Editorial

Twenty-Five Years of Inhalable Dust

L. C. KENNY† and T. L. OGDEN‡*

†Health and Safety Laboratory, Broad Lane, Sheffield S3 7HQ, UK; ‡40 Wilsham Road, Abingdon, Oxfordshire OX14 5LE, UK

In the 1960s, it was not widely understood that what was collected by ‘total dust’ samplers depended on local airflow and particle size, and that large errors could occur. A guide for British Factory Inspectors (Ministry of Labour, 1967) mentioned a target accuracy of ten per cent when comparing dust concentrations with exposure limits, although the few tests on samplers (e.g. May, 1967) showed that commonly-used devices could differ by several hundred percent in what they collected. At the 1975 Inhaled Particles Symposium, it was proposed that a logical approach would be to define ‘inhalable dust’ by the entry characteristics of the human head averaged over all wind directions. Measurements of these characteristics in windspeeds from 0.75 to 2.75 m/s were presented by Ogden and Birkett (1977). The directionally-averaged results agreed well with calm-air results (Ogden and Birkett, 1978), and these two sets of results were then proposed as the basis for standards and sampler design.

This concept influenced standards faster than it did practice. A working group of the ISO Technical Committee on Air Quality (TC146) was charged with specifying dust fractions for standards for sampling workplace and environmental aerosols. The concept of an inhalable fraction sub-divided successively into thoracic and respirable fractions was discussed in Gainesville, Florida in March 1980, and subsequently published as ISO (1983). The inhalable concept endured, but the Gainesville numerical recommendations were obsolete before they were published. The improved results were used in an important review by ACGIH (Phalen, 1985), and the numerical criterion has remained almost unchanged ever since.

In 1986, the UK proposed that ISO (1983) be revised to use the better inhalability findings, and a CEN Technical Committee was formed to produce standards in response to the European Directive (EC, 1988). This resulted in European Standard EN 481 and International Standard ISO 7708, with identical recommendations for the workplace (CEN, 1993; ISO, 1995). Liaison with the ACGIH Air Sampling Procedures Committee ensured that the standards criteria were identical to those proposed for use with TLVs (see Vincent, 1999).

Putting these international agreements into national practice was more complicated. The German MAK values had been the first exposure limits to recognise the sampling problem and, from the early 1970s, had defined ‘total dust’ as that collected by a sampler with an entry velocity of 1.25 m/s. In the US, the TLV values ignored the problem, but the 37 mm plastic aerosol sampler with a small entry orifice was the de facto standard. This sampler was used in Denmark with the entry hole enlarged, to meet the German specification at a flowrate of 1.9 l/min; in Sweden, the same sampler was used with the front cover removed. This lack of standardisation was usually forgotten when comparing national exposure limit values.

Britain had the advantage of standardising late. In the early 1980s there were still half a dozen recommended samplers, but HSE decided to specify the ‘modified UKAEA sampler’ for general use. This was an aluminium holder for a 25 mm filter, with the front plate penetrated by seven 4 mm diameter holes. Their reasons were that the Factory Inspectorate was already using it widely, and, significantly, its entry

Received 22 August 2000.
*Author to whom correspondence should be addressed. Tel.: +44 1235 534380; fax: +44 1235 534380; e-mail: ogden@tcp.co.uk
characteristics were believed to match the inhalable curve of ISO (1983). This belief was based on a limited set of measurements by Wood and Birkett (1979). These were carried out with the sampler on a mannikin facing a 1 m/sec wind, but the flow round a body meant that the sampler entry was side-on to the airflow even when the body itself was facing the wind; other results on blunt samplers (Ogden, 1983) suggested that the Wood and Birkett results would be a reasonable guide to performance in other windspeeds and directions. MDHS 14 (HSE, 1983) therefore defined ‘total dust’ as that collected by the 7-hole sampler but, quoting ISO (1983), stated: “A practical method is not yet available for measuring this inspirable1 fraction definitively, but the method proposed here for ‘total dust’ approximates to the ISO definition of inspirable fraction within the limits of available data”. MDHS 14 thus became the first national document to adopt the inhalable idea. British exposure limits have been linked to this concept ever since, so the problem of adapting exposure limits to the inhalable criterion (e.g. Lidén et al., 2000) has not arisen. The IOM sampler (Mark and Vincent, 1986) matched the inhalable sample better, and was incorporated into MDHS 14 in HSE (1989).

Conformity of sampling instruments with the definitions proved difficult to test. During 1989, the CEN Technical Committee examined the performance of various instruments, and began work on test methods, but considerable debate remained. This eventually led, in 1992, to an EU-funded pilot study of test methods (Kenny et al., 1997), which influenced several developments in the UK. During 1996 the WATCH committee, a tripartite working group that considers exposure limits and risk assessments, examined how well the modified UKAEA (or seven-hole) sampler and the IOM sampler conformed with the EN 481 sampling conventions. WATCH recommended that the CEN inhalable convention be adopted without altering the existing UK exposure limits, but also for this to be reviewed after three years.

HSE initiated further research to clarify the remaining issues surrounding the performance of UK sampling methods, and to assess the impact on enforcement, particularly of substances having Maximum Exposure Limits (HSE, 2000a). Baldwin and Maynard (1998) showed that low windspeeds predominated in most UK workplaces, and Kenny et al. (1998) then examined the performance of UK dust samplers in these conditions. Finally, HSE carried out a series of comparative workplace studies, which confirmed that Britain could adopt the inhalable sampling convention without changing any exposure limits (HSE, 2000b). This story illustrates how long it can take for a scientific concept to be realised in guidance, regulations and practice; for inhalable dust, this took 25 years. Paradoxically, as the position in Britain has finally been regularised, the European Union Chemical Agents Directive has made the European position in some senses less clear. The European Directive which led to the CEN work (EC, 1980, as amended by EC, 1988) has been repealed by the Chemical Agents Directive (EU, 1998). The earlier directive included definitions of respirable and inhalable dust, allowing for these to be superseded by CEN agreement. The Chemical Agents Directive does not contain these definitions or reference to CEN methods, instead referring to future ‘practical guidelines of a non-binding nature’. Thus, although the Chemical Agents Directive has strengthened the status of European exposure limits, it has the potential of allowing member states to choose their own definitions and methods in a way which will allow large differences in assessment of the same exposures. Clearly this situation will need careful monitoring by those giving technical advice to the policy makers.

The research outlined here has dominated the scientific career of several people and, as policy-makers stay in their jobs for less time than scientists, concepts have had to be explained several times over. The wording of the Chemical Agents Directive shows that the need for this will probably continue!

REFERENCES


Health and Safety Executive (1989) General Methods for the Gravimetric Determination of Respirable and Total Inhal-

1 ISO (1983) used the term ‘inspirable’ instead of inhalable. Inhalable had been used with the present meaning in the original discussions, but was then used by US EPA in a different sense, so the ISO report used inspirable. EPA later abandoned the term, so inhalable is now used internationally with the original meaning.
Twenty-Five Years of Inhalable Dust