIDELINE FOR WORK ENVIRONMENT MEASUREMENT 1976) was carried out by placing 5-9 dosimeters for the same time periods 140 cm above the floor in each workplace. A typical case of placing the dosimeters at the grid points is illustrated in Fig. 1. After the exposures were terminated, each carbon felt was extracted with 10 ml of carbon disulfide, an aliquot of which was subjected to the analyses with a FID gas chromatograph (Hitachi Model 163) equipped with 25% DOP on Celite 545 columns (KOIZUMI et al. 1980). Although several solvents other than toluene were detected

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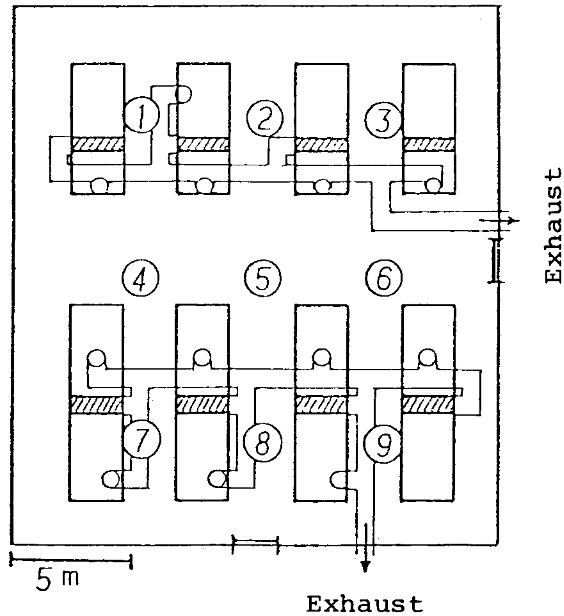

Fig. 1 A typical case of the grid sampling in a printing workplace.
Numbers in the circles show the sites (140 cm above the floor) of the stationary sampling with carbon felt dosimeters. The workplace was equipped with 8 printing machines. Shaded squares = ink pans.

as minor contaminants of the workroom air, toluene was the primary solvent to which the printers were exposed. Toluene concentration in each workplace was expressed in terms of the geometric mean and the geometric variance. In parallel to the determination of the solvent concentrations in the breathing zone and workroom air, the work done by individual printer at a given time was recorded at 5-minute intervals on a time study chart by an observer after the man-to-man system. Statistical analyses of the results were carried out utilizing an ACOS-1000 computer (Nippon Electric Co., Tokyo, Japan) in Tohoku University Computer Center.

RESULTS AND DISCUSSION

Eight geometric means were available as the indices of the environmental concentrations in the 8 workplaces together with 35 personal sampling results from the same number of the printers. When the former values were plotted against the latter, the regression line was calculated as

$$Y = 26.6 + 0.541\ X \quad (r = 0.41,\ p < 0.01)$$

where X is the geometric mean (n = 8) of the environ-

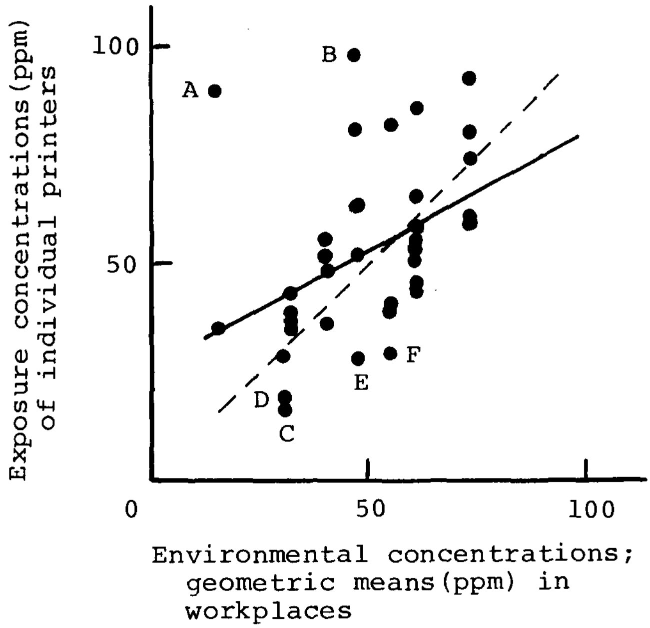

Fig. 2 Correlation between environmental concentrations and exposure concentrations
The solid line, Y = 26.6 + 0.541 X, is the calculated regression line and the broken line indicates Y = X. For A-F, see the text.

mental concentrations, and Y is the individual exposure concentration (n = 35)(Fig. 2). The correlation was not close even though significant. The mean exposure concentration will be higher than the geometric mean of the environmental concentrations when the latter is less than ca. 60 ppm, while the reverse will be the case with the latter of over 60 ppm. When the work of 6 individuals whose exposure concentrations were far from the regression line (A-F in Fig. 2) was analyzed, it was found that Subject A was engaged primarily in the preparation of ink which might be associated with heavy exposure to toluene, and Subjects E and F were somewhat away from the sites of vapor generation as they spent most of time on the inspection of printed products. No specificity in work was disclosed in the case of Subject B, C or D to explain the discrepancy.

Further analyses were made in relation to exposure concentrations and exposure-defining parameters. Stepwise multiple regression analysis was carried out with individual exposure concentration (in ppm) as the dependent variable. The following were taken as the independent variables; the geometric mean (X_1 in ppm) and the geometric variance (X_2, dimensionless) of the environmental concentrations, and the time spent by an individual printer for printing (X_3 in minutes), for preparatory work with possible heavy exposure (X_4 in minutes; e.g., preparation and mixing of ink, cleaning of printing rolls and ink pans, or supply of ink and thinner), for preparatory work with possible light exposure (X_5 in minutes; e.g., orientation meeting in the workplace, supply of paper rolls, or proof reading), for non-printing work (X_6 in minutes; e.g., inspection of products, patrol in the workplace, or rest inside of the workplace) and for work or rest outside of the work place (X_7 in minutes; e.g., carriage of ink or thinner containers, rest for smoking, or visit to restrooms). As better correlation would generally be expected in multiple regression analysis with increasing numbers of independent variables, the analysis was performed taking F_{in} of 3.22 and F_{out} of 3.22 as the criteria to accept the independent variable(s) proposed. It should be noted that the selection of variables under the conditions defined by the F value of 3.22 in F test is more specific than what would be done with $p < 0.05$. Thus, the calculation gives

$$Y = 0.61\ X_1 + 0.03\ X_3 + 14.5 \quad (R = 0.497,\ R^2 = 0.247,\ p < 0.05)$$

where Y is the exposure concentration (in ppm) of individual printer, and X_1 (in minutes) and X_3 (in minutes) are as defined above. X_2, X_4, X_5, X_6 and X_7 failed to clear the criteria. In other words, the 7 variables as a whole explain only 25% of total variance with the remaining 75% unexplained.

The findings indicate that the exposure concentrations and the environmental concentrations in the printing factory studied were only weakly correlated to each other. The estimation of exposure intensity by means of environmental concentration determination is hardly possible even if the work performance of each printer is evaluated in terms of time spent in printing and/or other auxilliary work.

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