Commentary

To celebrate the British Occupational Hygiene Society’s fiftieth anniversary this year, we are reproducing in our on-line edition ‘classic papers’ from past issues of the Annals, with a commentary giving personal views of their background and long-term significance.

The 1968 BOHS Chrysotile Asbestos Standard

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BACKGROUND

In the 1960s, the British Occupational Hygiene Society (BOHS) established a Standards Committee to advise members on hygiene standards for air contaminants and on associated matters such as measurement methods. Its first report (BOHS, 1968) proposed a hygiene standard for chrysotile asbestos, reproduced in the on-line edition of this issue of the Annals. It is perhaps the most influential thing that BOHS has ever done; but it is also probably the most controversial, to the extent that there is still no consensus view of it. Any commentary on it must therefore be a personal view.

There had been attempts to produce standards for asbestos since the 1930s. The Factory Inspectorate had established a ‘dust datum’ of acceptable conditions in spinning, based on sampling with a thermal precipitator and fibre counting using ×2000 oil-immersion light microscopy. Burdett (1998) used some of the original equipment to compare measurements of textile-grade crocidolite made in that way with measurements using the modern membrane filter method. He concluded that translated to modern methods the 1930s ‘dust datum’ corresponded to 10 fibres/ml by static sampling or 20 fibres/ml by personal sampling. These are much lower levels than is often assumed for the 1930s, but crucially we do not know how often they were achieved. In the USA, Dreesen et al. (1938) recommended a level of 5 million particles per cubic foot (mppcf), measured with a midget impinger. The results of Ayer et al. (1965) suggest that this was very roughly equivalent to ~30 fibres/ml by the 1960s membrane filter method (McDonald, 1984), or perhaps double that by the modern version of the method. Dreesen et al.’s level was adopted by the American Conference of Governmental Industrial Hygienists (ACGIH) in 1946. In the UK, the Factory Inspectorate reprinted the ACGIH TLVs in 1960, but King (1993) says that British hygienists of around that time tended to use a gravimetric limit of 0.1 mg/m³. In 1968, a Department of Employment and Productivity report to the Factory Inspectorate’s Senior Medical Inspector felt that if levels from 2.4 fibres/ml in doubling to 7.7 fibres/ml in carding could be achieved, ‘a great advance will be made’ (DEP, 1968).

MAKING A STANDARD

According to King (1993), who was its secretary, the asbestos sub-committee of the Standards Committee tried to decide on a risk level that would be acceptable to the workforce concerned. They did not (perhaps could not) ask the workforce itself about this, however. Moreover, there was a consciousness of the need to produce a standard that reflected the reality of economic dust control: taking into account that a problem ‘which is very difficult to resolve, is that of balancing the risks to health against the consequences of demanding excessive dust reduction’ (BOHS, 1968). The sub-committee decided that a 1% risk of contracting the first signs of asbestosis was acceptable. The ‘first sign’ they used was basal rales, a crackling and bubbling sound audible by stethoscope and produced by fluid in the air passages of the lung. With the cooperation of medical advisers to the asbestos manufacturers, they tried to relate this...
symptom to exposure in a group of 290 men in Turner’s Rochdale factory. Exposure for this group was generally measured by the thermal precipitator, which in Rochdale’s method of use was assumed to give the same results as the membrane filter method. If the measurements of environment and workforce had been representative, and if the symptom chosen had been non-progressive, this might have been seen as a very protective standard, and most of the sub-committee probably believed it was. It is the failure of these assumptions that later attracted most criticism.

Geoffrey Berry was a young statistician who had been called in at a late stage in the deliberations to apply expertise to the dose–response data. With the benefit of later experience, he defended the need for the standard, but characterized the main failings of the study as (Berry, 1978):

1. the study used current employees only, excluding workers who had left;
2. it was assumed that there would be no disease progression if there was no further exposure;
3. early dust levels had to be guessed;
4. the measurement of the health effects was by a single observer.

The first of these points meant that the study might have been biased to employees with less response, and this problem was mentioned in Appendix (ii) of the standard.

Greenberg (1997) examined the very incomplete records of the sub-committee’s deliberations, and felt that the study did not come up to the standards of the day; but the greatest weakness was surely that the risk estimates took no account of cancer. This was because, as the report said, ‘the quantitative relationship between asbestos and cancer risk is not known’, although the risk was expected to be less at lower exposures. With hindsight, we see that a risk estimate for asbestosis only was of little value; but the committee evidently still thought that setting a standard was useful for improving conditions.

The sub-committee’s report opened with the important statement

As long as there is any airborne chrysotile dust in the work environment there may be some small risk to health. Nevertheless, it should be realised that exposure up to certain limits can be tolerated for a lifetime without incurring undue risks.

The key finding was that the risk of basal rales would be <1% for a cumulative exposure of ~100 fibre-yr/ml measured by the membrane filter method, equivalent, for example, to 2 fibres/ml for a 50 yr working lifetime. The fine detail of the report stated that to be better than 95% certain that the risk was <1%, the level would have to be <1 fibre/ml. The fibre/ml limit would apply to an average over 3 months, determined either by continuous sampling or by random samples, taken at times decided in advance, in such a way that the upper 90% confidence limit of the average exposure was <2 fibres/ml. So the committee’s recommendation was not a 4 or 8 h limit of 2 fibres/ml, but a sampling strategy which gave a 90% confidence that the long-term average was <2 fibres/ml.

Greenberg (1997) found from industry records that the committee originally wanted 50 fibre-yr/ml, but relaxed this at the industry’s request. The standard states that the risk was ~1% at 100 fibre-yr/ml, so in the absence of records, it is difficult to disentangle this. It may be that the committee wanted to emphasize 1 fibre/ml to ensure that the upper 90% confidence limit of the average concentration was <2 fibres/ml, but this sophistication, and the 3 month sampling recommendation, were rapidly forgotten in application of the standard. There were various other recommendations about classification of work areas, medical examination of employees, subsequent review of the standard and use of other measurement methods.

 Later History of the Risk Estimate

In due course, the risk estimate was shown to be very optimistic. A BOHS committee revisited the problem in 1983, attempting to overcome some of the problems identified by Berry and others (BOHS, 1983). It concluded that the probability of occurrence of any one of seven adverse effects (but still excluding cancer) was 17–20% at 100 fibre-yr/ml and <2% at 25 fibre-yr/ml (or 0.5 fibres/ml for 50 yr). The difficult problem of cancer was taken into account by Doll and Peto (1985), who concluded that the overall risk of fatal disease (not basal rales!) in chrysotile textile manufacture was ‘of the order of 0.5% for exposure at an average concentration of 0.25 fibres/ml’. This study was influential, although it has been much criticized as giving a high estimate of chrysotile risk, because of the occasional use of crocidolite use at the Rochdale factory and because of the possibility of a threshold of effect at low exposures. Most recently, Hodgson and Darnton (2000) estimated the excess lung cancer risk from chrysotile as the equivalent of 0.5% at 100 fibre-yr/ml, but their estimates have also been criticized.

 Progress of the Standard

Returning to the situation in 1968, many aspects of the sub-committee’s recommendations, including their proposed sampling strategy, were forgotten, and it was the simple number of 2 fibres/ml that was rapidly disseminated worldwide. For Britain, the matter was considered internally by the Factory
Inspectorate at a meeting in April 1968, to decide how the forthcoming Asbestos Regulations would be applied. The view was expressed at the meeting that ‘there was hardly any sound biological evidence to justify the fibres per cc shortly to be adopted by the British Occupational Hygiene Society’, but ‘Even the best textile factories in the United Kingdom had fibre counts higher than 2 and some as high as 8’. A final outcome of these deliberations was that where the concentration over any 10 min period was <2 fibres/ml, the Inspectorate would not seek to enforce the regulatory requirements for exhaust ventilation and respiratory protection. If the 10 min concentration was between 2 and 12 fibres/ml, further sampling would determine if the average concentration over 4 h was >2 fibres/ml. If so, further control would be required (DEP, 1970). So 2 fibres/ml measured over a short period became the benchmark of good control. This guidance was evidently not written by any of the Inspectorate’s experts: the version of the membrane filter they used was incapable of measuring 2 fibres/ml over 10 min. By 1976, the guidance said that exposure should never exceed 2 fibres/ml when averaged over a 4 h period (Health & Safety Executive, 1976).

The weakness turned out to be that the Asbestos Regulations 1969 did not include any of these figures; they referred to dust ‘consisting of or containing asbestos to such an extent as is liable to cause danger to the health’. The fibres/ml figures were for guidance only. The Inspectorate found that in order to prosecute on a fibres/ml level, they had to call expert medical evidence that the level met the ‘danger to health’ criterion, and as the health risk estimates were based on a 50 yr exposure, there were few, if any, medical experts who would do this on the basis of a few 4 h measurements at 2 fibres/ml. This situation was not rectified until the Asbestos Regulations 1987.

The 10 yr following the introduction of the standard saw the rapid spread around the world of 2 fibres/ml as a starting point for standards, but the further undermining of its theoretical base by deeper examination of the measurement method. McDonald (1984) listed nine countries in 1981 with a 2 fibre/ml limit (including the USA, where the level was adopted by the Occupational Safety & Health Administration in 1971), three with 5 fibres/ml and one (Sweden) with 1 fibre/ml. However, Beckett and Attfield (1974) had shown that different laboratories, including Turner’s and the Inspectorate’s, differed very widely in the results they obtained on the same samples, so it was unclear what ‘2 fibres/ml’ meant. Subsequent work showed that this applied internationally, and that tightly specifying the details of the method did not completely solve the problem. It was necessary for counting laboratories to take part in regular sample exchanges and to have careful internal quality control if they were to get the comparable results. [Holdsworth et al. (1954) had demonstrated the same thing for counting of coal dust 20 yr earlier, and it seems to be true of any microscopical counting method.] By the mid-1980s, standardization and regular sample exchanges between laboratories had been adopted, and results since then have been fairly stable, but these changes, and others such as the adoption of personal sampling and the use of short-term as opposed to 3 month samples, make it hard to say how modern measurements relate to Turner’s measurements underlying the standard.

In Britain, the government and Health & Safety Commission appointed an Advisory Committee on Asbestos (ACA), which in 1979 recommended reduction of the asbestos standard for chrysotile to 1 fibre/ml (ACA, 1979). However, their method of derivation of the standard and its application were in the long term more influential than the number. The ACA made the social judgement that asbestos should not in general be banned, although some processes should be. It specifically rejected (para. 162) the approach of defining acceptable risk and deriving a corresponding exposure limit. It recommended instead that a concentration should be identified ‘at which further expenditure of effort to lower that level is out of all proportion to the reductions thereby achieved’; that this test should be applied where reduction is most difficult; that the resulting fibre/ml level should be compared with the risk estimates to ensure that the corresponding risk was not unacceptably high; that this number should be applied to all processes as a ‘control limit’; and that for all processes there should be an overriding regulatory requirement to reduce exposure below this limit to the minimum that is reasonably practicable. Thus the risk estimates were given very much a secondary role in determining what the limit should be. These concepts have continued to govern the British approach to asbestos exposure limits ever since, and were later applied to many other substances for which no safe level could be identified. (Risk quantification had a resurgence of importance in Britain in the 1990s, when governments required impact assessments for new regulations. It was therefore necessary to say what would be the saving of ill-health of a new limit and its consequent economic benefit, but this quantification remained uncertain, and of secondary importance in deciding the limits.)

The limit of 1 fibre/ml for chrysotile, averaged over 8 h, and the overriding requirement to reduce exposure as far as is reasonably practicable were incorporated in the 1983 European Directive (Council of the European Communities, 1983). This was implemented in Britain through the Asbestos Regulations 1987, which incorporated a stricter limit of 0.5 fibres/ml over 4 h. Currently the 4 h chrysotile limit in Britain is 0.3 fibres/ml, and the use of chryso-
tile is prohibited (with minor and temporary exceptions)—a measure which the ACA did not feel able to recommend.

CONCLUDING DISCUSSION

The 1968 chrysotile standard was of worldwide importance for 15 yr or so in terms of the numerical value, and permanently in its adoption of the membrane filter method. However, the standard generally adopted was to apply the 2 fibres/ml to single-shift samples, whereas the BOHS committee intended a 3 month average with a 90% confidence limit of <2 fibres/ml. It is hard to say which of these approaches is the tighter standard. Nor can we say exactly what were the effects of method standardization and quality control, although it is likely that the numerical value of 2 fibres/ml meant a tighter standard in the 1980s than in the 1960s.

A risk estimate that could not account for cancer was clearly flawed. This problem was permanently circumvented when the ACA report, followed by the European Directive, did away with the concept of deriving the limit primarily from a risk estimate.

The influence of the standard clearly went far beyond the expectations of the group that drew it up. As far as its shortcomings are concerned, it is hard to improve on the comments of Berry (1978), who drew attention to the severe problems of the underlying data, as summarized above, but pointed out that the standard mentioned the scantiness of the data, and avoided the terms ‘acceptable’ and ‘safe’. As Berry said:

… there had been no defined standard in the United Kingdom. One should surely make the best use of the data available while at the same time trying to obtain better data for the future.

… It was because members of the Society had not been sure about what advice to give to their management that a committee had been set up to try to make a recommendation based on the evidence available to members of the Society.

Looked at from this point of view, the standard, with all its flaws, was a landmark.

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REFERENCES


