WATCH/2009/3
Annex 1

A basis for setting Control Banding band limits for exposure to asbestos

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Although the questions before WATCH relate to exposure to asbestos, it is considered reasonable to assume that any principles applicable to asbestos can be equally applied to any substances or agents hazardous to health.

In setting "limits" for Control Banding bands the fundamental requirement must surely be that any exposures to substances or agents hazardous to health experienced by those working at the upper limit in any control band are restricted to ensure that the potential health risks do not exceed socially "acceptable" levels. In addition, the controls applied must ensure that any exposures to bystanders, such as those occupying buildings during the work or who will reoccupy the building after completion of the work, are restricted to ensure that the bystanders' potential health risks also do not exceed socially "acceptable" levels.

Setting such risk-based band limits involves:

1) Defining "acceptable" levels of risk;
2) Determining the likely pattern of exposure of those likely to be at risk;
3) Determining the exposure levels that will ensure any risk does not exceeded the "acceptable" level for either workers or foreseeable bystanders.

Defining "acceptable" levels of risk

HSE (1988, 1992, 2001) identified three risk regions: broadly acceptable, tolerable and unacceptable.

Paragraph 130 of HSE (2001) commented that: "HSE believes that an individual risk of death of one in a million per annum for both workers and the public corresponds to a very low level of risk and should be used as a guideline for the boundary between the broadly acceptable and tolerable regions.

The above figure of one in a million per annum was adopted in CD205, HSC (2005), in assessing the "acceptability" of the risk from the removal of textured coatings containing asbestos.

Paragraph 138 of HSE (2001) comments that HSE: "… does not advise against granting planning permission on safety grounds for developments where such individual risk is less than 1 in a million a year. (Somewhat different criteria are applied to sensitive developments where those exposed to the risk are more vulnerable, e.g. schools, hospitals or old peoples' homes, or to industrial or leisure developments, reflecting the different characteristics of the hypothetical person used to assess individual risk)."

Paragraph 3 of Appendix 4 of HSE (1992) noted that for land planning criteria: "… an additional lower bound of 1 in 3 million per year for developments with higher proportions of highly susceptible persons."

Conclusion 1

It is considered that each Control Banding band should be intended to limit risks to "acceptable" levels of 1 excess death per million per year for workers and adult bystanders and to 1 death in 3 million per year in areas where "highly susceptible" persons may be exposed, e.g. as in residential premises, schools or hospitals.

Determining the likely pattern of exposure of those likely to deliberately disturb asbestos containing materials

Mesothelioma risk for a given exposure to a given type of asbestos depends on the combined effects of age at beginning of exposure and the duration of service.

In Figure 4 and paragraph A64 of Annex D(A) of CD205 it was noted that the average age of asbestos removal operatives was 32.5 years with significant numbers having been exposed from age 20 and that 90% of such operatives worked in the industry for 5 years or less.

Detailed service data for 1056 operatives employed by members of the Asbestos Removal Contractors Association (ARCA) in 2005 were available.

Mr. Sadley, the Chief Executive of ARCA, kindly permitted these data to be analysed for this note.

The ARCA data were analysed and provided the following relevant data:

Distribution of age at entry to the asbestos removal industry:

Age at entry	<20	20-24	25-29	30-34	35+
No of operatives	127	240	207	174	308
% of operatives	12	23	20	16	29
Cumulative %	12	35	54	71	100

Distribution of years of service:

Service (yr)	30+	25-<30	20-<25	15-<20	10-<15	5-<10	2-<5	<2
No of operatives	10	29	78	111	133	232	283	180
% of operatives	1	2.7	7.4	11	13	22	27	17
Cumulative %	1	3.7	11	22	34	57	83	100

As service and age of entry interact, in that it is not possible for a 40 year old man with 20 years service to have entered the industry after age 20, the Doll and Peto (1985) factor [(80-age at entry)^4-(80-age at present)^4] was calculated for each operative.

Distribution of the population mesothelioma risk accumulated by individual operatives on the assumption of equal exposure throughout service:

% of population risk	2.5	5	10	15	25	50
No of operatives	6	12	26	42	76	199
% of operatives	0.6	1.1	2.5	4.0	7.2	18.8
Average age at entry	16.5	17.3	18.1	18.4	19.6	22.4
Average service (yr)	28.7	27.4	26.0	23.6	22.3	18.8

From the above tables it can be seen that: about 10% of the operatives had entered the industry before age 20, about 10% of the operatives had over 20 years service and about 1% of the operatives had accumulated 5% of the total mesothelioma risk accumulated by all 1056 operatives.

Some of the above operatives will continue working in the industry. The above service figures are therefore unlikely to reflect these individuals' likely eventual total service; and thus their eventual total risk.

Although the CD205 risk assessment for the removal of textured coatings containing asbestos was based on average risk it is considered that a valid risk assessment should be based on protecting 90-95% of persons.

Conclusion 2

As there is no restriction on persons entering the asbestos removal industry or construction industry trades immediately on leaving school, it is concluded that for assessing risk for Control Banding purposes for asbestos, the assessment of mesothelioma risk should be based on the assumptions of first exposure on leaving school at age 16 and on a possible likely exposure duration of 30 years, i.e. on the assumption that exposure to asbestos will occur between ages 16 and 46.

Determining the exposure levels that will ensure any risk does not exceeded the "acceptable" level for either workers or foreseeable bystanders

From Conclusions 1 and 2 above it is necessary to determine the exposure levels of asbestos that will generate a risk of 1 per million per year for a 30 year exposure beginning at age 16.

In Annex E of CD205 annual risk was calculated by dividing the assessed lifetime risk by an assumed survival period of 50 years from the time of first exposure.

However, paragraph 167 of HSE (1992) commented that: "In order to permit comparison with conventional risks it is necessary to average the total radiation risk over the number of years of exposure."

As the major effect of exposure to ionisation radiation is mainly to increase the statistical probability of developing cancer in later life, just as occurs from exposure to asbestos, the annual risk of developing mesothelioma should be determined by dividing the total lifetime risk by the duration of exposure rather than by dividing by the survival period.

There are a number of reasons why determining annual risk by dividing by the survival period may be incorrect: a number of authors have reported that the latent period for mesothelioma is related to the severity of exposure, being shorter for the more severe exposures, e.g. Bianchi et al (2001); application of the Doll and Peto (1985) model supports such a relationship, although such relationship from the model may be a mathematical artefact; in practice only a small proportion of mesotheliomas develop within 20 years of first exposure and about half develop in the final 10 years of survival, so giving a variable annual rate depending on what period is used as the divisor; and, the factor that can potentially be controlled is the rate at which risk is accumulated.

Assuming that annual risk is calculated by dividing total lifetime risk by the duration of exposure, the limiting lifetime risk for annual risk of 1 per million from a 30 year exposure to asbestos is 30 per million. However it should be appreciated that the actual annual risk in the earlier years of exposure will be higher than in the later years.

Application of the Hodgson and Darnton (2000) model

From Hodgson and Darnton (2000), as modified by Andy Darnton at the WATCH meeting of 7th November 2007, the correction factor, equivalent to those shown in Table 9 of Hodgson and Darnton (2000), for exposures starting at age 16 would be about 2.8. The total correction factor for a 30-year exposure from 16 to 46 would therefore be about times 8 for risks resulting from exposure between ages 30 and 34.

At the WATCH committee meeting in October 2008 it was agreed that the Hodgson and Darnton (2000) model could be applied for cumulative exposures of 0.1 fibres/ml.years.

The Committee paper for the WATCH meeting of 24th February 2009 noted that the “best estimate” cancer risks for crocidolite, amosite and chrysotile at 0.1 fibres/ml.years would be 1200, 210 and 10 per million respectively for a 5 year exposure from age 30. Note that 0.1 fibres/ml.years over 5 years equates to a continuous occupational exposure to 0.02 fibres/ml.

A continuous 30-year occupational exposure to 0.02 fibres/ml, equivalent to a cumulative exposure of 0.6 fibres/ml.years, from age 16 would generate total lifetime risks from crocidolite, amosite and chrysotile of 9,600, 1,680 and 300 per million and corresponding annual risks of 320, 56 and 10 per million respectively.

Continuous occupational exposures to 0.02 fibres/ml for 30 years from age 16 would therefore generate annual risk levels factors of 320, 56 and 10 too high for crocidolite, amosite and chrysotile respectively.

The Hodgson and Darnton (2000) model therefore cannot be used to quantify “acceptable” levels of risk for any of the three main types of asbestos.

However, as I raised at the February 2009 WATCH meeting, the min-max risk figures in the Committee paper fail to address the relative extrapolations for the three types of asbestos.

From Table 1 of Hodgson and Darnton (2000) the average cumulative exposures in the pure crocidolite, amosite and chrysotile cohorts, weighted by the number of mesotheliomas observed, were 27, 57 and 567 fibres/ml.years respectively. That is, at 0.1 fibres/ml.years the extrapolations for crocidolite and amosite are about a tenth of the extrapolation for chrysotile.

I consider that the min-max figures in the Committee paper should reflect the degree of extrapolation from the data on which the model is based.

If the model can be extrapolated to 0.1 fibres/ml.years of chrysotile, it should be able to be extrapolated to 0.01 fibres/ml.years for crocidolite and amosite with the same accuracy as achieved when extrapolating chrysotile to 0.1 fibres/ml.years.

From Table 11 of Hodgson and Darnton (2000) the mesothelioma risk from a 5 year cumulative exposure of 0.01 fibres/ml.years from age 30 would be 200 per million for crocidolite and 30 per million for amosite. Note that 0.01 fibres/ml.years over 5 years equates to a continuous occupation exposure to 0.002 fibres/ml.

A continuous 30-year occupational exposure to 0.002 fibres/ml, equivalent to a cumulative exposure of 0.06 fibres/ml.years, from age 16 would generate total lifetime risks from crocidolite and amosite of 1,600 and 240 per million and corresponding annual risks of 32 and 8 respectively.

Conclusion 3

It is considered that if the Hodgson and Darnton (2000) model can be extrapolated to 0.1 fibres/ml.years of chrysotile and 0.01 fibres/ml.years of crocidolite and amosite, the annual risks resulting from 30 years continuous occupational exposure to 0.02 fibres/ml of chrysotile or 0.002 fibres/ml of crocidolite or amosite would be 10, 32 and 8 per million respectively.

Comments

Risk reduction

Assuming that mesothelioma risk continues to vary as cumulative exposure to the power 0.75 for exposures below 0.1 fibres/ml.years, exposures will vary as risk to the power 1/0.75 = 1.33. To reduce risk by factors of 10, 32 and 8, exposures would need to be further reduced by factors of 10^1.33, 32^1.33 and 8^1.33 for chrysotile, crocidolite and amosite respectively to maintain “acceptable” levels of risk.

Given that operatives can be protected by a combination of working practices, enclosure extraction and personal protective equipment such combinations should be designed to reduce inhalation exposures to as far below 0.002 fibres/ml of amphiboles or 0.02 fibres/ml of chrysotile as can be practicably achieved.

However, building occupants and those who will reoccupy buildings once the asbestos works have been completed cannot be expected to wear personal protective equipment. It is therefore essential that the enclosures and operative and equipment decontamination procedures adopted ensure that any “leakage” into buildings during asbestos disturbance or enclosure removal is maintained below 0.002 fibres/ml of amphibole fibres and that clearance procedures, particularly in schools and residential properties, achieve the same level rather than the current figure of 0.01 fibres/ml.

It is considered highly unlikely that “mini-enclosures” with neither extraction nor airlocks will able to main such performance for any work involving disturbance of amphiboles or which involve breaching the integrity of the enclosure by removing ceiling or wall panels.

Sampling and analysis

Although there is tendency to define the Limit of Quantification of asbestos sampling as being 0.01 fibres/ml, the actual Limit of Quantification is a count of 20 fibres, which, in a sample of 0.5 m^3 and a sampling filter area of about 390 mm^2, is equivalent to a concentration of 0.01 fibres/ml.

If the sample volume is increased to, say, 2 m^3, and 500 microscope fields are counted, the Limit of Quantification for 20 fibres counted will be 0.001 fibres/ml.

Both above modifications comply with current guidance.

Current sampling and analysis techniques can therefore quantify 0.001 fibres/ml.

If concentrations below 0.001 fibres/ml are to be quantified, or if shorter duration sampling is important, sensitivity can be further improved by reducing the effective area of the sampling filter. However, there is a possibility that such samples may be obscured by non-fibrous particles on the sampling filter. Such obscuration can be reduced by using size selecting samplers to minimise the collection of non-fibrous particles.

WHO (1997) recognised the possible requirement for the use of both reduced area filters, page 5, and size-selecting sample heads, page 8. See also Stacey (1995) regarding the use of reduced area sampling filters.

Given the number of non-asbestos fibres present in many environments, it will probably be necessary to use MDHS87, HSE (1998), discrimation techniques or PCME analysis using transmission electron microscopes for high sensitivity samples.

Although such analysis is more expensive than conventional PCM, the cost of such analysis is trivial in the context of the total asbestos removal costs or the costs of decontamination, e.g. following the Silverhill school incident in Derby the school was closed for two months and the clean-up cost £750,000.

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