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ADVANCES IN AEROSOL SAMPLING SCIENCE AND ITS PRACTICAL APPLICATIONS

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Aerosol sampling is carried out for a wide range of purposes, ranging from sampling in relation to environmental and climatological effects from aircraft high in the earth's atmosphere, to sampling in relation to human exposures and associated health effects in terrestrial living and working environments. Our level of understanding in aerosol mechanics over the past few decades has taught us that, in the act of withdrawing a sample of an aerosol from a particle-laden atmosphere, the particle size distribution of the sampled aerosol may change significantly. In a given situation, therefore, the question then is: how has it changed and how representative is the collected sample of the aerosol of interest?

Practical aerosol samplers come in a wide variety of shapes and sizes, ranging from the more idealised sharp-edged probes of the type used for sampling in stacks and ducts and from aircraft, to the more complex, blunt configurations used in occupational and environmental hygiene. We know that the air movement near any of these samplers is distorted by the presence and aspirating action of the sampler. This in turn influences the motion of suspended particles both outside the sampler and inside it as particles are being transported to the sensing zone or filter (e.g., by the effects of inertial, gravitational and electrostatic forces). Aerosol sampling science has striven to understand the nature of such effects so that samplers can be designed to either (a) minimise or reduce them, or (b) control them in a way that makes sampling performance match a given particle size-selective criterion. A considerable body of work has emerged over the years, including notably the recent mathematical studies of Derek Ingham, Sarah Dunnett, Derek Dunn-Rankin and Nurtan Esmen, and experimental studies from the laboratories of Klaus Willeke, Genady Lipatov, David Mark, Trevor Ogden, William Hinds and others (including the author).

Recent research has set out to investigate aerosol sampling science specifically from the standpoint of connecting what has been learned from such previous studies with how aerosol sampling is carried out in the real world. The gap that exists concerns the roles of the shape and state of symmetry of the sampling device and its orientation with respect to the prevailing external air motion. The challenge is considerable, not least because the air flow in the vicinity of an aerodynamically blunt body with aspiration placed at large angles with respect to the wind is itself very complicated and - to this day - not at all well-understood.

Much current interest is driven by the special case of a small personal sampling device which is worn on the torso (i.e., in the lapel region) of a worker and carried with him/her throughout the whole working day. Such devices are widely used in occupational hygiene for the purpose of assessing the health-related exposure of the worker, and are required to collect particles in a manner which reflects how such particles are inhaled. Only in that way can the measured exposure be expected to correlate with the risk arising from the exposure. Standards setting bodies and occupational and environmental regulatory jurisdictions around the world are now requiring that aerosol sampling should be carried out according to this philosophy. Yet, as has been reported in many laboratory and field studies, most of the personal samplers which are used by occupational hygiene practitioners do not meet such criteria. Unfortunately, aerosol sampling science has not yet reached the point where new personal samplers can be designed from the outset with the desired performance. As a result, progress has been achieved primarily by the empirical testing of candidate samplers in wind tunnels, accepting only those which happen to meet the criteria in question and rejecting the others.

For the specific case of personal sampling, the experimental problems involved in such testing are formidable. It is widely held that the samplers to be tested should be mounted on a full-size torso, since we know that testing them in isolation does not give relevant results. In turn, this suggests that the experiments must be carried out in a sufficiently large wind tunnel to accommodate the sampler/torso system with minimum wind tunnel blockage problems. This therefore requires a wind tunnel of cross-section at least 1 m^2, bringing with it the technical difficulty of achieving uniform air flow and aerosol concentration distributions. As a result, the experiments that have been reported, e.g., most recently by Mark and his colleagues (Kenny *et al.*, 1997), have been extremely difficult and, whilst they achieved excellent results, they were extremely time-consuming and the results were obtained at great cost. So the idea is now dawning that this might not be realistic as the basis for a long-term standardisation strategy.

Recent research, however, is starting to point the way towards a workable alternative approach. In one study carried out in Willeke's laboratory (Witschger *et al.*, 1998), it was shown that the performances of some personal samplers mounted on relatively small bluff bodies in a much smaller wind tunnel than the ones used in the other studies referred to above gave results which were in close agreement with those large-scale studies. In a study carried out in our own laboratory at the University of Minnesota (Ramachandran *et al.*, 1998), it was shown that scaling laws can be developed which suggest a scaling down not only of the physical dimensions but also the range of particle sizes that need to be used in the experiments. Such scaling allows the use not only of a small wind tunnel (where highly constant test aerosol can be injected to provide very uniform spatial aerosol distribution) but also the application of direct-reading detection techniques (e.g., the aerodynamic particle sizer, or APS) by which very copious amounts of aerosol sampler performance data can be acquired very rapidly. Such research opens the door to testing procedures for aerosol samplers which are likely - if they can be validated - to be much more universally acceptable. Here, therefore, aerosol sampling science is leading the way towards improved design and testing procedures for practical aerosol samplers.

REFERENCES

Kenny, L.C., Aitken, R.A., Chalmers, C., Fabries, J.F., Gonzalez-Fernandez, E., Kromhout, H., Liden, G., Mark, D., Riediger, G. and Prodi, V. (1997), A collaborative European study of personal inhalable aerosol sampler performance, *Ann. Occup. Hyg.*, 41, 135-153.

Ramachandran, G., Sreenath, A. and Vincent, J.H. (1998), Towards a new method for experimental determination of aerosol sampler aspiration efficiency in small wind tunnels. *J. Aerosol Sci.*, 29, in press.

Witschger, O., Willeke, K., Grinshpun, S., Aizenberg, V., Smith, J. and Baron, P.A. (1998), Simplified method for testing personal aerosol samplers, *J. Aerosol Sci.*, 29, in press.