HSC/05/103 F

HEALTH AND SAFETY LABORATORY RESEARCH INTO AIRBORNE FIBRE RELEASES DURING THE REMOVAL OF TEXTURED DECORATIVE COATINGS

EXECUTIVE SUMMARY

1. The Association of British Insurers (ABI) and HSE jointly commissioned this work, which was managed and co-ordinated by the Health and Safety Laboratory (HSL). The aim of the study was to measure the airborne fibre and asbestos concentrations released during the removal and repair of damaged chrysotile containing textured coatings, at some forty sites. The sites, identified by ABI for sampling, were all domestic premises.

Sampling, analysis and site data collection

2. Airborne sampling at the sites and the initial analysis of half filters for the fibre number concentration was carried out by Casella Hazmat, based on the procedures in MDHS 39/4. A number of the sites were also sampled by HSL field sampling staff. HSL also carried out further analysis of the samples to discriminate between the fibre types. Questionnaires, completed by the site sampling personnel, were used to standardize information relating to, the cause and nature of the damage, the removal techniques employed and to identify work activities during sampling using activity codes. This information was used to classify work practises and help interpret the results and where possible to calculate the time weighted average (TWA) airborne fibre concentrations. As many of the jobs were less than 4 hours duration some assumptions had to be made.

3. Both the sampling and analysis of textured coating removal proved to be a challenge and there were a number of problems to overcome.

4. The nature of the removals and the material meant that most jobs were difficult to wet and proved to be very dusty, with much of the dust coming from the backing material (e.g. plaster) rather than the textured coating. Consequently at many jobs only limited numbers of short duration samples were taken, as the on-site sampling personnel attempted to avoid overloading the samples with airborne dust so that the filters could be analysed by optical phase contrast microscopy (PCM) for the numbers of fibres present. One result of the limited sampling times and volumes of air sampled was that the limit of quantification (LOQ)[1] was much higher than for longer-term samples. To overcome this and to improve the LOQ, pooling of the individual sample data by job or work activity was carried out.

5. Another important consequence of taking limited numbers of short duration samples, during the dustiest phase of the removal, was that it was difficult to accurately calculate the four-hour time weighted averages (TWA) required for assessment to the control limits. Other estimations of four-hour TWAs were therefore made using pooled averages (for the duration of the removal) and also for an upper limit (a worst-case scenario, based on continuous exposure at the highest individual recorded airborne fibre concentration measured during each job). To overcome the sampling problems, at later sites the sampling protocol was changed so that the flow rates of some samples were set much lower than the 1 litre per

[1] Based on 20 fibres in 200 fields of view.

minute required for personal samples. This often allowed a single sample for the job to be collected overcoming issues related to the collection of many separate short-term samples.

6. Analysis of the initial samples by transmission electron microscope (TEM) and energy dispersive x-ray analysis (EDXA) techniques indicated that many of the fibres countable by PCM were calcium sulphate fibres (from the under laying plaster) and not asbestos fibres. Additionally the presence of large amounts of non-fibrous calcium sulphate particles rendered some filters uncountable (over loaded). To overcome this problem a treatment technique was developed by HSL, to remove the soluble calcium sulphate particles from the filter prior to the sample filter being mounted for analysis by PCM and TEM. This meant that the Casella –Hazmat PCM results were for untreated samples which included a significant proportion of calcium sulphate fibres but HSL results were for both treated and untreated samples.

PCM results for the Untreated Samples:

7. One hundred and ninety-one samples, other than clearance samples, were collected from thirty-five sites. The average airborne fibre concentration from eighty-three samples analysed without any treatment was 0.28 f/ml. The overall four-hour TWA for these untreated samples was 0.04 f/ml and average (per job) total sampling time was 150 minutes (2½ hour).

PCM results for the Treated Samples:

8. The average airborne fibre concentration, determined from the analysis of one hundred and six samples treated to remove soluble material was 0.09 f/ml.

9. The short term TWAs calculated for fifty-one treated samples with sampling times of less than twenty minutes was 0.124 f/ml. One treated sample had a short term TWA that exceeded 0.6 f/ml.

10. The average for the upper limits to the four-hour TWAs (treated samples) was 0.096 f/ml with four of the eighteen jobs exceeding the 0.1 f/ml control limit. Using the more realistic estimates based on pooled data and job duration estimated from start of sampling to start of clearance sampling, then the average four-hour TWA (treated samples) was 0.047 f/ml with only one of these eighteen jobs exceeding the 0.1 f/ml control limit.

11. A sub-set of sixteen treated samples, each of which was for sampling times in excess of two hours (average 152 minutes) and for the full duration of the removal (in that area or room) had an average four-hour TWA of 0.02 f/ml.

TEM results – Treated Samples:

12. TEM analysis was carried out using the ISO10312:95 method to determine the concentration of PCM equivalent asbestos fibres (i.e. fibres >5 µm long, 0.2 –3 µm width and with an aspect ratio >3:1). Due to cost only a limited sub-set of samples were analysed by TEM. The TEM sub-set was selected based on a high PCM count being present. The pooled average PCM equivalent airborne asbestos fibre concentration from twenty-eight samples analysed using TEM techniques was 0.014 f/ml. Extrapolating to the whole set of treated samples (using the ratio of the average PCM value for this subset to the overall PCM average) suggested that the average TEM PCME airborne fibre concentration for the whole population would be about 0.01 f/ml.

13. Over half of the samples analysed by analytical TEM had air volumes equal to, or less than twenty litres (this implies sampling times of <20 minutes), therefore if a single fibre was counted the airborne concentration would exceed 0.6 f/ml (the proposed new short term control limit), and would bias the results, thus overestimating the percentage of jobs/ activities exceeding the control limits.

14. Only chrysotile asbestos fibres were found in the TEM analysis. Many chrysotile fibres were present in some samples, which would not be visible or counted by PCM and were not included in the TEM counts of PCM equivalent fibres. These <5 µm long and <0.2 µm diameter fibres are present in all chrysotile releases but the PCM count (or its equivalent) is used as the index to assess the exposure and calculate risk.

PCM results using the WHO Fibre Counting Rules

15. Changes in the directive (2003/18/EC) will introduce the World Health Organisation (WHO) method for fibre counting. Two important changes in regard to sample analysis are that: it will allow fibre discrimination to be carried out using other methods than PCM when assessing against the control limit: and changes in the counting rules will now include all >5 µm fibres visible by PCM in the count (fibres attached to particles >3µm diameter are currently excluded in the MDHS 39/4 counts). The PCM results from a sub-set of counts carried out using both counting protocols (MDHS 39/4 and WHO) increased the number of fibres (all types) counted by a factor of two (2.2). However, the increase is likely to be limited if fibre discrimination techniques are used to dissolve calcium sulphate fibres.

Summary of Means and TWA's from the pooled data

16. A summary of the pooled averages of the individual samples for the various analyses is given in the table below.

Summary of the pooled individual values

Method	Individual samples		
	Pooled mean♦ (f/ml)	4 - hour TWA (f/ml)	10 - minute TWA (f/ml)
Control limit (f/ml TWA)		0.1	0.6
PCM – MDHS39	0.06 (86 samples)	0.03 (37 samples)	0.36 (48 samples)
Treated PCM - MDHS39	0.03 (106 samples)	0.012 (57 samples)	0.124 (51 samples)
Treated PCM - WHO	0.14 (21 samples)	0.04 (8 samples)	0.35 (12 samples)
Treated TEM PCME asbestos fibres	0.014 (28 samples)	~ 0.005*	~ 0.06*

The values in brackets are the number of samples or jobs from which the values were derived.

Four-hour TWAs for individual samples were only calculated if the sampling time exceeded twenty minutes. It was assumed that during the remaining part of the four hours no exposure occurred.

If the sampling time was less than twenty minutes (individual samples) then only short term, ten-minute TWAs were calculated.

♦ These are the pooled means for the raw data before time weighting.

* Difficulties in calculating TWAs for the TEM data meant these values could only be derived by applying the ratio of the pooled means [treated PCM (MDHS39/4) and TEM PCME asbestos fibres] to the treated PCM MDHS 39/4 TWAs.

17. Direct determination of the TEM four-hour TWA was not possible due to the limited subset of data but comparisons with the PCM data suggest that it would reduce the airborne asbestos concentration to about 0.005 f/ml. Although these values are extrapolations from the measured data they do give a reasonable indication of TWA airborne asbestos fibre concentrations. Calculation of the TEM ten-minute TWAs presented no such problems. The average ten-minute TWA, 0.06 f/ml was not only about one tenth the 0.6 f/ml ten-minute control limit but was also below the 0.1 f/ml four-hour TWA.

18. All the four-hour TWA estimates were made assuming that there was no further exposure after the completion of sampling, or if less than four hours had elapsed before the end of the job.

Conclusions

19. Although the PCM data indicates that the airborne fibre concentrations for all fibres may on some occasions have exceeded the four-hour control limits, the TEM analyses indicated that most of these fibres were not asbestos and the PCM equivalent airborne asbestos concentrations during the removal of textured coatings were usually much lower. The pooled TEM average 0.014 f/ml (without time weighting) was one-seventh the proposed 0.1 f/ml, four-hour control limit and time weighting, considering the duration of most of these jobs, would further reduced this value.

20. Chrysotile fibres were the only type of asbestos detected in the TEM samples analysed.

21. The lower flow rate sampling strategy and removal of soluble particles before analysis overcame most of the problems associated with the sampling of this type of work.

Further work

22. The techniques developed in this study for the sampling and analysis of work with textured coatings should be further developed and introduced into HSE guidance.

23. A risk assessment should be carried out based on this new data to determine whether removal of chrysotile containing textured coatings should continue to done only by a licensed asbestos removal contractor.

HSL RISK ANALYSIS OF LICENSED WORK WITH TEXTURED DECORATIVE COATINGS

Introduction

24. The proposal to remove textured coatings from the licensing regulations (ASLIC, 1983) can be assessed in terms of risk. However, the calculated risk needs to be viewed in context with other asbestos containing materials (ACMs). As the information available to HSE on licensed ACMs is of much greater quality than unlicensed ACMs, the relative risk for all licensed materials has been calculated for comparison with textured coatings.

25. The HSE database for licensed asbestos removal is held by the FOD Health Unit (HU) and contained some 97,940 job notifications from a 3-year period, amounting to a total of 709305 working days (job-days). The database is based on information supplied by licensed asbestos removal contractors on the standard ASB5 notification forms. The forms specify five categories of asbestos materials: asbestos insulating board (AIB), asbestos insulation (AI), asbestos coatings (AC), textured coatings (TC) and others (OTH). One or more of these are recorded for each job with the most abundant material first. Figure 1 summarises the number of jobs by material type. Textured coatings accounted for 15.6% of all licensed removal jobs.

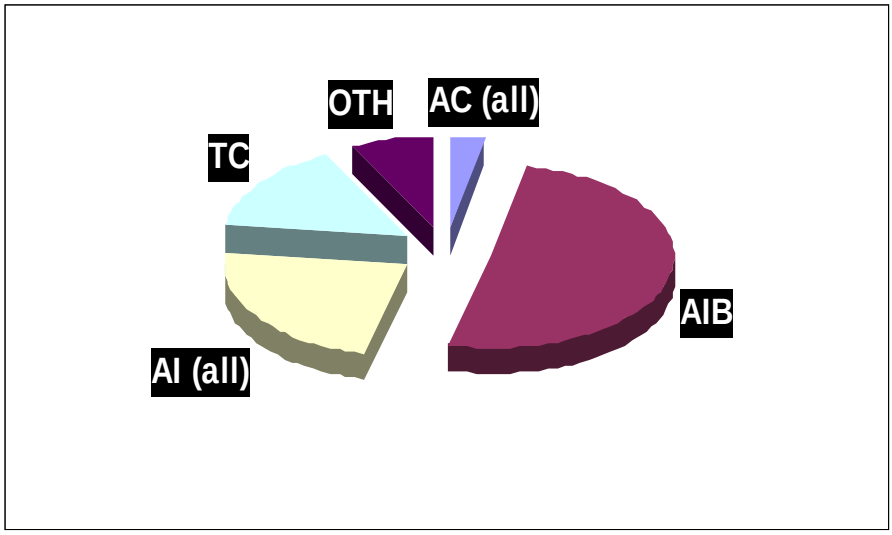

Figure 1: Relative frequency of asbestos material type encountered during licensed removal work (by number of jobs)

26. Work with textured coatings (and other licensed materials) not-exceeding a total of 2 hours does not require a licensed contractor to carry out the work or notification to HSE. It is likely many small jobs on textures coatings take place associated with: lighting, plumbing and cabling. All work with asbestos is covered by CAW, (2002) and one of two approved codes of practices (L27 & L28), with a duty to ensure airborne exposures to workers and the spread of asbestos are kept as low as reasonably practicable.

Method for estimation of the risk from removing textured coatings from the licensing regulations

27. The method for estimating risk requires information on the exposure of workers. The following main parameters have been assessed to estimate the average exposure to licensed asbestos removers:

- The type of activity and frequency which it is carried out;
- The types of material being disturbed or removed;
- The average concentration of airborne asbestos fibres produced by the different types of activity;
- The effectiveness of controls.

28. The lifetime risks related to the asbestos exposure are calculated using a model derived from Hodgson and Darnton (2000). The main inputs into the model that will affect the calculated risk are:

- The arithmetic mean exposure;
- The age first exposed and survival age;
- The frequency and duration of the exposure;
- The type of asbestos released.

Risk estimation for licensed asbestos removal workers

29. Data from the ASB5 notification forms was used to compile a table of the number of notified licensed asbestos removal jobs carried out over the last three years. These are summarised by both number of jobs and the actual number of job days. Removal of textured coating was found to be the shortest category of licensed asbestos removal work with an average time of 3.8 days compared to the overall average of 6.9 days per job. Therefore although removal of textured coatings account for 15.6% of the jobs, it only represents 8.7% of the exposure to licensed asbestos removal workers in job days.

Table 1: Summary of FOD database for licensed removal work

	By number of jobs		By job-days		
Type of ACM	Number of Jobs	Percentage of total	Number of job days	Percentage of total	Average duration of job (days)
AC	2276	2.32%	23056	3.43%	10.1
AC & AIB	289	0.30%	4589	0.68%	15.9
AC & AI	220	0.22%	2620	0.39%	11.9
AC, AI & AIB	262	0.27%	6738	1.00%	25.7
AIB	49608	50.65%	290134	43.20%	5.8
AI	20303	20.73%	167579	24.95%	8.3
AI & AIB	2440	2.49%	39795	5.93%	16.3
Other	7245	7.40%	78891	11.75%	10.9
TC	15297	15.62%	58239	8.67%	3.8
Total	97940	100%	671641	100%	6.9

Calculation of exposure by job from FOD HU database

30. By combining the frequency of work with the fibre concentration data for each category of asbestos material it was possible to calculate the average annual exposure to all asbestos removal workers in terms of job days. The fibre concentrations were primarily derived from HSL data collected inside enclosures during asbestos removals in the UK to reflect the wet removal process that should be taking place. Mostly the removal data is for a single type of asbestos. Where multiple ACM types were recorded in the HU database it should be in order of amount but we had no indication of the actual amount of each type. Therefore the fibre concentrations from mixtures are calculated from a simple arithmetic average of the fibre concentrations for each individual ACM types. A fibre concentration for "other" asbestos has to be assumed to complete the exposure assessment. A weighted mean concentration in terms of number of jobs was calculated and used but if "other" was truly other non-licensed materials rather than a mixture of licensed materials the average fibre concentration may be lower.

31. Very limited data for textured coatings was available because it is very difficult to monitor many removal jobs and as the coating is usually on a plaster surface calcium sulphate fibres are released and counted as asbestos fibres using the current phase contrast microscopy (PCM) counting methods. Very recent data where analytical transmission electron microscopy (TEM) analysis has been carried out to identify fibre types showed that for small-medium scale work, the average exposure of asbestos may be an order of magnitude lower than the value used (0.084 f/ml), which is based on PCM data.

Table 2: Calculated annual exposure to asbestos removal workers (based on an average of a 3-year period 2000 – 2003).

	Arithmetic mean personal exposure	Cumulative exposure in 1 year	Percentage of total exposure
Type of ACM	(f/ml)	f/ml.job-days	
AC	14.36	110361	22.4
AC & AIB	7.39	11297	2.3
AC & AI	9.28	8105	1.6
AC & AI & AIB	6.32	14202	2.9
AIB	0.41	39652	8.1
AI	4.2	234611	47.6
AI & AIB	2.31	30576	6.2
Other	1.60*	42075	8.5
Textured coatings	0.08	1553	0.3
Total		492432	100.0

* Value estimated as a mixture of licensed ACMs

Calculation of worker exposure

32. Two key pieces of information for risk assessment are lacking: (i) the number of workers employed, which is required to estimate the total exposure duration of all workers, i.e. to get from job-days to man-days; (ii) the asbestos type(s) encountered in the various jobs, on which the risk is strongly dependent. The maximum number of workers is given on the ASB5 notification form but is not recorded in the HU database. The asbestos type does not appear on the ASB5 form but is usually given in the accompanying Job Plan.

Additional information from ASB5 notifications and Job plans

33. To obtain this additional information a sub-set of 903 ASB5 notifications and Job Plans from the Sheffield and Manchester Area Offices, covering periods of about 3 months up to October/November 2004. Table 3 gives the number of jobs and the calculated number of job days and person days from the ASB5 forms (e.g. worker-days = total number of workers on site x length of job in days). These are likely to be overestimates for duration of exposure as not all workers will be inside the enclosure removing asbestos for the entire time and during set up and take down lower exposures are likely than attributed from the air monitoring data.

Table 3: Analysis of Job Notifications in a sample of ASB5s by ACM Type

Type of ACM	Number of jobs	Job-days	Total person-days	Average person-days
AC+AI+AIB	3	735	10245	3415.0
AC+AI	2	35	205	102.5
AC+AIB+TC	2	40	220	110.0
AC+AIB	5	107	424	84.8
AC	7	77	435	62.1
AI+AIB+O	2	42	168	84.0
AI+AIB	35	405	2263	64.7
AI+O	5	113	448	89.6
AI	135	1214	5080.5	37.6
AIB+O	11	80	285	25.9
AIB+TC+O	1	2	6	6.0
AIB+TC	10	136	690	69.0
AIB	446	3868	12746.5	28.6
O	53	806	3282	61.9
TC+AI	1	4	12	12.0
TC+O	4	308	1036	259.0
TC	181	589	1665.5	9.2
Overall Aver.				43.4
Total	903	8561	39211.5	

34. As the required information on asbestos type was given in only 723 of the 903 plan of work / notifications examined, some figures for asbestos type(s) present in each ACM type are statistically poor. Rounded off values of the asbestos types listed against various types of ACM are given in Table 4. These were used to calculate risk factors for the ACM based on the HD relative risk factors of: chrysotile =1, amosite = 100 and crocidolite = 500. Overall,

the average relative estimate of asbestos type for chrysotile: amosite: crocidolite were 10:85:5 giving a relative risk factor of 110.1 compared to chrysotile exposure only.

Table 4: Information from plan of work data for the asbestos types present for different Types of ACM

ACM Type	Type of Asbestos Present (%)			Calculated risk factor
	Chrysotile (CH)	Amosite (AM)	Crocidolite (CR)	
AC *	5	75	20	175
AC + AIB	3	85	13	148
AC + AI	5	73	23	185
AC + AI+AIB	3	80	17	163
AIB	0	95	5	120
AI	5	70	25	195
AI + AIB	3	83	15	158
O	13	85	2	95
TC	100	0	0	1
All data	10	85	5	110

Calculation of relative risk compared with other licensed ACMs

35. Table 5 brings together all the data from tables 1-4 above and then uses this information to calculate the relative risks. Total worker exposure in f/ml.person-days per year (column 6) is calculated by multiplying columns 4 and 5. The percentage of total worker exposure contributed by each ACM type is given in column 7. The asbestos type taken from a sample of Job Plans in table 4 and the calculated risk factors for each type of ACM are entered in column 8. Multiplying f/ml.person-days per year by the risk factor gives a value adjusted for the relative risk (column 9) from which the contribution to the total risk from each ACM types can be calculated (column 10). It is worth noting that the relative risks for the various combinations of licensed materials varies between 1% - 43%, except for textured coatings which are some three orders of magnitude lower.

Table 5: Calculation of relative risks

Type of ACM	Number of jobs in 3-year period	Number of jobs per year	Average worker-days per job	Worker-days per year	Fibre concentration (f/ml)	Exposure (Worker-days f/ml/yr.)	Percent of total exposure (%)	Risk Factor for asbestos type	Weighted risk from work with various ACMs	Percent of total risk by type of ACM (%)
Column No.	1	2	3	4	5	6	7	8	9	10
Source/Calc	HU	HU	ASB5	(C2xC3)	HSL	(C4xC5)	(From C6)	Table 4		
AC	2276	758.7	62.1	47145.7	14.36	677012.5	15.7	175.1	118.51	16.41
AC & AIB	289	96.3	84.8	8169.1	7.39	60328.6	1.4	147.5	8.90	1.23
AC & AI	220	73.3	102.5	7516.7	9.28	69754.7	1.6	185.1	12.91	1.79
AC & AI & AIB	262	87.3	3415.0	298243.3	6.32	1885892.0	43.7	163.4	308.09	42.67
AIB	49608	16536.0	28.6	472592.3	0.41	193762.8	4.5	120.0	23.25	3.22
AI	20303	6767.7	37.6	254689.8	4.20	1069697.3	24.8	195.1	208.64	28.89
AI & AIB	2440	813.3	64.7	52587.8	2.31	121214.9	2.8	157.5	19.09	2.64
Other	7245	2415.0	61.9	149547.7	1.60	238610.4	5.5	95.1	22.70	3.14
TC	15297	5099.0	9.2	46919.2	0.08	3955.3	0.1	1.0	0.004	0.0006
Total	97940	32646.7	41.9	1368618.5		4320228	100.00		722.10	100.00

Calculated risks using the Hodgson & Darnton (HD) Model

36. HSE data on the number of asbestos-related medical examinations show that the average years working per asbestos removal worker man is 3.09 but the majority of workers (71.5%) only have one examination, i.e. work for less than 2 years. Just over 90% of workers work for 5 years or less. The average age at the first medical was 32. The "best" estimate of the lifetime risk is 2.8 excess deaths per 100,000 for constant exposure to chrysotile at 0.08 f/ml from the removal of textured coatings for 5 years (for 240 days per year) from the age of 30 assuming no respiratory protective equipment (RPE) is worn. If RPE was worn with a protection factor of 100, the lifetime risk reduces to 0.1 excess deaths per 100,000. Clearly it is unlikely that a person would be removing textured coating every working day for 8 hours so the risk estimates are unlikely to be an underestimate.

37. To compare with the Tolerability of Risk (TOR) model currently used by HSE to categorise the scale of the risk in societal terms (R2P2), the units have to be adjusted to the annual risk of premature death per million. The annual risk was in this instance obtained from a linear estimate from the overall lifetime risk, by a simple division of the lifetime by the remaining life expectancy. A figure of 50 was used for the average life expectancy (this equates with the actual age of the first medical at 32 and a life expectancy of > 80 years. This gives a value of 0.6 per million annual risk of death for no RPE and 0.02 per million annual risk of death with RPE. The TOR approach considers annual risks of <1 per million to be the divide between "Broadly acceptable" and tolerable.

Summary

38. Textured coating is currently included along with decorative coatings in the licensing regulations. As far as is known these textured coating contain only chrysotile asbestos up to a maximum of 4-5 % but due to progressive substitution the asbestos content may be lower and from 1992 their marketing and use was prohibited and non-asbestos containing coatings were used instead. These coating have been widely used on the ceilings and walls of domestic premises and are also found in commercial premises.

39. Removal of the coatings is normally difficult and is often a dusty process, as the coating is often on a plaster surface and is painted so it will not readily absorb water. As the chrysotile is bound in a matrix work with this material does not readily produce high levels of airborne asbestos fibres unless power tools are being used. The presence of plaster and its dusty nature means that many non-asbestos (calcium sulphate) fibres can be released if inappropriately handled.

40. Average releases of chrysotile asbestos fibres of the order of 0.01 – 0.1 f/ml are likely using good removal practice and peak levels from poor removals are unlikely to exceed 1 f/ml.

41. The removal of textured coatings account for 15.6 % of the total number of licensed removal jobs notified to the HSE but due to the relatively short time for carrying out the work accounts for only 8.7% in terms of job days. Due to the relatively low airborne asbestos fibre concentrations the textured coating account for only 0.1 % of the total airborne exposure to asbestos removal workers. The lower risk associated with chrysotile compared to other asbestos types, means that the risk associated with textured coatings (<0.0001%) is several orders of magnitude below the risk compared to all other licensed asbestos materials (1-43%).

42. The calculated lifetime excess risk for a typical asbestos removal worker who spent 5 years of continuous removal work on chrysotile containing textured coatings is 2.7 deaths / 100,000. In terms of annual risk it falls well into the broadly acceptable category (< 1 per

million) even when it is assumed no RPE is worn. More recent evidence suggests that the actual airborne asbestos concentration is nearer to 0.01 f/ml than the average 0.084 f/ml concentration used for the above calculations.

43. Based on risk alone, there appears no justification for this material to require the extra provisions currently provided by the asbestos licensing regime. Removal from the licensing regulations but continuing restrictions under CAW would be unlikely to increase the annual risk sufficiently to take it out of the of the “Broadly acceptable” category used by HSE in the TOR model.