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PERFORMANCE EVALUATION OF PERSONAL AEROSOL SAMPLERS USING FULL-SIZE MANIKIN AND SIMPLIFIED TORSO

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Development of alternative protocols for performance evaluation of personal aerosol samplers has shifted to the forefront of aerosol science and practice. Traditional evaluation protocols developed for large wind tunnels utilizing full-size manikins are time consuming and expensive. In addition, the accuracy and precision of the tests performed in a large wind tunnel are often not sufficient, particularly because of the limitations in achieving uniform aerosol concentration in the test zone (Kenny et al., 1997, Ramachandran, Sreenath, and Vincent, 1998).

Several approaches have recently been proposed to solve this problem. One of them suggests using the scaling relationship and semi-empirical aspiration models (Ramachandran et al., 1998). This allows to address spatial and temporal concentration uniformity issues. Another approach introduces a small torso as an integral part of a simplified protocol which can be utilized in a smaller wind tunnel (Witschger et al., 1998). This protocol permits significant reduction of the number of experiments involved in the comprehensive performance evaluation of personal aerosol samplers. At the same time, accuracy and precision of these experiments can be maintained at acceptable levels. In this study, the simplified protocol was evaluated with three commercially available personal aerosol samplers using a full-size manikin and a small (simplified) torso.

A closed-loop wind tunnel with the cross-section area of 1.22 x 1.83 m (National Institute for Occupational Safety and Health, Cincinnati, Ohio, USA) was used. In the first phase of this study, the sampling efficiency of the three inhalable aerosol samplers (the GSP, IOM, and the 37-mm conductive closed-face cassette) mounted on the full-size manikin was determined. The tests were conducted using three monodisperse aerosols with the particle aerodynamic diameters of 7, 29, and 70 μm at two wind velocities of 0.5 and 2.0 m/s that respectively represent indoor and outdoor ambient air environments. The sampling efficiency measurements were conducted at three principal orientations of the manikin to the wind: 0^0, 90^0, and 180^0 (the manikin was not rotated). Also, the direction-averaged sampling efficiency values were calculated by weighted summation of the measured data within the interval of [0, 360^0]. These values were in good agreement with those found by Kenny et al. (1997) at the wind velocity of 0.5 m/s when testing with rotating manikin in a different wind tunnel.

In the second phase, the simplified torso having dimensions of 33 x 21 x 21 cm was tested. Two identical samplers of each type were mounted on each of the bigger faces of the simplified torso. Thus, two samplers were evaluated in one test under three orientations to the

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wind direction. In other words, one experiment with the simplified torso yielded the same amount of data as up to six experiments with the full-size manikin. Besides, the use of discrete sampling orientations simplifies the interpretation of the sampling efficiency data using the physical principles of aerosol sampling (Vincent, 1989). In addition to the direction-averaged sampling efficiency data, the information on the performance of personal aerosol samplers at certain fixed angles is important in many particular sampling situations. It was found that sampling efficiency can be successfully measured using the simplified torso. As an example, Fig. 1 illustrates the sampling efficiency correlation between the two torsos when sampling particles of 70 μm with all three samplers at U_w = 0.5 m/s.

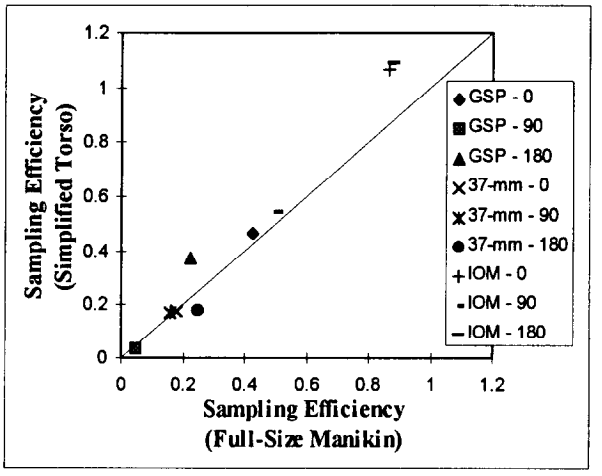

Fig. 1. Correlation between sampling efficiencies measured with the full-size manikin and simplified torso. U_w = 0.5 m/s, d_a = 70 μm.

The simplified protocol for testing personal aerosol samplers promises to be a time- and cost-effective and versatile tool.

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